IMPACT OF MICROBIAL AND PHYSICO-CHEMICAL QUALITIES OF TREATED WASTEWATER EFFLUENT ON RECEIVING WATER BODIES IN DURBAN

SHALINEE NAIDOO

Submitted in fulfilment of the academic requirements for the degree of Master of Science (MSc) in the Discipline of Microbiology; School of Life Sciences; College of Agriculture, Engineering and Science at the University of KwaZulu-Natal, Durban.

As the candidate's supervisor, I have approved this dissertation for submission.

Signed: __________________ **Name:** __________________ **Date:** __________________

Form EX1-5

COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE

DECLARATION 1 - PLAGIARISM

I, …………………………………………….……………………….., declare that,

1. The research reported in this dissertation, except where otherwise indicated, is my original research.

2. This dissertation has not been submitted for any degree or examination at any other University.

3. This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

4. This dissertation does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a. Their words have been re-written but the general information attributed to them has been referenced

b. Where their exact words have been used, then their writing has been placed in italics and inside quotation marks, and referenced.

5. This dissertation does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the thesis and in the References sections.

Signed

………………………………………………………………………………

CMC Feb 2012

COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE

DECLARATION 2 - PUBLICATIONS

Details of contributions to publications that form part and/or include research presented in this dissertation (include publications in preparation, submitted, *in press* and published and give details of the contributions of each author to the experimental work and writing of each publication).

Publication 1

Publication 2

Publication 3

Signed:

“We have lived our lives by the assumption that what was good for us would be good for the world. We have been wrong. We must change our lives so that it will be possible to live by the contrary assumption, that what is good for the world will be good for us. And that requires that we make the effort to know the world and learn what is good for it.”

- **Wendell Berry**

ACKNOWLEDGEMENTS

- Professor A. O. Olaniran for his endless guidance, constant support and encouragement. Without your supervision, this would not have been possible. Thank you.
- Professor B. Pillay for his guidance, support and encouragement.
- Professor M. Taylor for her guidance with viral recovery and detection.
- National Research Foundation (NRF) for financial support.
- Medical Research Council for financial support.
- Basil Naidoo for his time and assistance.
- Mnqayi Wisemen Sakhi and Bewu Gambana for their time and help during samplings.
- The Erasmus Mundus SAPIENT Scholarship Program and Radboud University Nijmegen for providing me with the opportunity to study abroad.
- The Water Research Group of Lab 4 for bringing the entire research project together. May we never stop in our fight to save mankind's precious resource.

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

\- Margaret Mead

ACKNOWLEDGEMENTS

- **My parents –** without your constant guidance and never ending support, this would not have been possible. You have shown me that with passion and hard work, I can achieve anything. To my father, **Sagaran Naidoo** – thank you for your constant help during monthly samplings and with construction of the viral recovery system. To my mother, **Krishnee Naidoo** – thank you for all your support and advice and for travelling 9364 kilometers to ensure I was okay.

"If I have seen further than others, it is by standing upon the shoulders of giants"

- Isaac Newton

- **My sister - Jineshnee Naidoo -** Thank you for always being there for me and taking the time to understand the true meaning of PCR and DGGE. This journey has been a long one but there is no one else who I'd rather have by my side when I lose my wallet in Barcelona, leave my iPod on the train in London or break my glasses in Nijmegen. Here's to the amazing things past and to the wonderful things which the future holds. May our bond always stay strong.

- **Deseree Alvika Rajpal –** we have come a long way – from weighing soil, collecting wastewater, failed PCR's and Real Time troubleshooting. Late nights in the lab, googling random theories, finally understanding the Mauna Loa curve and of course, travelling across Europe and exploring the world. This has been a long journey which would not have been possible without you. These five lines will never be able to express a thank you big enough for being more than a friend and always knowing the right thing to say. May we never forget the last two years.

- **Ashmita Arjoon and Sphephile Nzimande –** In you, I have found more than friendship, it is a sisterhood bound by the warmth of endless lattes and conversations about life. Thank you for your constant words of encouragement, support, advice and help throughout this study.

- **To my international colleagues and friends of Radboud University Nijmegen and The Erasmus Mundus SAPIENT Scholarship Program –** behind every great achievement is an amazing story and my time abroad is testament to that. It has been one of the most enriching experiences for both my personal and academic career, allowing me to grow into a more free-thinking, independent member of society. I will always hold these six months close to my heart.

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Increase in magnitude of the global freshwater crisis together with the constantly changing demographics, hydrological variability and rapid urbanization will allow for continuous over exploitation of existing water resources, in an attempt to satisfy the rising socioeconomic demands. Increasing pressure on existing wastewater treatment plants, together with inefficient hygiene practices have exacerbated the nutrient and microbiological loads constantly entering surrounding water systems. This, coupled with the use of outdated guidelines has resulted, not only in an increase in waterborne related diseases but also an increase in waterborne-disease-related deaths. The current study investigated the physicochemical and microbiological quality of treated effluent from two independent wastewater treatment plants as well as their impact on the receiving watershed within Durban, South Africa over a one year period. Microbiological and physicochemical profiles were determined using standard methods whilst conventional PCR was used for the seasonal detection of human enteric viruses. Monthly variations were observed for all parameters with eight and six out of 12 month samples exhibiting increases in turbidity at the discharge point for the NWWTP and NGTW respectively, relative to before chlorination. Similarly, increases in nitrate and phosphate levels at the discharge point were also noted with the highest being recorded during December (215.23%) and September (12.21%) respectively. Temperature profiles ranged between 12 – 26 °C and 12.7 – 26 °C for the NWWTP and receiving Umgeni River whilst for the NGTW and receiving Aller River, it ranged between 16.5 – 26 °C and 12 – 25.7 °C respectively. Seasonal averages revealed relatively high COD values downstream of the Umgeni River during winter (263.22 mg/l) and spring (177.93 mg/l). Eight out of twelve samples exhibited increases in turbidity at the discharge point for the NWWTP with the highest values obtained during April (76.43 NTU). Significant positive correlations ($p \leq 0.05$) were observed upstream and downstream of the Umgeni River between temperature and BOD ($r = 0.624$); turbidity ($r = 0.537$); TDS ($r = 0.437$); TSS ($r = 0.554$) and DO ($r = 0.516$). Percentage reduction of bacterial indicators at the discharge point ranged between 0.52 – 100% and 41.56 – 100% across the sampling period for the NWWTP and NGTW, respectively. Treated effluent from both plants did not meet the required guidelines, with a 100% reduction in the faecal coliform load

being detected only during October 2012 for both plants. In addition, higher levels of indicator bacteia were observed at the discharge point for the NWWTP during February 2013 with observed counts (in CFU/ml) as high as 12.27×10^3; 6.61×10^3; 2.99×10^3; 1.6×10^3 and 1.17×10^3 for total coliforms, *E.coli*, faecal coliforms, faecal streptococci and enterococci, respectively. Similarly, higher levels of both somatic and F-RNA bacteriophages were detected during April (106.67 PFU/ml), May (309.33 PFU/ml). June (346.67 PFU/ml) and August (126.67 PFU/ml) compared to samples collected before chlorination for the NWWTP. Enteroviruses were detected in 100% of unchlorinated final effluent samples, 87.5% of chlorinated final effluent and 93.75% of receiving river samples whilst human adenoviruses were detected in 50% of final effluent samples before chlorination, 62.5% in samples collected at the discharge point and 62.5% of river water samples. This study revealed that whilst the independent treatment plants monitored, exhibited effluent qualities that met acceptable standards for some parameters such as pH and temperature, the effluent quality fell short of other standard requirements. Ensuring efficient surveillance and management of existing treatment plants coupled with guideline revision and monitoring compliance is imperative in preventing further risk of pollution to both the environment and human health.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Safe drinking water and proper sanitation have constantly been recognized as indispensable factors to sustain life. The magnitude of the global freshwater crisis is underestimated, with many people struggling to have access to safe water which is a critical natural resource upon which all socio-economic development and ecosystem functions depend. The importance of this finite resource was further stressed at the Bonn 2011 Conference amongst both energy and food security issues in conjunction with The Rio+20 Summit (2012) indicating water as a major critical player in sustaining a Green Economy (Jägerskog and Clausen, 2012). According to the World Health Organization (WHO), approximately one billion people, worldwide, lack access to adequate water supplies. Furthermore, despite constant progress towards reaching the Millennium Development Goals (MDG) it is already known that the world lags behind on the sanitation target with an additional 1 billion people still lacking adequate sanitation facilities (Bigas, 2012). This crisis is further compounded by factors such as increasing poverty, accelerated population growth and rapid urbanization coupled with hydrological variability and climate change. In mid-lateral developing countries, access to clean water and sanitation are a luxury, with constant national, international and trans-boundary conflicts arising in an attempt to provide adequate food, water and health security for entire populations, thus hindering any developmental progress (WWAP, 2012). These socio-economic and environmental factors place even further stress on the deteriorating water and sanitation infrastructure, more so in developing regions, where billions are still at risk of Water, Sanitation and Hygiene (WaSH) related diseases (GLAAS, 2012).

Despite meeting the MDGs regarding access to potable water, the depletion of existing finite water resources still continues to be a major problem, with projections that approximately 605 million people will still lack access to improved drinking water by 2015 (UNICEF/WHO, 2012). In addition, the lack of access to potable water is estimated to cost countries between 1 – 7% of their annual GDP, with slow water and sanitation-related progress further impeding national economic growth (GLAAS, 2012). This together with the above named factors serve as the major driving force behind the increased use of wastewater, surrounding surface water and grey water for various recreational, agricultural and aqua-culture activities (WHO, 2011a). In addition, the mortality of global water-associated diseases exceeds 5 million people annually with approximately 50% arising from microbial intestinal infections (Cabral, 2010). In 2008, Stockholm's International Water Institute estimated that approximately 1.4 billion people live in closed basins which are defined as regions where a range of agricultural, industrial, municipal and environmental needs cannot be met by existing water supplies. In 2007, The United Nations Food and Agriculture Organization (FAO) estimated that 1.2 billion people live in water scarce countries, with population numbers expected to rise to 1.8 billion by 2025, thus further increasing the number of countries and regions that would experience a water scarcity problem (Water Industry Market, 2010). These projected increasing demographics have resulted in a constant competition with the environment for currently diminishing water resources and together with an increasing number of rivers no longer reaching the ocean, the rate of surface and groundwater contamination has greatly increased (GLAAS, 2012).

Reliable wastewater treatment systems serve as a good indicators of the level of development within a municipality as well as community health, with the degree and quality of treated wastewater determining the impact of these treatment plants on surrounding water sources into which it is released (DWA, 2011). Over the last few years, the quantity of municipal wastewater produced has drastically increased due to the constant increase in population numbers together with an increased dependence on diminishing water resources. This coupled with the discharge of inefficiently treated wastewater into surrounding surface water sources serve as a direct threat, not only to the macro- and micro-flora and fauna present but also to the greater provision of good quality water required for all socio-economic functions. Thus, the constant monitoring of the operational status of existing wastewater treatment plants (WWTPs) as well as increasing emphasis on environmental and water resource health have become key factors in determining the quantity and quality of wastewater generated by respective municipalities.

Most waterborne diseases result from some form of faecal pollution. In order to ensure the protection of current and future water resources, organisms such as coliforms, *E. coli*, Clostridium, Enterococci and Faecal Streptococci which serve as indicators of contamination, are used to assess water quality. Testing for individual pathogens would be impractical and expensive due to extensive analytical costs as well as various technical difficulties associated with detecting certain pathogens generally present in low quantities and chemically complex environments (DWAF, 1996a). This in conjunction with various legally enforceable standards, guidelines and target water quality ranges have been set in order to ensure that these contaminants do not exceed the minimal infectious dose in order to prevent severe disease outbreaks and extensive damage to surrounding environments (Barrell *et al.*, 2000). Previous studies have shown counts of coliform bacteria excreted from the human gut ranging between

100 – 400 billion counts per day, raising a high degree of concern with diseases related to human waste. Due to a large degree of waterborne diseases being transmitted as a result of human-contaminated water sources, the absence of coliform indicator bacteria is usually taken as an indication that the sample is free of pathogenic microorganisms (WHO, 2003a).

1.2 Sources of domestic and industrial wastewater

Wastewater is defined as any clear water, storm water, industrial, domestic or commercial sewage or any combination thereof carried by water (EPA, 2007). Several types of sewage have been nationally defined by the Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT, 2009) based on sewage source components; namely black water; grey water and yellow water. The type and volume of wastewater generated is determined by both, the population numbers and the combination of surrounding domestic, recreational and industrial activities, all of which affect discharge patterns as well as the chemical status of the treated effluent. In order to set up an efficient waste management system, proper identification and characterization of the influent entering a wastewater treatment plant is essential (Mara, 2004). This is based on the physical, chemical and biological characteristics of the influent; the quality required for maintaining the surrounding environment into which the wastewater will be discharged as well as the current environmental and discharge standards.

Four main types of wastewater have been identified namely domestic, industrial, agricultural and urban. Generally, the focus is mainly on domestic and industrial sewage as a source of plant influent and contamination, however agricultural runoff is now becoming increasingly important due to the high quantities of pesticides and fertilizers being used, ultimately contributing to surface water eutrophication (DWA, 2011). Domestic wastewater is defined as sewage which generally consists of black water composed of fecal matter (human and animal wastes) together with grey water, composed of wastewater sources originating from a range of household activities (washing and bathing) with each forming approximately 32.5% and 67.5% of domestic sewage respectively (EPA, 2007). Initially, this water is used for drinking, food preparation, hot water systems, bathing and personal hygiene, washing, gardening and may ultimately form part of the domestic wastewater being excreted into the environment (DWAF, 1996a). Within a household, individual domestic wastewater streams all contribute different amounts to the overall nutrient and elemental load contained in the discharged effluent. Industrial wastewater however, is defined as sewage consisting of industrial wastes such as pulp, paper, petrochemical runoff as well as various chemicals, salts and acids. These sources vary widely in composition and often require special tertiary treatment in order to comply with discharge regulations. The composition of industrial wastewater varies based on the type of surrounding industry together with the respective contaminant and pollutant composition with general classification into inorganic or organic industrial wastewater (Rosenwinkel *et al.*, 2005).

1.3 Overview of steps involved in wastewater treatment

Initially, all wastewater was discharged directly into natural waterways, where a dilution effect would occur in conjunction with the degradation of organic matter by existing microorganisms. However, due to the constant increase in population numbers and densities, as well as an increase in the production of both domestic and industrial waste, the pollution of surrounding environments and deterioration of public health has escalated. This resulted in the need to introduce WWTPs that would aid and accelerate the purification process prior to discharge into any natural waterway (USEPA, 2004). In addition, provided that these plants operate efficiently, the treated wastewater effluent and sludge produced could serve as a valuable resource when safely reused. The overall wastewater treatment process can be broken down into four main stages namely the pretreatment, primary, secondary and tertiary stages (Figure 1.1).

1.3.1 Pretreatment

The first stage of treatment involves the use of screens to remove larger debris such as paper, plastic or any other foreign material which may damage downstream equipment, followed by further removal of grit and silt which may be harmful to plant equipment. In addition, the screened materials are often hazardous and must be safely disposed off to prevent fly breeding, excessive odours or downstream hazardous effects to public and environmental health. One such suitable disposable method is deposition in trenches covered with soil. In addition, the incineration of solids prior to burial is often preferred (DWA, 2011). Excess grit such as sand, silt and stones can cause severe operational problems, affecting a range of subsequent treatment steps, ultimately causing severe pump blockages. Grit removal is therefore essential to protect mechanical equipment and pumps from abrasion and to reduce blockages. In addition measuring daily flows within a plant to ensure the maintenance of functional capacity is imperative in producing effluent of good quality (Sonune and Ghate, 2004).

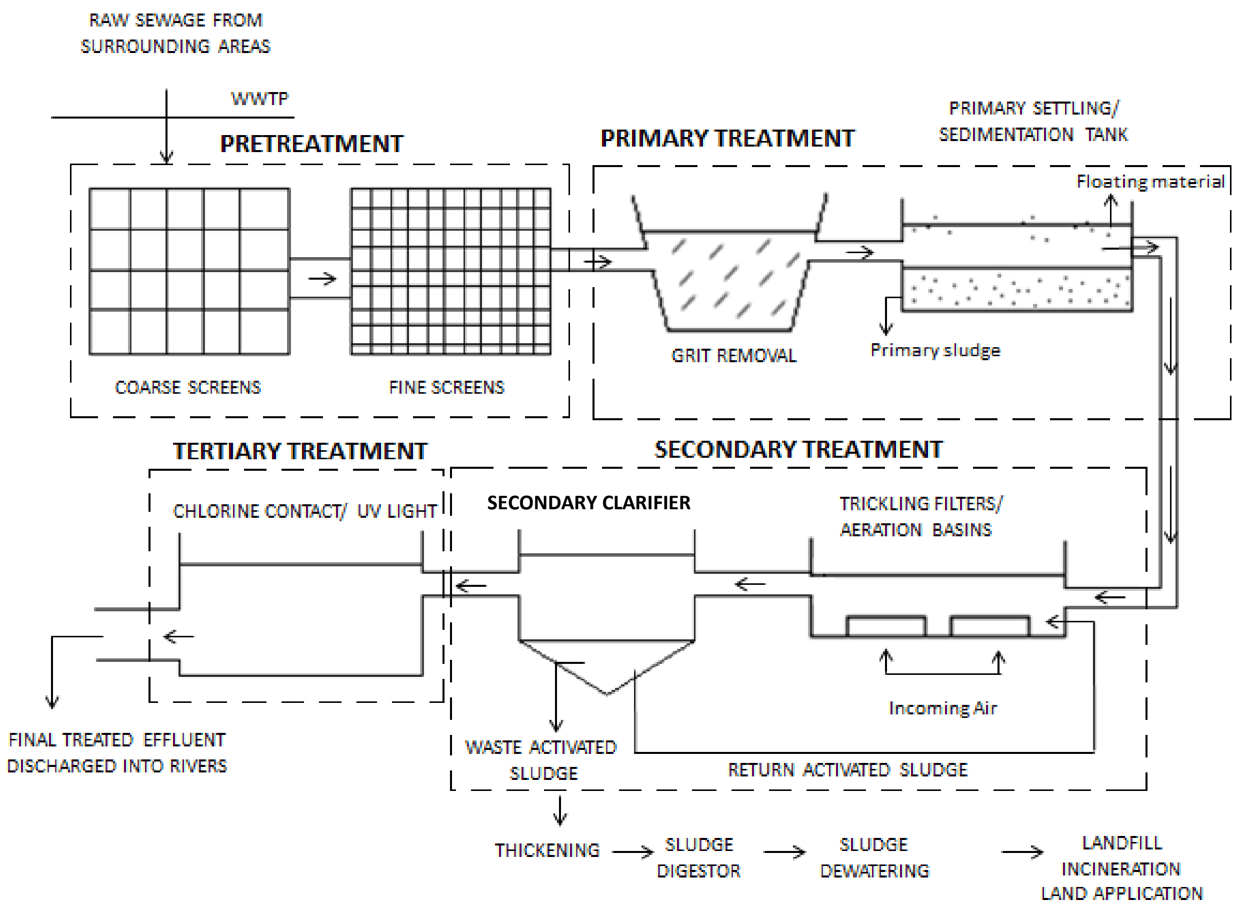


Figure 1.1: Overview of treatment stages within a wastewater treatment plant

(Adapted from EPA, 1997; UNEP, 2012)

1.3.2 Primary treatment

The main purpose of primary treatment is to reduce any settleable solids, as well as oils, grease, fats, sand and grit within the wastewater via settling and sedimentation processes. The steps involved in primary treatment are entirely mechanical by means of filtration and sedimentation (Sonune and Ghate, 2004). After initial screening to remove larger debris, wastewater still contains dissolved organic and inorganic constituents as well as suspended solids which are removed via the process of primary settling, sedimentation, chemical coagulation or filtration.

This allows for separation of the solid and liquid phases in the wastewater by removing those settled organic solids as well as any floating materials such as fats, oil and grease. Wastewater enters a sedimentation tank, where the flow rate gradually slows down, enabling the wastewater to sit in these settling tanks which have been designed to hold the wastewater for several hours, during which, most of the heavy solids sink to the bottom of the tank, forming primary sludge which reduces the suspended solid content of the wastewater. In addition, any surface floating materials is usually siphoned off (USEPA, 2004).

1.3.3 Secondary treatment

Following primary treatment, wastewater flows into the next stage whereby the remaining suspended solids are decomposed and the microbial load is greatly reduced. A variety of secondary treatment options are available (Table 1.1) which are classified into three main categories, namely, wastewater stabilization ponds, suspended growth systems or fixed film systems ultimately resulting in an organic matter removal of approximately 90%. Wastewater stabilization ponds may be constructed either singularly or in parallel with the number of ponds increasing as the volume of waste being processed by the plant increases. These ponds are classified by the type of bacteria responsible for the decomposition process as well as the duration for which the waste will remain in the pond (Mara, 2004). On the other hand, suspended growth systems are generally applied to smaller communities and consist of 3 main types: activated sludge, sequential batch reactor and aerated lagoons whilst fixed film systems involve the passage of raw wastewater onto a filter medium to which bacteria can attach, build up and accumulate in biomass which is subsequently removed.

Table 1.1: Overview of various secondary treatment options available

TREATMENT	DESIGN CRITERIA	EFFLUENT QUALITY	ADVANTAGES	DISADVANTAGES	REF
			WASTE STABILISATION PONDS		
Anaerobic ponds	2 - 5 m deep, pH usually below 6.5; less surface area; covered either by gravel, plants, steel, and plastic. Loaded at high rates to prevent inlet of any oxygen	BOD Removal of 60 - 85%	Low cost, little excess sludge produced, Small pond volume needed; Low nutrient requirements; Low operating costs; no electricity required; Methane by-product	Requires more land; Long start-up period;Post treatment always required, can produce an unpleasant odour; Requires sludge removal more often; Operates optimally at warmer temperatures (>25 °C)	Alexiou and Mara, (2003); Norton *et al.*, (2012)
Facultative ponds	Shallow – 1-3 m deep; Length to breadth ratio should be a minimum of 2:1; lined with compact clay (minimum thickness 0.3 m) or polyethylene; formation of two layers - aerobic at surface and anaerobic at bottom	BOD removal of 70 - 85%	Efficient BOD reduction; Nutrient reduction by aerobic and anaerobic bacterial processes as well as by surrounding plants; Natural aeration of the upper layer via movement of air; Low energy consumption	Significant space requirements; Efficiency is strongly affected by environmental factors; continuous maintenance required	Norton *et al.*, (2012)
Maturation ponds (polishing ponds)	Shallow – 0.9 - 1 m deep; allows for light penetration; completely aerobic; high pH and high concentration of dissolved oxygen due to algal activity; little biological stratification; size and number depends on required effluent pathogen concentration	Little BOD removal because most has been removed in previous stages	Removes excess nutrients and pathogens such as faecal coliforms	Small BOD removal; additional costs; additional land requirements	Norton *et al.* (2012)
			SUSPENDED GROWTH SYSTEMS		
Activated sludge	Oxygen supplied for initial sludge decomposition and provide agitation to promote flocculation; 85% sludge removed whilst 15% recirculated	BOD removal of 90 - 98%	Production of high quality effluent; reasonable operational and maintenance costs;	High capital costs; high energy consumption; regular monitoring required; back washing needed	
Batch reactor	Equalization, biological treatment and secondary clarification are performed in a single reactor vessel using a timed control sequence; aeration may be provided by bubble diffusers/floating aerators	BOD removal of 89 - 98%	Initial capital cost savings; all processes carried out in a single reactor vessel; timed cycles; requires limited land; equalization of processes	Higher level of sophistication and maintenance required as timing must be controlled; may discharge settled or floating sludge; clogging of aeration devices; requires oversized outfalls as effluent discharge is timed	USEPA, (1999a); Mahvi (2008)

TREATMENT	DESIGN CRITERIA	EFFLUENT QUALITY	ADVANTAGES	DISADVANTAGES	REF
Aerated lagoons	Should be lined with clay or some natural source, 1.8 – 6 m depth, 10-30 day retention time, oxygen supplied by additional mechanical means	BOD removal of up to 95%	Low cost, low maintenance and energy requirements, can be well integrated into surrounding landscapes, reliable treatment even at high loads,	Nutrient removal is less efficient due to short retention times	USEPA, (2002) FUCHS, (2011)
			FIXED FILM SYSTEMS		
Conventional biofilters (trickling filters)	Bed with supportive media such as stones, plastic, wood; 0.9 – 2.4 m deep; oxygen supplied via natural flow of air;	BOD Removal of between 80 - 90%	Low land requirement Moderate level of skill required for operation and maintenance Suitable for small to medium communities	Accumulation of excess biomass will affect performance; high level of clogging thus regular backwashing is required; if suddenly shut down – anaerobic conditions result in reduced effluent quality; odour and snail problems	Chaudhary *et al.* (2003); USEPA (2000)
Rotating biological contactors			High contact time; high effluent quality; resistant to shock hydraulic or organic loading; short contact periods; large active surface area; silent; low sludge production; easy transfer of oxygen from air;	Continuous power supply required; oxygen may be a limiting substrate;	Kadu and Rao (2012)
Biological aerated filters	Consists of a reactor container, media for supporting biofilm growth, influent distribution and effluent collection system; Optimal conditions – pH 6.5 – 7.5 with mixing; Media should be chemically stable, high surface area and low weight eg: sunken clay, floating polystyrene beads, pure polypropylene	High nutrient removal (80 – 100%)	Environmental factors such as pH, temperature will aid microbial growth; high bacterial and nutrient removal efficiencies; can combine ammonia oxidation and solids removal in a a single unit	Media may become clogged due to biomass growth and accumulation – may create resistance to air and flow of liquid; regular back washing is required to remove excess biomass and particles	Mendoza-Espinosa and Stephenson (1999); Asiedu (2001)

1.3.4 Tertiary treatment

Tertiary treatment generally follows secondary treatment and aids the removal of those wastewater constituents and pathogenic microorganisms such as faecal coliforms, streptococci, *Salmonella* sp. and enteric viruses that were not removed by previous treatments (SOPAC, 1999). Disinfection or tertiary treatment may be divided into three main categories i.e., chemical, physical and irradiation. Physical treatments generally involve one or a combination of treatments such as rapid sand filtration, nitrification, denitrification or carbon adsorption which is employed prior to chlorintion to remove any remaining suspended solids as well as reduce the amount of nitrates, phosphates and soluble organic matter present. Following this, disinfection by chemicals and irradiation may occur and generally involves one or a combination of treatments involving chlorination and ultra violet light exposure or ozonation, the choice of which depends solely on the incoming effluent quality, ease and cost of installation, maintenance and operation as well as the effects on flora and fauna. The disinfection processes commonly used are discussed below:

1.3.4.1 Chlorination

Chemical oxidation processes include ozone, hydrogen peroxide and chlorine which may be applied in various forms such as pure chlorine, chlorine dioxide or chlorine compounds such as calcium hypochlorite or sodium hypochlorite. The major factors that need to be taken into consideration when evaluating the performance of chemical disinfectants are contact time, efficiency of mixing, type and concentration of chemicals used, residual remaining, pH and the concentration of interfering substances which may reduce the effectiveness of the disinfectant (USEPA, 1999c). Chlorination is the commonly used treatment for disinfection of surface and groundwater sources, reacting with any form of organic matter that may be present in previously treated effluent (EPA, 1997). Chlorine gas is a strong oxidant that is most commonly used in larger treatment plants since it is more cost effective than other methods of tertiary treatment as well as allowing for easy and accurate application. Chlorine dioxide is a powerful oxidant that is capable of oxidising iron and manganese as well as removing any colour components in the effluent. It is generally prepared on-site and is one of the most economical methods available. Calcium hypochloride, also known as high test hypochlorite is available in the form of granules, powder and tablets whilst sodium hypochlorite, also known as household bleach is a 13% solution of chlorine which is equivalent to 10 - 12.2% available chlorine (USEPA, 1999c). This compound however is extremely unstable and deteriorates rapidly. When elemental chlorine comes into contact with water, it is hydrolysed to hypochlorous acid (HOCl) and hypochlorite (-OCl), with HOCl being one of the strongest disinfecting agents. In addition, chlorine also reacts with ammonia to produce a range of mono- and dichloramines which serve as less potent disinfectants.

$$NH_3 + HOCl \rightarrow \mathbf{NH_2Cl} + H_2O \text{ (monochloramine)}$$

$$NH_2Cl + HOCl \rightarrow \mathbf{NHCl_2} + H_2O \text{ (dichloramine)}$$

$$NH_2Cl_2 + HOCl \rightarrow \mathbf{NCl_3} + H_2O \text{ (nitrogen trichloride)}$$

One of the major disadvantages, however, associated with chlorination is the production of toxic byproducts such as trichloromethanes and other chloramines which cause severe harmful effects on the receiving water bodies into which they are discharged (Gross and Farrell-Poe, 2004).

1.3.4.2 Ultraviolet light

The use of ultraviolet light as a means of disinfection involves the use of electromagnetic energy from a mercury arc lamp to irradiate and disinfect wastewater effluent. The efficiency of this disinfection method depends on the dose as well as achieving an optimal wavelength range between 250 – 270 nm. In addition, a range of factors have to be taken into consideration such as effluent quality, UV light intensity, path length from the source lamp to the respective pathogenic microorganisms as well as exposure time (USEPA, 1999b). The UV light penetrates the cell wall of exposed microorganisms, ultimately damaging their genetic material and preventing survival. However, often when UV is applied at lower doses, microorganisms tend to reverse the damage through their own cell repair mechanisms (SYRIA; USEPA, 2004). In addition, routine cleaning of the arc lamp should be conducted due to the large amount of interference that may occur from chemical components present in the wastewater being treated.

1.3.4.3 Ozonation

Ozone is a highly reactive, unstable gas that is generally used as a disinfectant and does not leave any residual behind, reacting with any organic matter present within the wastewater.

$$O_2 + \text{energy} \rightarrow O + O, \text{ then } O + O_2 \rightarrow O_3$$

Due to its unstable nature, it must often be generated onsite in ozone generators by the passage of oxygen through a high voltage electric field. The required ozone dosage is dependant on a range of factors, the most important being type of effluent being treated. In addition, other competing reactions within the water environment may also contribute to the overall ozone demand. Previous studies have shown ozone requirements ranging between a few mg/l to greater than 10 mg/l for primary effluent (Lazarova *et al.*, 1999). Ozone is generally used as it results in the elimination of any odours, does not result in any residual compounds, can be easily generated from air thus resulting in the process being entirely dependent on the available power source. However, the major disadvantages include the high costs involved (USEPA, 1999a).

1.3.5 Nutrient removal

Tertiary treatments involving nutrient removal are often referred to as advanced methods of wastewater treatment and usually occur after or in conjunction with conventional biological secondary treatment to aid both nitrogen and phosphorous removal from wastewater. Generally these methods may include some form of physical or chemical technique such as flocculation, precipitation or membrane filtration. Two such commonly used techniques include Biological Nutrient Removal (BNR) and the Enhanced Nutrient Removal (ENR) which serves as a modification of the suspended growth treatment systems, achieving nitrogen and phosphorous removals of 8 - 10 mg/l; 1 – 3 mg/l and 3 mg/l; 0.3mg/l per respective process (Hartman and Cleland, 2007). Wastewater containing nitrogen is generally present in the form of ammonia and is not usually removed by prior conventional secondary treatments. Therefore, the advanced treatment methods successfully aid in the conversion of ammonia and other organic forms via nitrification and denitrification to non-toxic nitrate and subsequently nitrogen gas. Generally secondary biological treatment processes achieve phosphorous removal rates of less than 20%, requiring the need for additional removal methods. Physical precipitation such as filtration techniques as well as chemical precipitation such as flocculation after lime or alum addition may occur which aids in achieving phosphorous reduction rates of up to 95%.

1.4 Effect of improperly treated wastewater effluent

1.4.1 Effect on the environment, micro- and macrofauna

The biggest concern associated with microbial pollution is the risk of human and livestock related illnesses after exposure to contaminated water sources. Often the discharge of improperly treated effluent from WWTPs results in the deposition of large amounts of organic matter and nutrients which has major detrimental effects on the surrounding environments as well on the micro- and macro-fauna present. Excessive nutrient loading can lead to eutrophication and temporary oxygen deficiencies that ultimately alter the energy relationship and water balance, disrupting biotic community structure and function. Excessively turbid effluent discharge can also result in the deposition of sand and grit into the aquatic system ultimately disrupting sediment characteristics and hindering natural water flows (Wakelin *et al.*, 2008). In addition, the overall hydrological and physicochemical environment is often affected due to the discharge of improperly treated effluent with many of the micro- and macro- fauna within these water bodies exhibiting distinct physiological tolerance levels. Disturbances to the overall environment can severely affect those intolerant individuals either in the form of adverse behavioural characteristics or more severely in the form of death. Often death decreases a large degree of resource competition and predation within the environment thereby resulting in the proliferation of tolerant organisms. This ultimately causes an imbalance amongst the group of organisms present and the overall alterations to the surrounding environment in the form of nutrient modifications, light and oxygen content, food sources as well as habitat loss (Coetzee, 2003). In addition, the deposition of excessive nutrients leads to profuse plant growth along river banks which in certain cases may be visually pleasing but may serve as a health hazard due to entanglement. In addition, benthic microbial and algal growth may cause rock and wood surfaces to become slippery, posing a threat to human safety.

1.4.2 Effect on human health

Communities situated downstream or close to municipal sewage outfalls or contaminated water sources are at the highest risk of illness due to increased microbial pathogens and deteriorating physicochemical parameters (Wakelin *et al.*, 2008). Often the discharge of extremely turbid effluent in conjunction with dense algal blooms results in poor visibility within these water bodies resulting in submerged hazards not being visible thus creating dangerous situations for recreational users. In addition, water bodies used for full contact recreational activities may serve as a source of a wide range of infectious diseases which may be contracted either by ingestion of contaminated water or through full body contact (DWAF, 1996b). However, depending on the type of waterborne disease and on the physical health of the individual concerned, the person may either recover completely from the resultant disease or suffer permanently. In addition, a variety of skin and ear infections may arise as a result of contaminated waters coming into contact with broken skin or penetration of the ear. The discharge of improperly treated effluent often results in increased number of bacterial, viral and protozoan pathogens which may result in a range of waterborne related diseases such as gastroenteritis and infections of the ear, nose and throat (Okoh *et al.*, 2010). A number of indirect health hazards such as chemical contaminants, disease-transmitting organisms, such as mosquitos and fresh water snails implicated in malaria and bilharzia may also arise depending on the state of the surface water source, leading to other additional human health hazards (Coetzee, 2003).

1.5 Methods of effluent disposal

The type of wastewater treatment chosen per plant will depend solely on the incoming waste as well as where the treated effluent will be discharged. The discharge of waste is grouped into two main categories, based on the spatial nature of the waste source namely, point and diffuse source with the latter initially being discharged as a point source, after which it migrates towards the water resource and has a diffuse impact (DWAF, 2003). The actual destination of discharges is important because it largely determines the extent and nature of the impact. In addition, the waste volume may also disturb natural cycles in receiving water bodies such as rivers ultimately affecting not only the water quality but also water flow. For larger municipalities located near coastlines, an additional option exists to discharge treated effluent into the ocean whereby oceanic processes can be used to reduce effluent contaminant concentrations to the required guidelines for recreational purposes and to comply with environmental standards (DWA, 2011). In addition, due to the constant changing physical conditions along South African coastlines, responsible disposal of wastewater to the marine environment is considerably allowed due to the reduction of concentrations brought about by the initial dilution of the effluent, the dispersion of the effluent plume and the decay of microorganisms. In addition, depending on the type of effluent, the surrounding areas, state of the coastline and the degree of dilution that can be achieved after oceanic discharge, the wastewater may require different degrees of pre-treatment prior to discharge (Table 1.2). Within the eThekwini Municipality itself, two major wastewater treatment works, namely The Central Works and Southern Works both discharge effluent into the Indian Ocean.

Within these plants, initial influent is subjected to conventional screening, de-gritting and primary sedimentation followed by subsequent discharge to the sea via outfall pipes.

Table 1.2: Overview of treatment requirements for selected effluent discharges

DESTINATION	PRELIMINARY	PRIMARY	SECONDARY	TERTIARY
IRRIGATION				
Produce eaten raw	YES	YES	YES	YES
Other produce	YES	YES	YES	NO
GROUNDWATER	YES	YES	YES	YES
SURFACE WATERS	YES	YES	YES	NO
SEA OUTFALLS	YES	YES	YES	NO

Adapted from USEPA (2012)

1.6 Commonly detected microbial indicators in treated wastewater effluent and associated infections

The WHO estimates that globally, approximately 1.1 billion people consume unsafe water with approximately 88% of diarrhoeal diseases and 1.7 million deaths being attributable to unsafe water, sanitation and hygiene (WHO, 2008). Microbiological examination and monitoring is commonly used worldwide to ensure the safety of a range of water sources whereby contamination with human and animal excreta could pose serious risks. Many potential pathogens (Table 1.3) could be associated with contaminated water however, it is both time consuming and expensive to test for all possible pathogens present. Hence, representative indicators associated with human and animal contamination are regarded as a means to detect such pollution (Barell *et al.*, 2000).

1.6.1 Total coliforms and faecal coliforms

Total coliforms have been defined as all those aerobic or facultative anaerobic, gram-negative, non spore-forming, rod-shaped bacteria that have the ability to ferment lactose with gas and acid formation within 48 hours at 35 °C whilst faecal coliforms have been defined as those coliforms which can proliferate at an elevated temperature of 44.5 °C (WHO, 2008). The total coliform group includes those microorganisms that can survive and proliferate within the water environment, serving as an indicator of water quality and not as a determinant of faecal pathogens only. Total coliforms have also been found to occur in both sewage and natural water sources with some of these bacteria being excreted in the faeces of humans and animals. In addition, they are far more sensitive to disinfection than enteric viruses and protozoa and thus should be absent immediately after disinfection indicating that their presence serves as an indication of inadequate wastewater treatment (Ashbolt *et al.*, 2001).

Table 1.3: Pathogens associated with waterborne diseases and sources of contamination

	MICROORGANISMS	DISEASES	SOURCE	NUMBERS (Raw Sewage) (CFU.ml)
Bacteria	*Salmonella typhi*	Thyphoid fever	Human faeces	
	Salmonella paratyphi	Paratyphoid fever	Human faeces	0.2 – 8000
	Other *Salmonella* sp.	Salmonellosis/ gastroenteritis	Human/animal	
	Shigella sp.	Dysentery	Human faeces	0.1 - 1000
	Vibrio cholerae	Cholera	Human faeces	
	E. coli	Gastroenteritis	Human faeces	10^6 - 10^7
	Campylobacter sp.	Gastroenteritis	Human/ animal	10^4 - 10^5
	Clostridium perfringens		Human/ animal	$6x10^4$ - $8x10^4$
	Faecal streptococci		Human/ animal	$4.7x10^3$ - $4x10^5$
	Enterococci		Human/ animal	
Viruses	Poliovirus	Poliomyelitis	Human faeces	180 - 500000
	Rotavirus	Diahorrea, vomiting	Human faeces	400 - 85000
	Adenovirus	Gastroenteritis	Human faeces	
	Norwalk virus	Diahorrea, vomiting	Human faeces	
	Hepatitis A Virus	Hepatitis	Human faeces	
Protozoa	Cryptosporidium parvum	Diahorrea		0.1 – 39
	Entamoeba histolytica	Amoeba dysentery		0.4
	Giardia lamblia cysts	Diahorrea		12.5 - 20000

Adapted from Grabow *et al.* (2001)

1.6.2 *E. coli*

E. coli is commonly regarded as one of first microorganisms of choice in water monitoring programs and serves as the general primary indicator for water contaminated with faecal matter due to their prevalence in the gut of warm-blooded animals as well as their high numbers excreted in human and animal faeces (NHMRC, NRMMC, 2011). Most strains of *E. coli* are non-pathogenic however there are six major pathogenic classes that have been identified namely, enterotoxigenic *E. coli* (ETEC), enterohaemorrhagic or shiga-toxin producing *E. coli* (EHEC), enteroinvasive *E. coli* (EIEC), enterpathogenic *E. coli* (EPEC), enteroadherent-aggregative *E. coli* (EA-AggEC) and diffuse adherent *E. coli* (DAEC) (Nataro and Kaper 1998). The most important is EHEC which includes the -O111 and -O157 serogroups, all of which produce a shiga-like toxin resulting in mild diarrhoea to haemorrhagic colitis. Enteropathogenic *E. coli* (EPEC) have been primarily associated with outbreaks of infantile gastroenteritis whilst enteroinvasive *E. coli* (EIEC) are known to produce dysentery by a mechanism similar to *Shigella* sp. causing severe bloody diarrhoea whilst enterotoxigenic *E. coli* (ETEC) are known to possess a heat-labile enterotoxin similar to the cholera toxin (WHO, 2011b).

1.6.3 Faecal streptococci and enterococci

Faecal streptococci belong to the traditional indicator group of fecal pollution and are defined as gram-positive, catalase-negative, non-spore forming cocci that grow at 35 °C and in a medium containing bile salts and sodium azide. Enterococci are gram-positive facultative anaerobic bacteria which possess the ability to grow in the presence of 6.5% sodium chloride at a high temperature of 45 °C. Enterococci form a sub-group of the larger faecal streptococci group and consist of the species *E. faecalis*, *E. faecium*, *E. durans* and *E. hirae* which are well known for their association with faecal pollution (WHO, 2011b). Members of this group are typically excreted in the faeces of humans and other warm-blooded animals and are present in large numbers in water environments polluted by sewage or wastes from humans and animals. In addition to being tolerant to sodium chloride and alkaline pH levels, they do not multiply in water environments (NRMMC, 2011). They are also known to survive for longer periods in water environments when compared to *E. coli* and are more resistant to chlorination making them suitable indicators of contamination or inefficient disinfection processes (WHO, 2011b). The intestinal enterococci group has been used as an index of faecal pollution, with studies showing recorded numbers of intestinal enterococci in human faeces being about an order of magnitude lower than *E. coli* (Cabral, 2010). Several studies that examined both human and animal faeces have concluded that both *E. faecalis* and *E. faecium* were present in only human faeces whilst *E. avium*, *E. cecorum*, *E. durans*, *E. gallinarum* and *E. hirae* were found in animal faeces.

1.6.4 *Salmonella* sp.

Salmonella sp. belong to the family Enterobacteriaceae and are motile, gram negative bacilli that are oxidase negative and catalase positive. They produce gas from D-glucose, utilize citrate as a sole carbon source and are commonly transmitted via the faecal-oral route. *Salmonella* sp. infections are characterised by mild to full blown diarrhoea, nausea, vomiting, septicaemia, typhoid and enteric fever (WHO, 2008) with host specific human infections being grouped into two main categories namely (1): typhoid and paratyphoid and (2): gastroenteritis. Other strains such as *S. typhimurium* and *S. enteritidis* are known to infect both humans and a wide range of animals such as poultry, cows, pigs, sheep, birds and even reptiles (Angulo *et al.*, 1997). The main habitat of *Salmonella* sp. is the intestinal tract of both humans and animals. These pathogens are not known to multiply significantly in the environment, however previous studies have shown prolonged periods of survival in both water and soil environments, provided external temperature, humidity and pH conditions are favourable. In addition, infected individuals are known to carry the bacteria for extended periods of time without any signs of infection. Previous studies have shown that *Salmonella* sp. can survive wastewater treatment processes thereby entering surface water sources and serving as a source of contamination to filter feeders such as shellfish, ultimately entering the food chain (Cabral, 2010).

1.6.5 *Shigella* sp.

Shigella sp. are defined as gram negative, non-spore forming, non-motile, catalase positive, oxidase negative rod-like members of the family *Enterobacteriaceae* and are characterized based on the presence of their O-antigens (Cabral, 2010). Approximately 164.7 million cases of waterborne diseases within developing regions can be attributed to *Shigella*-related infections annually, with approximately 61% of all shigellosis-related deaths occurring in children under five years of age. *Shigella sp.* is generally an inhabitant of the intestinal tract of humans and animals and is often spread by faecal contaminated water, food sources or by direct contact with infected individuals. In addition, *Shigella* sp. is known to survive for extended periods of up to 6 months at room temperature, thus aiding their survival and transmission within the water environment. There are four important species which have been implicated in numerous global *Shigella*-related epidemics namely, *S. dysenteriae*, *S. flexneri*, *S. boydii* and *S. sonnei*. *Shigella* sp. infections are characterised by an extremely low infectious dose, ranging between 10 – 100 infectious particles with symptoms consisting of abdominal cramps, fever and watery diarrhoea after 24 - 72 hours of infection (WHO, 2011b). In addition, *S. dysenteriae*, *S.sonnei and S. flexneri* are known to produce the cytotoxic Shiga-toxin which inhibits mammalian protein synthesis as well as a LPS endotoxin which is produced together with a range of plasmids coding for a host of virulence genes. These genes encode for the production of adhesins aiding attachment, invasion plasmid antigens and factors aiding transport or processing functions (Cabral, 2010).

1.6.6 *Vibrio* sp.

Vibrio sp. are non-spore forming, motile gram negative rods with a single flagellum defined as being facultative anaerobes and oxidase positive. They are frequently found in a range of water sources, usually transmitted via the faecal–oral route with infections generally caused by the ingestion of faecal-contaminated water and food (Cabral, 2010). There are a number of pathogenic species, including *V. cholerae*, *V. parahaemolyticus* and *V. vulnificus* with *V. cholerae* being the major pathogen of concern in freshwater environments. Whilst non-toxigenic *V. cholerae* is widely distributed in water environments, toxigenic strains are not distributed as widely with only the O1 and O139 serovars known to cause the related-cholera symptoms due to the production of the cholera endotoxin. Infected individuals are known to have alterations in ionic fluxes across the intestinal mucosa leading to severe water and electrolyte loss (WHO, 2011b; 2002).

1.7 Coliphages as alternative indicators of viral contamination

Coliphages, also known as bacteriophages, use certain bacteria as hosts, replicating within these hosts and as a result are shed in large numbers in the faeces of warm-blooded animals and humans. They are often used in water quality assessments and are divided into two major groups namely, somatic and F-RNA coliphages, based on their route of infection. They have served as valuable models for enteric viral detection due to the simple, inexpensive and rapid techniques available (NRMMC, 2011). In addition, many similar properties are shared between coliphages and human enteric viruses such as structure, composition, morphology, size and site of replication, thus making them suitable indicators of both faecal pollution and certain pathogenic viruses (WHO, 2008). Numerous studies have shown the presence and survival of coliphage populations within the water environment to be similar to that of human viruses, thus allowing these coliphages to serve as suitable indicators of viral contamination (DWAF, 1996b). Structural and morphological analysis indicate the presence of a nucleic acid molecule, more specifically the genome, which is surrounded by a protein coat also known as the capsid. Generally, somatic coliphages have been found to outnumber F-RNA coliphages in water environments by a factor of approximately 5 and cytopathogenic human viruses by a factor of about 500 (WHO, 2011b). Contaminant source identification together with their physical structure, composition and morphology have allowed phages to serve as a means to distinguish between faecal pollution of human and animal origin and is an ideal indicator of the presence of human enteric viruses.

1.7.1 Somatic coliphages

Somatic coliphages are DNA viruses and consist of a wide range of phages belonging to members of the families - Myoviridae, Siphoviridae, Podoviridae and Microviridae with a vast range of morphological types (WHO, 2008). They replicate more frequently in the gastrointestinal tract of warm-blooded animals with a population range of less than 10 to 10^8 plaque-forming units per gram. They have also been known to replicate in water environments and are easily detectable by simple and inexpensive plaque assays (Grabow, 2001). These phages possess the ability to infect hosts such as *E. coli* and other closely related members of the Enterobacteriaceae family by attaching to receptors permanently located on the cell wall of hosts. These phages tend to initiate infection of the respective *E. coli* host by adsorbing to receptors located in the host cell wall (DWAF, 1996b).

1.7.2 Male-specific F-RNA coliphages

F-RNA coliphages are defined as single stranded RNA phages that are morphologically similar to that of picornaviruses. These phages possess an icosahedral capsid and belong to the family Leviviridae which have further been divided into four serological groups allowing for source contamination identification. Male-specific F-RNA coliphages have been classified into four main groups based on their serological and physiochemical properties, namely; MS-2, f2, and JP501 in Group 1; GA, BZ13 and JP34 in Group 2; Qβ, VK and TW18 in Group 3 and SP, F1 and TW28 in Group 4 with Groups 2 and 3 being associated with human faecal contamination and Groups 1 and 4, associated with animal contamination (Sundram *et al.*, 2005). These phages initiate infection in hosts that possess the fertility (F^+) plasmid and which produce the required fertility fimbriae. Of importance is the production of these fimbriae, which are only produced when hosts are in the exponential phase and at temperatures greater than 30 ºC, indicating the restriction of these hosts to grow within the gastrointestinal tract thus serving as a more reliable indicator of faecal contamination (WHO, 2008). As a result of their mode of replication and host specificity, F-RNA coliphages are generally excreted by a lower percentage of humans and animals compared to somatic coliphages. Schaper *et al.* (2002) confirmed this with F-specific RNA phages being detected in 10% of human, 45% of bovine and 60% of porcine faecal samples. In addition, detection methods are not as simple as that for somatic coliphages due to specific requirements of the host bacterium which needs to be grown at temperatures greater than 30 ºC and in the log phase to ensure that fertility fimbriae to which the phage attaches are present, thus indicating the need for timeous preparation of host cultures (Grabow, 2001; WHO, 2011b). Also, numerous studies have revealed that F-RNA phage counts outnumber enteric viruses by a factor of approximately 100 in wastewater and raw water sources. However, one of the major disadvantages is that currently utilised F-RNA coliphage detection schemes are not as simple due to the requirement of adequate host preparation prior to detection.

1.7.3 Phages that infect *Bacteroides fragilis*

Considerable attention has been given to *Bacteroides fragilis* as an indicator of water quality and disinfection processes as they are found solely in human faeces and they also show resistance to a range of chlorine disinfection steps when compared to other pathogens, such as poliovirus, rotavirus, certain coliphages, *E. coli* and *Streptococcus faecalis*. Two groups of *B. fragilis* phages are used as indicators in water quality assessments. They differ by their respective bacterial host strains, *Bacteroides* HSP40 and RYC2056 which inhabit the gasterointestinal tract. The first group belongs to the family Siphoviridae and are restricted solely to the human gasterointestinal tract and hence their detection within the environment provides a strong indication of human faecal contamination. The second group however includes a wider range of phages which are detected in both human and animal faeces (WHO, 2008). However, as with all indicators, one of the major disadvantages is that HSP40 phages are excreted by approximately 10 – 20% of humans in certain parts of the world and hence occur in relatively low numbers in sewage, polluted water environments and drinking water sources, indicating that their absence does not confirm the absence of other pathogens such as enteric viruses. In addition, detection methods have proven to be more complex and expensive than those for somatic and F-RNA coliphages due to the need for antibiotics and anaerobic environments (Grabow, 2001).

1.8 Current guidelines for treated effluent

Guidelines range from providing required public advice, numerical data as well as a respective classification system. Various guidelines and water quality criteria have been set in both local and international committees, however, due to the vast differences in methodology and development; these values tend to differ greatly. Whilst some guidelines tend to exhibit the maximum concentration of a particular contaminant others attempt to define the ideal concentration thus leading to confusion. In addition, these guidelines need to be flexible and adaptable to suit local, regional and national scenarios by taking the current socio-economic and environmental conditions into consideration (WHO, 2003a). This should be followed by subsequent transposition of guidelines into legally enforceable national standards by Government. Despite an outdated guideline for treated effluent being discharged into any catchment or river (Table 1.4), a South African Green Drop Certification Program was recently started by the Department of Water Affairs in an attempt to regularly monitor and improve the wastewater sector. This program allows local municipalities to generate information from data pertaining to their treatment plant efficiency and effluent characteristics, in order to monitor and report back, regarding their wastewater management systems. In addition, it provides the respective water regulators with an overview of required information allowing for improved trend monitoring and decision making as well as providing the public with access to relevant information regarding their regions (DWA, 2011).

Table 1.4: Currently used guidelines by the eThekwini Municipality (South Africa) for treated effluent being discharged into a receiving catchment

PARAMETER	A	B
Colour/ Odour/ Taste	None	None
pH	5.5 – 7.5	5.5 - 9.5
Dissolved Oxygen (mg/l)	75% saturation	75% saturation
Faecal Coliforms (CFU/100 ml)	0	0
Temperature (°C)	25	35
Chemical Oxygen Demand (mg/l)	30	75
Electrical Conductivity (mS/m)	250	250
Total Suspended Solids (mg/l)	10	90
Sodium Content (mg/l)	50	90
Soap/ Oil/ Grease	None	2.5
Residual Chlorine (mg/l)	0	0.1
Free/ Saline Ammonia (mg/l)	1	1
Nitrate (mg/l)	1.5	None
Orthophosphate (mg/l)	1	1

Adapted from Government Gazette, 1984; (A): Guidelines for effluent being discharged into any catchment area/ river or a tributary (B): Guidelines for effluent being discharged into any area other than that specified by A.

1.9 Enteric viruses commonly detected in the water environment and associated pathogens

Human enteric viruses generally include enteroviruses – namely polio, coxsackie A and B, echoviruses, enteric adenoviruses, reoviruses, rotaviruses, hepatitis A and E viruses, caliciviruses and astroviruses - all of which enter the water environment through the discharge of sewage contaminated water as well as through recreational river, sea and groundwater sources. The presence of viruses in high numbers in raw wastewater as well as inefficient wastewater treatment procedures result in their discharge in high numbers as well as increased persistence within the water environment. In addition, the discharge of inefficiently processed sludge may result in the persistence of viral particles within sediments and in the water column (Bosch, 1998). Infections occur as a result of swimming, canoeing or other related recreational uses of viral-contaminated waters. Viruses are shed in extremely high numbers from infected individuals with gastroenteritis patients excreting between 10^5 – 10^{11} viral particles per gram of stool. Transmission routes (Figure 1.2) may be diverse and includes consumption of shellfish grown in contaminated waters, consumption of contaminated drinking waters, food crops irrigated with contaminated wastewater, sewage polluted recreational waters or person to person contact (Wyn-Jones and Sellwood, 2001). These viral agents cause a range of diseases such as gastroenteritis, meningitis, myocarditis, hepatitis, respiratory illness and diarrhoea with viral particles being shed in extremely high numbers in the faeces of infected individuals. Recent studies have detected the presence of human enteric viruses in groundwater intended for drinking purposes in Seoul, Korea with 4.8% of samples testing positive for rotaviruses whilst an additional 3.2% of samples were positive for human adenoviruses and noroviruses (Park *et al.*, 2010).

1.9.1 Enteroviruses

Enteroviruses are naked icosahedral particles, stable within a pH range of 3 – 10 and generally present within the gastrointestinal tract as vaccine remnants and usually of low pathogenicity (Wyn-jones and Sellwood, 2001). They are usually transmitted via the faecal–oral route and infection can be acquired through person to person contact, contaminated water and food sources (Figure 1.2). Most enteroviral infections are asymptomatic, however in certain cases, enteroviral symptoms range from the general cold and flu to more severe paralysis, meningitis and in certain instances, resulting in fatal diseases (Fong and Lipp, 2005). Compared to most pathogens and bacterial indicators, the minimal infectious dose is extremely low with known cases of infection occurring with a single viral infectious particle. Previous studies on the survival rate have shown varying rates ranging from 6 - 7 months in river waters; 2 - 6 months at temperatures between 4 – 10 ºC and approximately 4 - 6 months in frozen water samples such as ice and snow for poliovirus, coxsackievirus and echovirus depending on the temperature, pH, humidity and the enteroviral genus under investigation (Kocwa-Haluch, 2001).

1.9.2 Adenoviruses

Adenoviruses are members of the family Adenoviridae and have been classified into six groups (A-F), based on their physical, chemical and biological properties. They are non-enveloped viruses and possess a linear double stranded DNA genome (Benko and Harrach, 2003). Human adenoviral contamination via domestic sewage serves as one of the major sources of contamination due to these viruses being shed in extremely high numbers as well as low seasonal variability and persistence in the water environment (Jiang, 2006). In addition, human adenoviruses have shown resistance to current purification and disinfection processes such as chlorine and UV light, whilst host-cell DNA repair mechanisms may repair UV-damaged DNA using human adenoviral DNA strands as a template for replication thus prolonging survival rates (Van Heerden *et al.*, 2005). Of the 51 serotypes, 30% are known to be pathogenic to man whilst only serotypes 40 and 41 cause gastroenteritis and are shed in large quantities in the faeces (Carter, 2005). These serotypes tend to survive longer than faecal bacteria in sewage and the surrounding environment, thus resulting in possible discharge with contaminated treated effluent that may already meet indicator bacterial standards (Jiang, 2006). In addition, previous studies have shown the occurrence of adenoviruses in 4% of 413 tested drinking water samples within South Africa, with additional research showing further detection in 4% of 204 and 30% of 198 finished drinking and tap water sources (Van Heerden *et al.*, 2003; 2005; 2004).

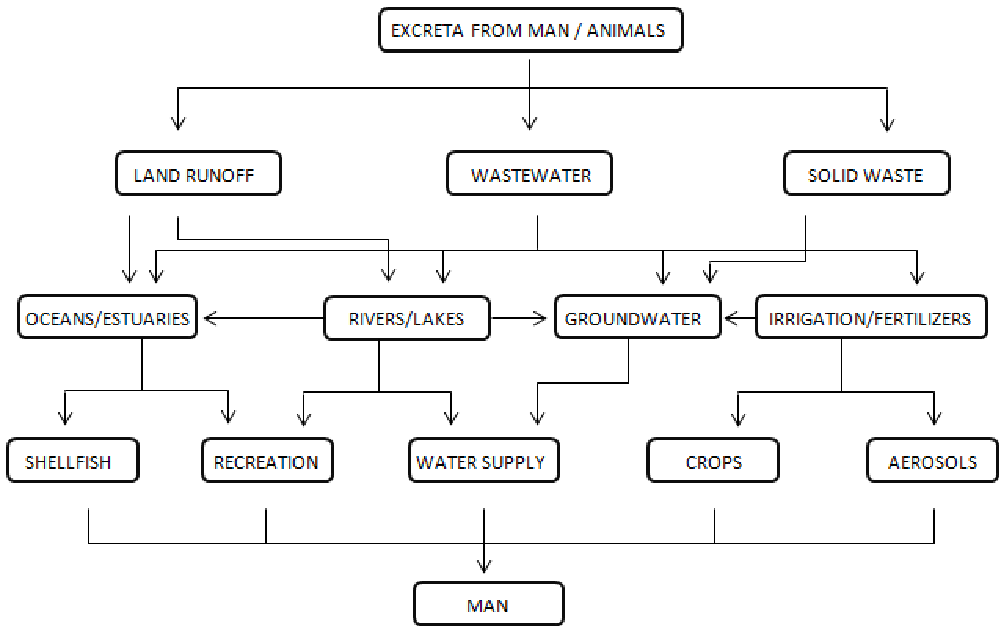


Figure 1.2: Transmission routes of human enteric viruses

(Adapted from WHO, 1979; Charles *et al.*, 1975; Gerba *et al.*, 1979; Bosch *et al.*, 2006)

1.9.3 Caliciviruses

Caliciviruses include norovirus, sapovirus, lagovirus and vesivirus, with only the first two genera being comprised of human pathogens. These viral agents are included on the U.S Environmental Protection Agency's Contaminant Candidate List (CCL) (Table 1.5). They are small non-enveloped RNA viruses that have characteristic cup-shaped depressions on a spherical capsid surface and range in size between 27 – 35 nm. Outbreaks associated with this virus generally occur within the colder months of the year (Mounts *et al.*, 2000). Noroviral symptoms differ from others in that it is the most significant cause of viral diarrhoea and induces a high level of explosive vomiting. Furthermore, due to the multiple noroviral serotypes, immunity in humans is generally short-lived. Sapoviruses on the other hand induce infections mainly in children, with most being infected between the ages of 3 months and 6 years. Norwalk-like and Sapoviral human pathogens have been differentiated based on their morphology, size, nucleic acid content and protein profile. However, one of the major challenges associated with this group of viruses is their inability to be cultured in a laboratory setting (Blacklow, 1996). Numerous studies have confirmed their presence in a range of faecal samples from infected individuals as well as surrounding environmental samples. A study conducted in Japan using qPCR to determine the presence and distribution of human sapoviruses in wastewater by Kitajima *et al.* (2011) confirmed their presence in 100% and 58% of influent and final effluent samples respectively.

1.9.4 Rotaviruses

Rotaviruses are RNA viruses, approximately 60 – 80 nm in diameter, belonging to the family Reoviridae. Infection with this virus is generally characterized by diahorrea and vomiting after an incubation period of 4 – 7 days, with infectious particles being shed in extremely high numbers (10^9 per gram of stool) in faeces, where infectivity can be maintained for up to one week (Table 1.6). Rotaviral infections are one of the major leading causes of diahorroea in children leading to approximately 40% of child-related diahorreal hospitalizations and approximately 600 000 child-related deaths in developing countries (Hashizume *et al.*, 2008). Rotaviruses have been shown to survive for long periods in a range of water sources – from treated sewage to surface water to groundwater sources - in some cases, surviving longer than poliovirus whilst survival rates in surface waters range between 8 – 32 days and in tap water for greater than 64 days (Kocwa-Haluch and Zalewska, 2002).

Table 1.5: Microbial contaminants on the United States Environmental Protection Agency Contaminant Candidate List and associated infections

Microbial contaminant	Waterborne associated infections
Adenovirus	Respiratory and gastrointestinal illnesses
Caliciviruses (including Noroviruses)	Mild self-limiting gastrointestinal illnesses
Campylobacter jejuni	Mild self-limiting gastrointestinal illnesses
Enterovirus (including poliovirus, coxsachievirus and echovirus)	Mild self-limiting respiratory illnesses
E. coli O157	Gastrointestinal illnesses / kidney failure
Helicobacter pylori	Colonizes the human gut, causing ulcers / cancer
Hepatitis A Virus	Liver disease, jaundice
Legionella pneumophila	Lung diseases
Mycobacterium avium	Lung infections
Naegleria fowleri	Primary amoebic meningoencephalitis
Salmonella enterica	Mild self-limiting gastrointestinal illnesses
Shigella sonnei	Mild self-limiting gastrointestinal illnesses / bloody diarrhea

Adapted from USEPA, 2012

1.9.5 Hepatitis A and E viruses

Hepatitis A (HAV) and E (HEV) are distinctly recognised from other types of human viral hepatitis, namely hepatitis B, C and D. Being non-enveloped viruses, they are transmitted mainly via the faecal-oral route whereas the latter types frequently progress to chronicity and are enveloped viruses, transmitted principally via blood (Purcell and Emerson, 2001). HAV is a member of the Picornavirus family, containing an icosahedral particle of 28 nm in diameter, composed of 30% RNA and 70% protein. It contains a single stranded RNA genome of 7.48 kb, possesses no envelope, and replicates in the cytoplasm. The surface proteins VP1 and VP3 serve as major antibody-binding sites. Previous studies have shown the virus to be stable to disinfection, acid and heat treatments, being able to withstand temperatures up to 60 ºC

(Melnick, 1992). HAV is generally transmitted via the faecal oral route either by direct contact with an HAV infected individual or by consumption of HAV-infected food or water and is characterised by symptoms such as anorexia, fever, nausea, vomiting and jaundice (Fiore, 2003).

HEV was originally considered to be a Calicivirus due to similar genome organization but is now, however, currently declassified due to studies showing differentiation of HEV's viral genes. It is a self-limiting virus, found worldwide, with the highest prevalence being in the East and South Asia. Genotype 1 is usually found in developing countries, resulting in outbreaks within various communities whilst genotype 3 is generally found in developed regions. Transmission of HEV is usually via the faecal-oral route with low socioeconomic regions exhibiting the highest serovalence rates, mainly due to poor sanitation and excessively contaminated water (Grabow, 2002).

1.9.6 Astroviruses

Human astroviruses are non-enveloped, small, circular shaped viruses, with an icosahedral symmetry of approximately 28 nm in diameter and a total genome length of approximately 6800 – 7900 nucleotides. They are noted for lacking a capsid and their characteristic star-like appearance when viewed under the electron microscope. Infection results predominantly in gastroenteritis, with incidence of infections spiking in winter months. A range of sero-prevalance studies suggest that more than 80% of children between the ages of 5 – 10 possess antibodies to the virus (Wyn-jones and Sellwood, 2001).

Table 1.6: Examples of waterborne viruses detected from various sites and common methods used for their detection

SAMPLE	SITE	VIRUS	NUMBERS (CU/litre)	DETECTION METHOD	REFERENCE
Freshwater	Loire river France	Entero	1.39	Cell culture	Le Bris *et al.* (1983)
	Besos River Spain	Entero	15.5	Cell culture	Bosch *et al.* (1986)
	Tiber river Italy	HAV	+	ELISA	Divizia *et al.* (1989)
	Umgeni River South Africa	Presumptive Adenovirus	+	Microscopy	Olaniran *et al.* (2012)
Food	Lettuce	HAV	2.03	RT-PCR	Croci *et al.* (2002)
	Cabbage	Polio	6.15	Cell culture	Ward *et al.* (1982)
	Lettuce	HAV	Less than 1.00	Cell culture	Bidawid *et al.*(2001)
	Assorted vegetables	Rota	+	Cell culture RT-PCR	Van Zyl *et al.* (2006)
Seawater	Italy	Entero	0.4 – 16	Cell culture	De flora *et al.* (1975)
	USA	Entero	0.01 0.44	Cell culture	Goyal *et al.* (1979)
	France	Entero	0.05 - 6.5	Cell culture	Hugues *et al.* (1980)
	Spain	Entero	0.12 - 1.72	Cell culture	Finance *et al.* (1982)
Drinking water	South Africa	Entero	+[a]	Cell culture and RT-PCR	Ehlers *et al.* (2005)
	South Africa	Rota	+[a]	Cell culture RT-PCR	Van Zyl *et al.* (2006)
	Korea	Entero/ Adeno	+[a]	Cell culture/ RT-PCR	Lee and Kim. (2002)

CU/litre – cytopathic units of virus per litre; (+) virus detected; *a*: molecular detection of viral RNA only

1.10 Scope of the present study

The escalating rates of urbanization, industrialization and population growth have contributed to the increase in water pollution and degradation of water quality. The Durban Metropolitan Area produces over 1.8 million tons of waste a year, the majority of which is disposed of in landfill sites with approximately 261 mega litres of treated wastewater being discharged into the sea daily. A further 242 mega litres are discharged into rivers (State of the Environment Report, 2007/8). Stresses such as chemical pollution, salinity, acid mine drainage, alteration of flow and eutrophication, especially when acting together, can have a significantly negative impact on river bodies, resulting in large amounts of organic matter and nutrients being discharged into waterways thereby affecting aquatic life as well as disrupting the biotic community structure and function (Wakelin *et al.*, 2008). Furthermore, the failure of large numbers of existing wastewater treatment plants to comply with national water standards as well as inefficient management and monitoring of these water treatment services, poorly maintained infrastructure, capacity problems and budget constraints have resulted in an increased decline in the effluent quality from treatment plants (DWA, 2012). This study therefore aims at assessing the microbial (bacterial and viral) and physico-chemical quality of treated effluent being discharged from two wastewater treatment plants in Durban as well as to assess their impacts on the quality of the receiving water bodies.

1.11 Hypotheses

1.11.1 It is hypothesized that treated final effluent from wastewater treatment plants being discharged into receiving water bodies in Durban are of a poor microbiological and chemical quality.

1.11.2 It is further hypothesized that treated effluent from these wastewater treatment plants contribute significantly to the poor microbial and chemical quality of receiving aquatic milieu.

1.12 Objectives

The following objectives were established:

1.12.1 To monitor the microbial (bacterial and viral) and physicochemical qualities of treated final effluent of two wastewater treatment plants and the receiving watershed in Durban over a one year period.

1.12.2 To assess the efficiency of the disinfection process of the two wastewater treatment plants for bacterial and viral pathogen removal from the treated effluent samples.

1.12.3 To determine the impact of the discharged treated wastewater effluent on the microbial and physicochemical quality of the receiving water bodies.

1.13 Aims

The following aims were pursued:

1.13.1 To collect wastewater samples at pre-designated points from two independent wastewater treatment plants as well as from upstream and downstream of the receiving rivers.

1.13.2 To analyze the collected water samples for various physicochemical parameters using standard methods.

1.13.3 To enumerate the presumptive total coliforms, faecal coliforms, enterococci, faecal streptococci, *E. coli* and total heterotrophic bacterial populations present in each collected water sample using the membrane filtration technique.

1.13.4 To correlate the physicochemical and microbial parameters using statistical analyses.

1.13.5 To enumerate somatic and F-RNA coliphages in the collected water samples using the double agar layer plaque assay.

1.13.6 To detect the presence of enteroviruses and human adenoviruses in the collected water samples across the seasons using PCR.

1.14 Experimental Design

In order to achieve the stated objectives, the present study was divided into five main chapters as described below.

- **Chapter One**

This chapter provides an overview of the global water crisis as well as the water situation within South Africa, focusing mainly on the effect of improperly treated wastewater effluent. In addition, the inadequacy of existing wastewater treatment plants for proper sewage treatment as well as the need for adequate wastewater management is highlighted. An overview of the commonly detected microbial indicators in treated effluent and receiving water bodies is also provided.

- **Chapter Two**

This chapter focuses on the physicochemical and nutritional profiles of treated wastewater effluent from two independently monitored treatment plants over a year, as well as the impact of the treated effluent discharged on the receiving watershed within the Durban area.

- **Chapter Three**

This chapter specifically focuses on the monthly enumeration of bacterial indicators, as well as somatic and F-RNA coliphages in the treated wastewater effluent and receiving watershed over a one year period.

- **Chapter Four**

This chapter investigated the presence/absence of human adenoviruses and enteroviruses within the treated wastewater effluent and the receiving watershed across the seasons.

- **Chapter Five**

This chapter provides an overview of the significant findings reported within the various chapters. In addition, possible limitations and potential for future developments of the study are also highlighted.

CHAPTER TWO

PHYSICO-CHEMICAL QUALITIES OF TREATED WASTEWATER EFFLUENT AND THE RECEIVING WATER BODIES IN DURBAN

2.1 Introduction

For decades, water has been regarded as the most essential of natural finite resources that is required for human development and existence as well as for a range of agricultural and industrial activities, all of which contribute to the socioeconomic development of not only individual communities but entire countries as well (Taiwo *et al.*, 2012). These existing water systems are constantly being manipulated due to fluctuating vegetation and land coverage, urbanization, industrialization and inter basin transfers which are aimed at increasing water availability for a range of anthropological activities. Vorosmarty *et al.* (2010) reported on a global scale analysis of threats to fresh water resources, with 30 of the 47 largest rivers being moderately threatened, especially at the river mouth. With approximately 80% of the world's population living in areas where human water security and biodiversity is threatened, the importance of ensuring both national and global water security has heightened. South Africa is one of the few countries in the world that formally recognises water as a human right, with its national water and sanitation programme being one of the largest national programmes in Africa (UNICEF, 2008).

Furthermore apart from the well-known Shattuck report, much evidence has shown that the provision of improved water and sanitation has resulted in a significant reduction in both mortality and morbidity rates as well as a range of waterborne diseases within previously disadvantaged communities (Shattuck, 1850; WHO, 2011a). Globally, freshwater is regarded as a vital resource, contributing not only to the maintenance of ecosystem health, sanitation and energy production but also to improve a vast array of domestic, industrial and agricultural activities. This valuable water resource is constantly under pressure as population numbers increase and economies expand, presenting an ever-increasing challenge for efficient water resource management and quality maintenance and monitoring (AMCOW, 2012). Jackson *et al.* (2001) projected that freshwater availability per capita will decrease with increasing population numbers by 2030. In addition, accessible runoff is unlikely to increase by more than 10% resulting in further freshwater resource imbalance, ultimately reducing ecosystem services, increasing the number of species facing extinction and increasing the fragmentation of existing water bodies such as wetlands, rivers, deltas and estuaries.

Maintenance of a healthy aquatic ecosystem is dependant on a range of physical and chemical profiles in conjunction with biological diversity (Venkatesharaju *et al.*, 2010). Pollution of waterways results in the introduction of several stressors, first known to drastically alter the chemical quality of the water body followed by subsequent depletion of biodiversity and community life with larger consequences for aquatic than terrestrial ecosystems (Joshi *et al.*, 2009; Sala *et al.*, 2000). Whilst the constantly changing natural processes, such as the hydrological cycle places an increasing pressure on these water bodies, surrounding anthropogenic activity such as the discharge of domestic waste, may result in the application of even further stress in the form of various nutrients, chemical constituents and increasing oxygen demand being introduced into the waterway (Adeyemo *et al.*, 2008). Various factors influence the operational efficiency of WWTPs, with treatment methods varying with plant size, influent characteristics and composition. Whilst inactivation of pathogenic organisms is essential, treatment processes such as sedimentation, anaerobic digestion and composting may also impact certain physicochemical properties of the final effluent such as dissolved oxygen, electrical conductivity, hardness and metal and non-metal ions (Samie *et al.*, 2009). This, in conjunction with inefficient nutrient reduction leads to the development of toxic algal blooms and ultimately the destabilization of aquatic ecosystem biodiversity (Morrison *et al.*, 2001). In addition, the use of these water bodies for a range of recreational activities results in the exposure of humans to toxic levels of discharged chemicals, which can have serious immediate as well as long term health effects (Smith *et al.*, 2000).

Water quality is a function of the physicochemical characteristics which vary with changing weather patterns, spatial and temporal variability in terms of flow as well as point and diffuse source pollution within the water body. Macro- and micro-fauna and flora within and around these water bodies have adapted within various ecosystems to these daily and seasonal changing conditions, ensuring the production of various goods and services which sustain and support surrounding communities. However, nearby anthropogenic and industrial activities further lead to habitat degradation (Nilsson and Renofalt, 2008). Numerous studies have indicated that poorly treated wastewater effluent serves as a source of chemical and microbiological pollution of receiving watersheds with unacceptably high levels of certain parameters being reported (Doughari *et al.*, 2007; Trajkovic *et al.*, 2008; Samie *et al.*, 2009; Igbinosa and Okoh 2009). However, limited studies incorporating wastewater treatment plants in the KwaZulu-Natal region have been done. Thus, this chapter focuses on the annual monitoring of various physico-chemical parameters of treated effluent of two independent wastewater treatment plants within the eThekwini municipality as well as the receiving watershed.

2.2 Materials and methods

2.2.1 Description of study areas

In this study, two wastewater treatment plants within the eThekwini Municipality, discharging treated effluent directly into rivers in and around the surrounding Durban area were chosen for investigation; namely, The Northern Wastewater Treatment Plant (NWWTP) and The New Germany Treatment Works (NGTW); (Figure 2.1). The NWWTP is one of the five biggest sewage treatment plants in the Durban area and has an overall plant capacity sufficient to deal with a sewage inflow of approximately 45 000 m^3 daily (Table 2.1), with its main treatment technologies being based on activated sludge, mechanical aeration and anaerobic digestion. Approximately 8% of the raw sewage being processed originates from surrounding industrial areas whilst the remaining 92% consists mainly of domestic waste, with the treated final effluent being discharged directly into the Umgeni River catchment. The Umgeni River supplies water to the third largest economic region in South Africa and spans an area of 441 km^2, with a river length of 225 km from source to mouth. In addition, it receives a mean annual precipitation of 410 – 1450 mm and a mean annual runoff of approximately 72 – 680 mm. This catchment serves as the main water catchment between the Kloof and Inanda Valley in the KwaZulu-Natal Midlands area to approximately 2 million people (RHP, 2011). The NGTW processes approximately 15% of industrial and 85% of domestic waste respectively. Being a smaller treatment plant, it uses activated sludge and mechanical aeration as its main sewage processing technologies. The treated final effluent is discharged into a small inland tributary on the lower Umgeni River, identified as the Aller River which runs through the New Germany Industrial, Clermont and KwaDabeka suburban area. A great deal of the pollutant load within this tributary arises from the surrounding commercial and industrial activities within the New Germany area as well as from surrounding informal settlements. In addition, numerous alien plant vegetation located along the riparian zone and extensive solid waste disposal have been noted to affect water quality.

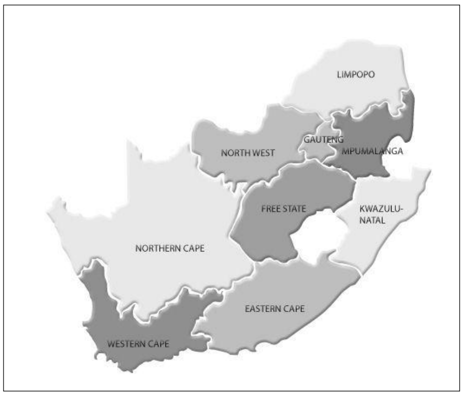
Table 2.1: Major operational areas for the NWWTP and NGTW

OPERATIONAL AREA	NGTW	NWWTP
Design capacity (ml/day)	7	70
Operational capacity (%)	10.9	80
Microbiological compliance (%)	67	42
Chemical compliance (%)	73	79
Physical compliance (%)	83.3	89
Annual average effluent quality compliance (%)	74.4	70
Use of effluent	Discharged into river	Discharged into river

Adapted from The Greendrop Handbook (DWA, 2012)

2.2.2 Collection of samples

Water samples were collected on a monthly basis between March 2012 and February 2013 from pre-designated sites along the water surface (0 - 30 cm depth) namely, the final effluent before chlorination, at the discharge point after chlorination as well as approximately 500 m upstream and downstream of the receiving rivers. Samples were collected in 5 ℓ plastic containers which had been previously sterilised with 70% (v/v) alcohol and rinsed with water at the respective sampling points prior to collection. Each water sample was collected by holding the mouth of the container against the water current or by artificially creating one by pushing the container forward, leaving approximately 50 mm of headspace to allow for sufficient mixing during laboratory analysis (APHA, 1998). Samples collected at the discharge point were dechlorinated with sodium thiosulphate at a final concentration of 100 mg/ℓ. After collection, samples were protected from direct sunlight and transported on ice to the laboratories at the Department of Microbiology, University of KwaZulu-Natal (Westville campus). Samples were stored at 4 °C and analyzed within 48 hr of collection. In addition, various plant operational malfunctions as well as tidal patterns, precipitation and anthropogenic activities such as illegal domestic and industrial dumping; fishing and human defecation taking place along river sampling points were noted for the duration of the study.



PLANT	SAMPLE	LATITUDE	LONGITUDE
NORTHERN WWTP	BC	29° 47.775´ S	030° 59.754 ´E
	DP	29° 47.988´ S	030° 59.518 ´E
	US	29° 48.203 S	030° 59.571 ´E
	DS	29° 48.519 S	031° 00.83 ´E
NEW GERMANY TW	BC	29° 48.353 S	030° 58.829 ´E
	DP	29° 48.353 S	030° 53.835 ´E
	US	29° 48.340 S	030° 53.724 ´E
	DS	29° 48.345 S	030° 53.847 ´E

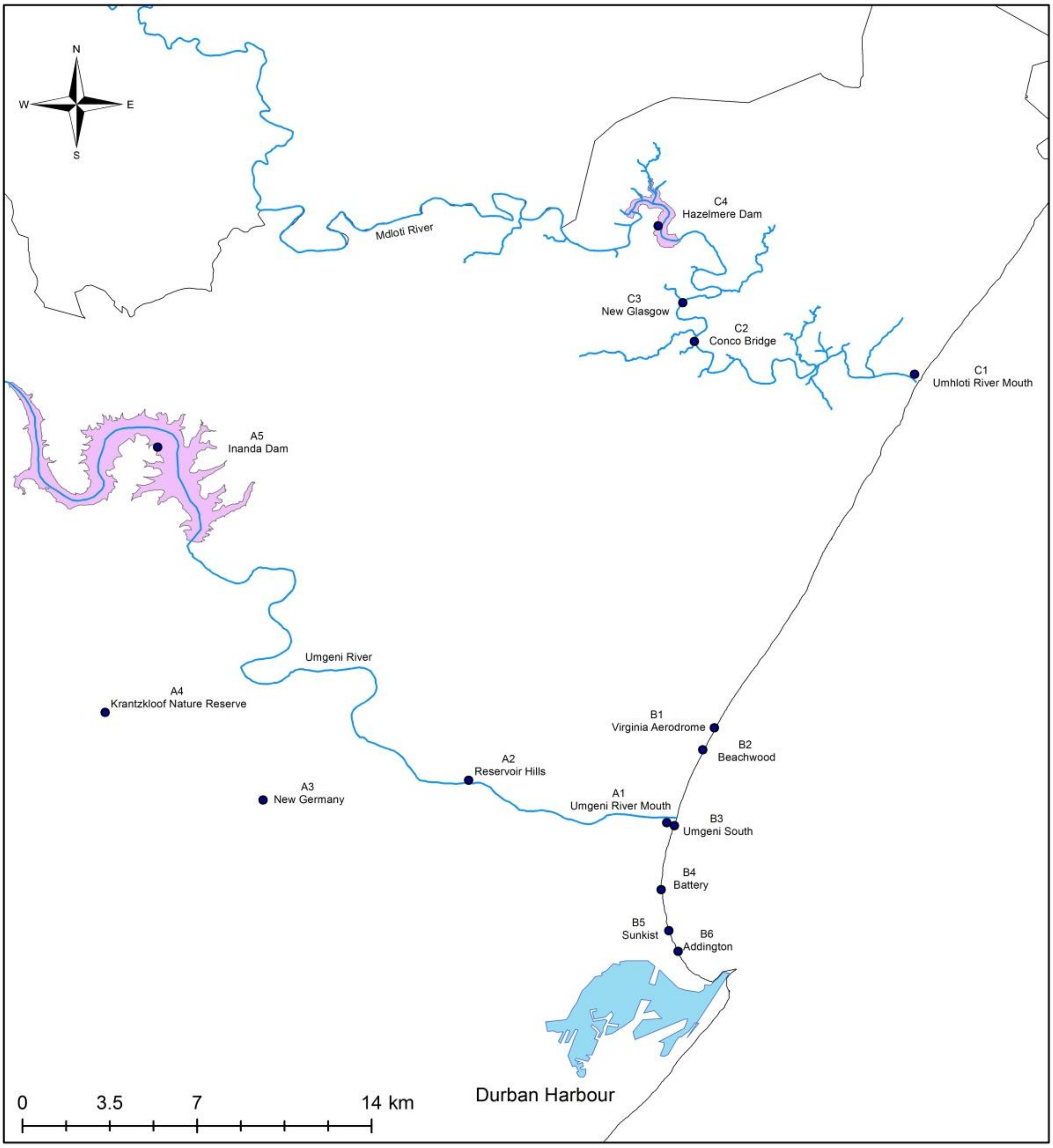


Figure 2.1: Map of study area showing major sampling points (Olaniran *et al.*, 2012)

Figure 2.2: Images illustrating various activities noted during sampling: A: overflow from broken pit latrine toilets (Upstream Aller River); B: Informal settlements located on the banks of the Aller River; C: Discharge of domestic waste from surrounding rural settlements (Upstream Aller River); D: Excessive red larvae (Aller River); E: Discharge of poorly treated effluent at NWWTP; F: Poor chlorine treatment within NGTW.

2.3 Laboratory analyses

Replicate analyses were conducted on all samples using standard methods for wastewater analysis (Standard methods, 1998).

2.3.1 Physico-chemical analyses

Collected samples were analysed for major physico-chemical water quality parameters such as temperature, turbidity, total dissolved solids (TDS), total suspended solids (TSS), pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), salinity, electrical conductivity (EC), resistivity, ammonium, nitrate, phosphate, sulphate and residual chlorine. All equipment was checked and calibrated according to the manufacturers specifications. Temperature was measured on-site, immediately after collecting samples using a standard mercury thermometer. Turbidity was determined using the nephelometric method and measured using a 2100 P HACH Turbidimeter whilst pH was measured using a Beckman 50 pH meter. TDS, salinity, electrical conductivity and resistivity were determined using the HACH HQ40d Portable Meter, with parameter specific probes whilst DO and BOD were measured using the CDC401 probe. Biological oxygen demand was determined according to the HACH protocol - Method 8043 (2007). Chemical oxygen demand was determined photometrically according to the chromo sulphuric acid oxidation method using the SpectroQuant Nova 60 COD cell test (Merck) measuring in the range of 10 – 150 mg/L. Samples were digested with a thermo reactor model HACH DRB 200 for 120 min at 148 °C, followed by photometric analysis using the spectroquant NOVA 60 photometer (Merck Pty Ltd). Total suspended solids was determined using a gravimetric protocol according to the

EPA – Method 160.2. In addition, collected water samples were outsourced to Cleanstream Scientific Services for respective nutrient analyses.

2.3.2 Statistical Analyses

All statistical analyses were performed using the Statistical Package for Social Sciences - Version 21.0. (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.). Data was subjected to descriptive statistical analyses with a 95% confidence limit ($p \leq 0.05$). Means ± standard deviations are presented for all continuous variables. Continuous variables were tested for normality prior to parametric testing. If skewed, data was normalised using the log transformation. The Pearsons Product-moment correlation coefficient matrix was used to determine the linear relationships between the measured physicochemical parameters.

2.4 Results

Seasonal and monthly variations in the physicochemical profiles of the treated effluents from NWWTP and NGTW and the receiving watershed between March 2012 and February 2013 are presented in Figure 2.3; Figure 2.5; Figure 2.7 and Table 2.2 (NWWTP) whilst those of NGTW are shown in Figure 2.4; Figure 2.6; Figure 2.8 and Table 2.3. Temperature ranged between 12 – 26 °C and 12.7 – 26 °C for the NWWTP and the receiving river (Umgeni River) whilst for the NGTW and receiving river (Aller River) it ranged between 16.5 – 26 °C and 12 – 25.7 °C respectively. The highest temperature reading was recorded during autumn (March) for both plants and receiving rivers whilst the lowest temperature was recorded in June and July for the NWWTP (Table 2.2) and NGTW (Table 2.3), respectively. The pH values ranged between 6.60 – 7.80 and 6.37 – 7.87 in samples collected before chlorination at NWWTP and NGTW respectively whilst pH at the discharge point ranged between 6.68 – 7.88 and 6.39 – 7.72, respectively. The pH values observed for the receiving watershed ranged between 6.41 – 7.65 and 6.3 – 7.93 upstream of both receiving rivers whilst the highest pH values of 7.87 and 8.08 were obtained downstream for both rivers during the month of February. Dissolved oxygen (5.93 – 8.65 mg/l and 7.44 – 8.71 mg/l), BOD (2.23 – 5.15 mg/l and 2.64 – 5.42 mg/l) and COD (less 10 – 311.11 mg/l and 54.11 – 31044 mg/l) concentrations obtained at the discharge point varied widely over the twelve month period for both treatment plants (Table 2.2). Seasonal averages revealed the highest BOD (winter: 9.61 mg/l and 9.15 mg/l) and COD (spring: 309.67 mg/l; summer: 294.15 mg/l) values upstream of both receiving rivers (Tables 2.2 and 2.3). Relatively high COD values were obtained downstream during winter (263.45 mg/l) and spring (177.93 mg/l) for the NWWTP (Table 2.2) and winter (228.22 mg/l) for the NGTW (Table 2.3). Increases in BOD values were observed at the discharge point relative to samples collected before chlorination, every month except for November (3.72% reduction) for the NWWTP (Figure 2.5) and April (1.45%

reduction) and June (11.75% reduction) for the NGTW (Figure 2.6). Overall, the greatest reduction in BOD was observed at the discharge point (3.68 mg/l) for the NGTW relative to the final effluent before chlorination (4.17 mg/l). Electrical conductivity varied seasonally with higher values being obtained at the discharge point throughout the entire study period for both plants except during September and October whereby a 8.6% and 4.91% reduction was noted for the NWWTP (Table 2.2) and NGTW (Table 2.3) respectively, relative to before chlorination. The highest EC values were noted during February and September for the final effluent before chlorination (925.33 µS/m) and the discharge point (970 µS/m) for the NWWTP whilst the highest EC of 1148.33 µS/m and 1253.67 µS/m was observed during May in samples collected before chlorination and at the discharge point of NGTW respectively. Salinity values varied across the sampling period and sampling sites with upstream and downstream values ranging respectively between 0.15 – 0.72 mg/l and 0.29 – 1.4 mg/l for the Umgeni river and 0.15 – 0.34 mg/l and 0.24 – 0.46 mg/l for the Aller river. Varying salinity values were measured within both rivers, with salinity patterns changing due to external factors such as rainfall and tidal fluctuations (Figures 2.3 and 2.4). Fairly low seasonal averages for salinity were measured within the receiving rivers during the wet seasons of spring (200.73 mm) and summer (115.73 mm), where the highest average rainfall was recorded (Figure 2.3 and 2.4).

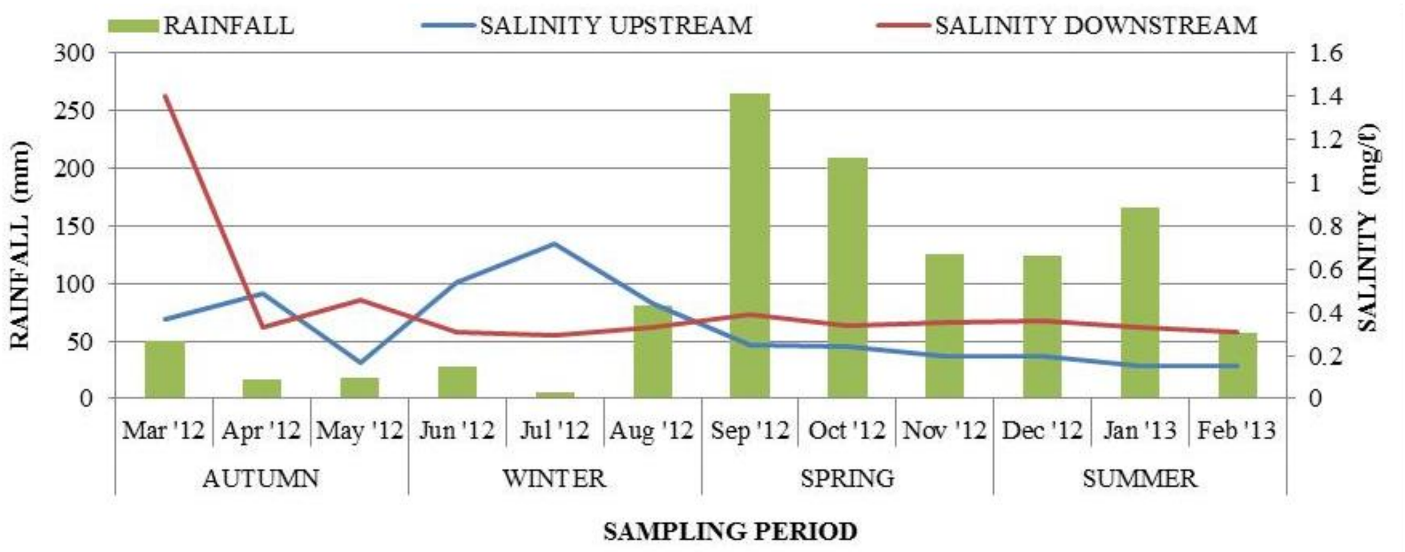


Figure 2.3: Monthly variations of salinity vs rainfall for the Umgeni River between March 2012 – February 2013.

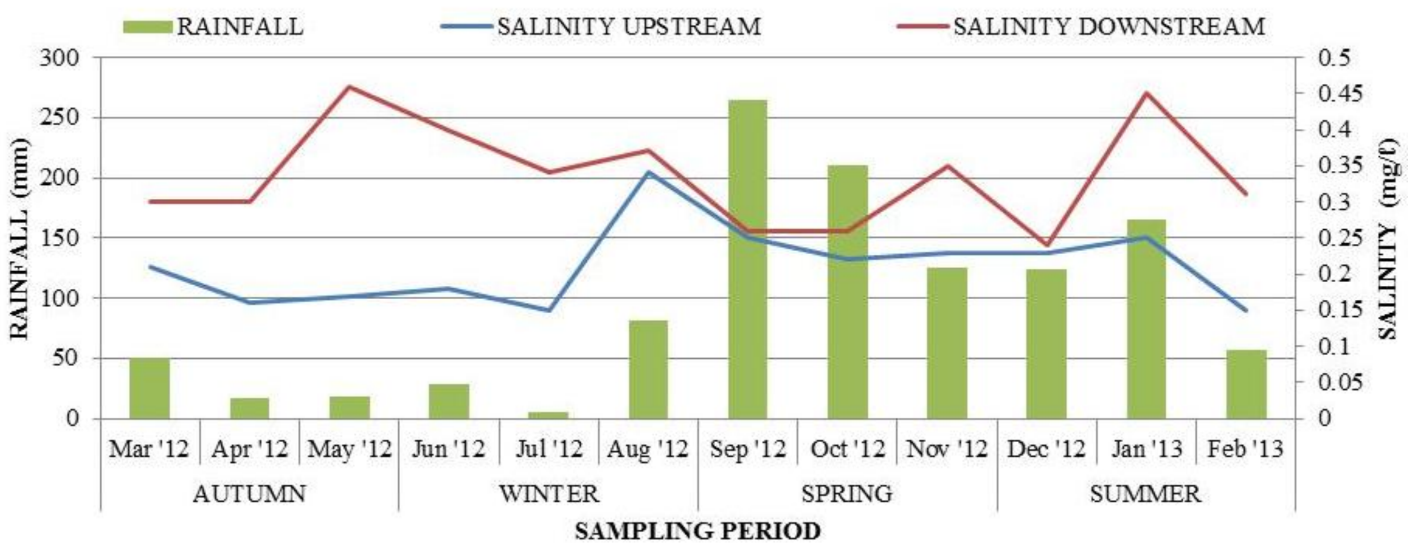


Figure 2.4: Monthly variations of salinity vs rainfall for the Aller River between March 2012 – February 2013.

Table 2.2: Physicochemical profiles of treated effluents of the NWWTP and its receiving watershed over the sampling period

Season	Month	Site	T (°C)	TDS (mg/l)	pH	DO (mg/l)	COD (mg/l)	EC (µS/m)	SAL. (mg/l)	RES.(‰)
AUTUMN	MAR '12	BC	26 ± 0	411.33 ± 0.58	7.10 ± 0.05	7.53 ± 5.57	104.78 ± 4.48	839.67 ± 0.58	0.41 ± 0.00	1191.00 ± 1.00
		DP	25 ± 0	436.00 ± 0.00	7.36 ± 0.07	8.14 ± 3.96	LESS 10	888.00 ± 1.00	0.44 ± 0.00	1126.00 ± 1.00
		US	26 ± 0	370.00 ± 1.00	7.25 ± 0.09	8.14 ± 5.62	161.33 ± 1.32	757.67 ± 2.52	0.37 ± 0.00	1320.33 ± 4.51
		DS	25.5 ± 0	348.67 ± 1.15	7.24 ± 0.06	7.97 ± 5.91	192.44 ± 2.37	714.67 ± 2.08	1.41 ± 1.82	1400.00 ± 4.36
	APR '12	BC	22 ± 0	383.00 ± 1.00	7.67 ± 0.06	7.60 ± 0.20	229.33 ± 0.00	783.33 ± 2.08	0.38 ± 0.00	1276.33 ± 3.21
		DP	22 ± 0	444.00 ± 1.00	7.40 ± 0.10	7.67 ± 0.18	311.11 ± 0.19	903.67 ± 2.08	0.44 ± 0.01	1106.67 ± 2.31
		US	21 ± 0	491.00 ± 1.73	7.41 ± 0.12	8.50 ± 0.01	304.33 ± 0.00	997.67 ± 2.89	0.49 ± 0.00	1004.00 ± 0.00
		DS	21 ± 0	330.67 ± 2.08	7.63 ± 0.66	7.86 ± 0.06	151.00 ± 0.00	679.00 ± 4.36	0.33 ± 0.00	1478.67 ± 2.31
	MAY '12	BC	22 ± 0	418.00 ± 0.00	7.08 ± 0.03	6.68 ± 0.06	38.22 ± 0.48	853.00 ± 0.00	0.42 ± 0.00	1173.00 ± 0.00
		DP	21 ± 0	475.00 ± 0.00	7.28 ± 0.02	7.99 ± 0.01	Less 10	966.00 ± 0.00	0.48 ± 0.00	1036.00 ± 1.00
		US	21 ± 0	1067.0 ± 3.46	6.91 ± 0.04	8.08 ± 0.02	20.22 ± 0.55	211.67 ± 0.58	1.08 ± 0.00	473.67 ± 1.15
		DS	22 ± 0	302.00 ± 1.00	7.13 ± 0.03	8.14 ± 0.02	309.11 ± 0.67	621.00 ± 2.65	0.30 ± 0.00	1612.33 ± 3.51
WINTER	JUN '12	BC	13 ± 0	342.67 ± 0.58	7.37 ± 0.00	7.99 ± 0.06	300.00 ± 2.04	703.00 ± 1.00	0.34 ± 0.00	1423.33 ± 2.52
		DP	12 ± 0	368.33 ± 0.08	7.35 ± 0.01	8.65 ± 0.02	110.00 ± 0.00	757.33 ± 2.08	0.37 ± 0.00	1320.33 ± 3.21
		US	13 ± 0	534.33 ± 1.15	7.65 ± 0.01	8.44 ± 0.04	112.89 ± 1.00	1082.33 ± 2.08	0.54 ± 0.00	924.00 ± 1.73
		DS	13.5 ± 0	308.00 ± 0.00	7.84 ± 0.01	8.43 ± 0.02	88.78 ± 0.33	633.33 ± 0.58	0.31 ± 0.00	1580.00 ± 1.73
	JUL '12	BC	16 ± 0	348.33 ± 7.37	7.48 ± 0.01	6.47 ± 0.27	114.78 ± 3.13	724.67 ± 6.51	0.34 ± 0.01	1370.67 ± 7.37
		DP	15 ± 0	416.33 ± 0.58	7.70 ± 0.00	7.47 ± 0.16	290.67 ± 0.33	849.67 ± 1.15	0.42 ± 0.00	1177.00 ± 1.00
		US	15 ± 0	710.00 ± 4.36	7.54 ± 0.01	8.26 ± 0.05	311.00 ± 0.00	1428.67 ± 4.16	1.72 ± 0.00	700.00 ± 1.73
		DS	15 ± 0	294.67 ± 0.58	7.87 ± 0.02	8.33 ± 0.08	311.00 ± 0.64	606.00 ± 1.73	0.29 ± 0.00	1650.33 ± 4.04
	AUG '12	BC	16 ± 0	348.33 ± 7.37	7.48 ± 0.01	6.47 ± 0.27	114.78 ± 3.13	724.67 ± 6.51	0.34 ± 0.01	1370.67 ± 7.37
		DP	15 ± 0	416.33 ± 0.58	7.70 ± 0.00	7.47 ± 0.16	290.67 ± 0.33	849.67 ± 1.15	0.42 ± 0.00	1177.00 ± 1.00
		US	15 ± 0	710.00 ± 4.36	7.54 ± 0.01	8.26 ± 0.05	311.00 ± 0.00	1428.67 ± 4.16	1.72 ± 0.00	700.00 ± 1.73
		DS	15 ± 0	294.67 ± 0.58	7.87 ± 0.02	8.33 ± 0.08	311.00 ± 0.64	606.00 ± 1.73	0.29 ± 0.00	1650.33 ± 4.04
SPRING	SEP '12	BC	22 ± 0	423.67 ± 2.31	6.75 ± 0.02	6.37 ± 0.11	308.67 ± 0.33	864.00 ± 4.36	0.42 ± 0.00	1156.67 ± 6.35
		DP	20 ± 0	386.33 ± 0.58	6.82 ± 0.04	6.61 ± 0.05	308.44 ± 0.33	789.67 ± 1.15	0.39 ± 0.01	1266.33 ± 2.08
		US	20 ± 0	246.67 ± 0.58	6.41 ± 0.05	8.12 ± 0.03	55.56 ± 0.33	509.33 ± 1.15	0.25 ± 0.00	1963.00 ± 3.46
		DS	20 ± 0	386.33 ± 0.58	6.52 ± 0.02	7.56 ± 0.07	139.67 ± 0.55	790.33 ± 1.53	0.39 ± 0.00	1265.33 ± 2.08
	OCT '12	BC	22 ± 0	407.33 ± 0.58	6.60 ± 0.06	7.30 ± 0.31	306.89 ± 0.33	831.67 ± 1.15	0.41 ± 0.00	1202.33 ± 2.08
		DP	23 ± 0	408.00 ± 0.00	6.75 ± 0.05	7.96 ± 0.07	109.89 ± 1.00	832.33 ± 0.58	0.41 ± 0.00	1200.67 ± 0.58
		US	24 ± 0	241.33 ± 0.58	7.02 ± 0.01	7.70 ± 0.20	195.22 ± 0.33	499.33 ± 0.58	0.24 ± 0.00	2003.00 ± 1.73
		DS	24 ± 0	336.00 ± 0.00	6.91 ± 0.01	7.67 ± 0.23	148.00 ± 0.33	689.67 ± 0.58	0.34 ± 0.01	1449.33 ± 0.58
	NOV '12	BC	22 ± 0	445.33 ± 0.6	6.79 ± 0.01	6.87 ± 0.04	123.78 ± 0.33	907.67 ± 1.15	0.44 ± 0.00	1102.00 ± 1.73
		DP	22.5 ± 0	477.33 ± 2.08	6.68 ± 0.03	6.87 ± 0.07	287.22 ± 0.00	970.00 ± 4.36	0.48 ± 0.01	1031.00 ± 4.36
		US	21 ± 0	206.87 ± 0.23	6.86 ± 0.01	7.59 ± 0.04	241.78 ± 0.24	429.00 ± 0.00	0.20 ± 0.01	2330.00 ± 0.00
		DS	23 ± 0	350.00 ± 0.00	6.72 ± 0.05	7.42 ± 0.05	246.11 ± 0.33	718.00 ± 0.00	0.35 ± 0.00	1392.33 ± 0.58
SUMMER	DEC '12	BC	15 ± 0	428.00 ± 0.00	6.78 ± 0.03	6.92 ± 0.05	170.78 ± 1.07	872.33 ± 0.58	0.43 ± 0.00	1760.33 ± 2.52
		DP	21 ± 0	473.00 ± 1.00	6.69 ± 0.01	7.60 ± 0.02	153.89 ± 0.63	961.67 ± 2.08	0.47 ± 0.00	1806.00 ± 2.65
		US	22 ± 0	200.03 ± 0.06	6.85 ± 0.01	7.49 ± 0.04	274.33 ± 0.33	415.33 ± 0.58	0.20 ± 0.00	2082.00 ± 2.00
		DS	22 ± 0	359.33 ± 0.58	6.84 ± 0.02	7.61 ± 0.04	205.33 ± 1.07	735.67 ± 1.15	0.36 ± 0.00	2010.33 ± 0.58
	JAN '13	BC	24 ± 0	393.67 ± 0.58	6.84 ± 0.01	7.60 ± 0.03	LESS 10	804.00 ± 1.00	0.39 ± 0.00	1244.00 ± 4.36
		DP	23 ± 0	412.33 ± 0.58	6.87 ± 0.03	7.66 ± 0.03	303.67 ± 1.71	841.33 ± 1.53	0.41 ± 0.00	1188.33 ± 2.08
		US	24 ± 0	155.10 ± 0.35	7.04 ± 0.01	7.53 ± 0.15	299.22 ± 0.78	323.67 ± 0.58	1.15 ± 0.00	3093.33 ± 5.77
		DS	24 ± 0	327.33 ± 0.58	6.92 ± 0.02	7.71 ± 0.10	150.11 ± 0.33	672.00 ± 1.00	0.33 ± 0.00	1488.33 ± 2.89
	FEB '13	BC	25 ± 0	454.33 ± 0.58	7.80 ± 0.01	5.93 ± 0.08	295.67 ± 2.07	925.33 ± 1.53	0.45 ± 0.01	1080.67 ± 1.53
		DP	25 ± 0	457.67 ±1.15	7.88 ± 0.01	6.86 ± 0.06	254.78 ± 0.33	931.00 ± 1.73	0.46 ± 0.00	1188.33 ± 2.08
		US	25 ± 0	153.07 ± 0.31	7.41 ± 0.01	7.49 ± 0.01	308.89 ± 0.33	319.33 ± 0.58	0.15 ± 0.00	3093.33 ± 5.77
		DS	27 ± 0	312.33 ± 0.58	7.77 ± 0.01	7.51 ± 0.02	309.33 ± 0.00	641.33 ± 1.15	0.31 ± 0.00	1488.33 ± 2.89
		G	**25**	**-**	**5.5 – 7.5**	**75% SAT**	**30**	**250**	**-**	**-**

Results represent Averages ± Standard Deviation. G: Guideline for treated effluent (Government Gazette, 1984); (-) no guideline; T: Temperature; TDS: Total Dissolved Solids; DO: Dissolved Oxygen; COD: Chemical Oxygen Demand; EC: Electrical Conductivity; SAL.: Salinity; RES.: Resistivity

Table 2.3: Physicochemical profiles of treated effluents of the NGTW and its receiving watershed over the sampling period

			T (°C)	TDS (mg/l)	pH	DO (mg/l)	COD (mg/l)	EC (µS/m)	SAL. (mg/l)	RES. (‰)
AUTUMN	MAR '12	BC	26 ± 0	436.00 ± 2.00	7.12 ± 0.21	8.16 ± 0.08	153.67±0.33	888.33 ±4.51	0.437 ±0.01	1125.67 ±5.51
		DP	26 ± 0	477.33 ± 5.51	7.18 ± 0.12	8.16 ±0.01	239.00 ± 0.00	970.33 ± 11.59	0.477 ± 0.01	1023.67 ± 1.53
		US	25.5 ± 0	207.97 ± 1.70	7.52 ± 0.09	8.59 ± 0.04	313.89 ± 0.67	431.33 ± 2.89	0.21 ± 0.00	2320.00 ± 17.32
		DS	26 ± 0	299.00 ± 1.00	7.51 ± 0.09	8.63 ± 0.03	141.33 ± 0.00	615.00 ± 1.73	0.30 ± 0.00	1626.00 ± 3.61
	APR '12	BC	20 ± 0	386.67 ± 1.53	7.04 ± 0.04	8.40 ± 0.01	202.78 ±0.50	790.33 ±3.06	0.39 ± 0.01	1265.33 ± 4.51
		DP	20 ± 0	433.67 ± 2.08	6.82 ± 0.01	8.51 ± 0.18	179.67 ±0.33	884.00 ± 4.58	0.43 ± 0.01	1131.33 ± 6.03
		US	18 ± 0	157.67 ± 0.71	7.08 ± 0.02	8.69 ± 0.00	104.22 ±0.58	328.67 ±1.53	0.16 ± 0.00	3004.33 ± 1.53
		DS	19 ± 0	305.33 ± 0.58	7.05 ± 0.04	8.69 ± 0.01	114.00 ± 0.00	627.33 ± 0.58	0.303 ± 0.01	1594.33 ± 2.08
	MAY '12	BC	19 ± 0	567.33 ± 2.52	6.91 ± 0.09	8.29 ± 0.05	312.22 ± 0.88	1148.33 ± 5.51	0.57 ± 0.00	871.00 ± 4.00
		DP	18.5 ± 0	621.33 ± 1.53	7.02 ± 0.01	8.19 ± 0.05	246.33 ± 1.15	1253.67 ± 3.06	0.62 ± 0.01	797.67 ± 2.52
		US	16 ± 0	174.67 ± 0.64	6.42 ± 0.05	8.78 ± 0.04	298.67 ± 0.33	363.67 ±1.15	0.17 ± 0.00	2733.33 ± 11.15
		DS	14 ± 0	462.00 ± 1.00	7.10 ± 0.00	8.59 ± 0.03	311.89 ± 0.09	939.67 ± 1.15	0.46 ± 0.00	1064.33 ± 1.15
WINTER	JUN '12	BC	18 ± 0	534.33 ± 1.53	7.62 ± 0.01	7.89 ± 0.02	310.00 ± 0.00	1084.33 ± 2.08	0.53 ± 0.01	925.33 ± 1.15
		DP	17.5 ± 0	577.33 ± 1.15	7.55 ± 0.01	8.10 ± 0.03	137.67 ± 0.00	1166.33 ± 2.08	0.58 ± 0.00	857.33 ± 1.53
		US	16 ± 0	184.53 ± 0.31	7.93 ± 0.01	8.22 ± 0.02	22.33 ± 0.00	383.67 ± 0.58	0.18 ± 0.00	2610.00 ± 0.00
		DS	14 ± 0	404.67 ± 0.58	7.83 ± 0.00	8.06 ± 0.04	73.33 ± 0.00	826.67 ± 1.53	0.4 ± 0.00	1209.33 ± 1.15
	JUL '12	BC	16.5 ± 0	467.00 ± 3.00	6.53 ± 0.10	7.19 ± 0.17	193.67 ± 0.33	974.67 ± 0.58	0.47 ± 0.01	1026.67 ± 0.58
		DP	17 ± 0	525.67 ± 2.31	6.89 ± 0.01	8.71 ± 0.03	308.67 ± 0.77	1069.00 ± 1.00	0.52 ± 0.01	935.33 ± 0.58
		US	13.5 ± 0	154.17 ± 0.23	6.30 ± 0.01	8.58 ± 0.06	309.67 ± 1.49	321.67 ± 0.58	0.15 ± 0.00	3110.00 ± 0.00
		DS	14.5 ± 0	344.67 ± 0.58	6.98 ± 0.02	8.46 ± 0.08	299.56 ± 0.00	706.67 ± 1.53	0.34 ± 0.00	1415.00 ± 2.65
	AUG '12	BC	17 ± 0	416.67 ± 0.58	6.71 ± 0.04	7.93 ± 0.06	139.56 ± 0.33	849.33 ± 1.53	0.417 ± 0.01	1187.00 ± 16.64
		DP	16.5 ± 0	471.00 ± 1.00	7.25 ± 0.11	8.07 ± 0.07	309.00 ± 0.24	958.00 ± 2.00	0.47 ± 0.00	1044.00 ± 2.00
		US	14.5 ± 0	344.67 ± 3.51	7.40 ± 0.02	7.56 ± 0.08	207.56 ± 0.58	706.67 ± 7.51	0.34 ± 0.00	1419 ± 11.36
		DS	12 ± 0	369.67 ± 1.15	7.65 ± 0.04	8.44 ± 0.05	311.78 ±0.24	757.33 ± 2.31	0.37 ± 0.00	1320.67 ± 4.04
SPRING	SEP '12	BC	22 ± 0	327.33 ± 0.58	6.75 ± 0.08	8.28 ± 0.01	98.22 ± 0.33	672.00 ± 1.00	0.33 ± 0.00	1488.33 ± 2.08
		DP	20 ± 0	380.67 ± 0.58	6.37 ± 0.03	8.21 ± 0.03	310.44 ± 0.00	778.67 ± 0.58	0.38 ± 0.00	1284.00 ± 1.00
		US	20 ± 0	256.00 ± 0.00	6.48 ± 0.02	7.76 ± 0.04	310.33 ± 0.00	528.67 ± 1.15	0.25 ± 0.00	1890.67 ± 4.04
		DS	20 ± 0	261.67 ± 1.53	6.59 ± 0.00	7.39 ± 0.03	189.89 ± 0.33	542.00 ± 6.56	0.26 ± 0.00	1841.67 ± 6.81
	OCT '12	BC	20 ± 0	358.67 ± 0.58	6.91 ± 0.09	8.11 ± 0.02	35.67 ± 0.33	733.67 ± 0.58	0.36 ± 0.00	1363.00 ± 1.73
		DP	20 ± 0	340.33 ± 0.58	6.85 ± 0.14	8.35 ± 0.03	54.11 ± 0.33	697.67 ± 0.58	0.34 ± 0.00	1433.33 ± 1.155
		US	17 ± 0	221.33 ± 0.58	6.97 ± 0.02	8.44 ± 0.02	311.89 ± 0.33	458.33 ± 1.53	0.22 ± 0.00	2180.67 ± 7.57
		DS	19 ± 0	264.67 ± 0.58	6.98 ± 0.03	8.50 ± 0.02	239.22 ± 0.88	545.67 ± 0.58	0.26 ± 0.00	1831.67 ± 2.08
	NOV '12	BC	20 ± 0	431.67 ± 4.51	6.82 ± 0.03	7.60 ± 0.06	69.11 ± 0.24	892.33 ± 6.66	0.43 ± 0.01	1116.33 ± 1.53
		DP	20 ± 0	534.67 ± 5.13	7.14 ± 0.04	7.64 ± 0.03	108.56 ± 0.33	1087.67 ± 3.06	0.54 ± 0.00	914.67 ± 2.31
		US	17 ± 0	228.00 ± 0.00	7.12 ± 0.01	7.84 ± 0.01	306.78 ± 0.58	472.00 ± 0.00	0.23 ± 0.00	2120.33 ± 0.58
		DS	18 ± 0	349.00 ± 1.00	7.16 ± 0.01	7.60 ± 0.02	257.56 ± 0.24	715.00 ± 1.00	0.35 ± 0.00	1397.33 ± 1.15
SUMMER	DEC '12	BC	25 ± 0	267.67 ± 0.58	6.39 ± 0.01	7.07 ± 0.07	93.33 ± 0.33	552.67 ± 1.53	0.27 ± 0.00	1760.33 ± 3.79
		DP	21 ± 0	275.33 ± 0.58	6.45 ± 0.01	7.44 ± 0.07	300.44 ± 0.33	568.00 ± 1.00	0.27 ± 0.00	1806.00 ± 2.65
		US	22 ± 0	232.00 ± 0.00	6.47 ± 0.02	7.88 ± 0.01	24.33 ± 0.00	480.33 ± 0.58	0.23 ± 0.00	2082.00 ± 2.00
		DS	22 ± 0	241.00 ± 0.00	6.51 ± 0.04	7.70 ± 0.02	35.33 ± 0.33	497.00 ± 0.00	0.24 ± 0.00	2010.33 ± 0.58
	JAN '13	BC	23 ± 0	417.67 ± 1.53	6.59 ± 0.02	7.25 ± 0.04	111.11 ± 0.50	848.00 ± 1.00	0.42 ± 0.00	1176.67 ± 1.15
		DP	23 ± 0	416.33 ± 0.58	6.61 ± 0.02	7.70 ± 0.04	240.78 ± 0.33	849.33 ± 0.58	0.42 ± 0.00	1177.33 ± 0.58
		US	22 ± 0	197.63 ± 0.23	6.71 ± 0.01	7.70 ± 0.03	80.33 ± 0.33	410.33 ± 0.58	0.20 ± 0.00	2440.00 ± 0.00
		DS	22 ± 0	253.00 ± 0.00	6.73 ± 0.00	8.03 ± 0.02	44.56 ± 0.33	522.00 ± 0.00	0.25 ± 0.00	1915.00 ± 1.73
	FEB '13	BC	24 ± 0	417.67 ± 1.53	6.59 ± 0.02	7.54 ± 0.05	158.89 ± 0.33	925.33 ± 1.53	0.45 ± 0.01	1080.67 ± 1.53
		DP	24 ± 0	416.33 ± 0.58	6.61 ± 0.02	7.75 ± 0.01	283.44 ± 6.33	931.00 ± 1.73	0.46 ± 0.00	1188.33 ± 2.08
		US	21 ± 0	197.63 ± 0.23	6.71 ± 0.01	7.19 ± 0.08	305.33 ± 0.00	319.33 ± 0.58	0.15 ± 0.00	3093.33 ± 5.77
		DS	23 ± 0	253.00 ± 0.00	6.73 ± 0.00	7.94 ± 0.03	272.89 ± 0.33	641.33 ± 1.15	0.31 ± 0.00	1488.33 ± 2.89
		G	**25**	**-**	**5.5 – 7.5**	**75% SAT**	**30**	**250**	**-**	**-**

Results represent Averages ± Standard Deviation. G: Guideline for treated effluent (Government Gazette, 1984); (-) no guideline; T: Temperature; TDS: Total Dissolved Solids; DO: Dissolved Oxygen; COD: Chemical Oxygen Demand; EC: Electrical Conductivity; SAL.: Salinity; RES.: Resistivity

Turbidity of the final effluent before chlorination and at the discharge point ranged between 7.91 – 56.53 NTU and 8.92 – 76.43 NTU for the NWWTP (Figure 2.5) and 1.52 – 28.7 NTU and 1.42 – 30.3 NTU for the NGTW (Figure 2.6) respectively. Turbidity values obtained upstream and downstream of the receiving rivers ranged between 3.18 – 28.73 NTU and 5.94 – 29.03 NTU for the Umgeni river (Figure 2.5) and 2.44 – 40.4 NTU and 5.10 – 28.1 NTU for the Aller river (Figure 2.6) respectively. Highest turbidity readings obtained during the sampling period were recorded at the discharge point during April (76.43 NTU) and upstream during August (40.4 NTU), for the NWWTP and NGTW respectively. Eight out of 12 months exhibited increases in turbidity at the discharge point for the NWWTP with March (195.83%) exhibiting the highest increase relative to before chlorination. A similar trend was observed for six out of 12 months for the NGTW with December (561.35%) exhibiting the greatest increase. Total suspended solids (mg/l) determined during the study period at the final effluent and discharge point ranged respectively between 0.014 – 0.096 and 0.01 – 0.066 for the NWWTP (Figure 2.5) and 0.004 – 0.06 and 0.004 – 0.07 for the NGTW (Figure 2.6). Seasonal averages of TSS at the discharge point show a 20% and 33.33% reduction during autumn and spring for the NWWTP whilst a 33.33% increase was observed during autumn for the NGTW relative to values for samples collected before chlorination.

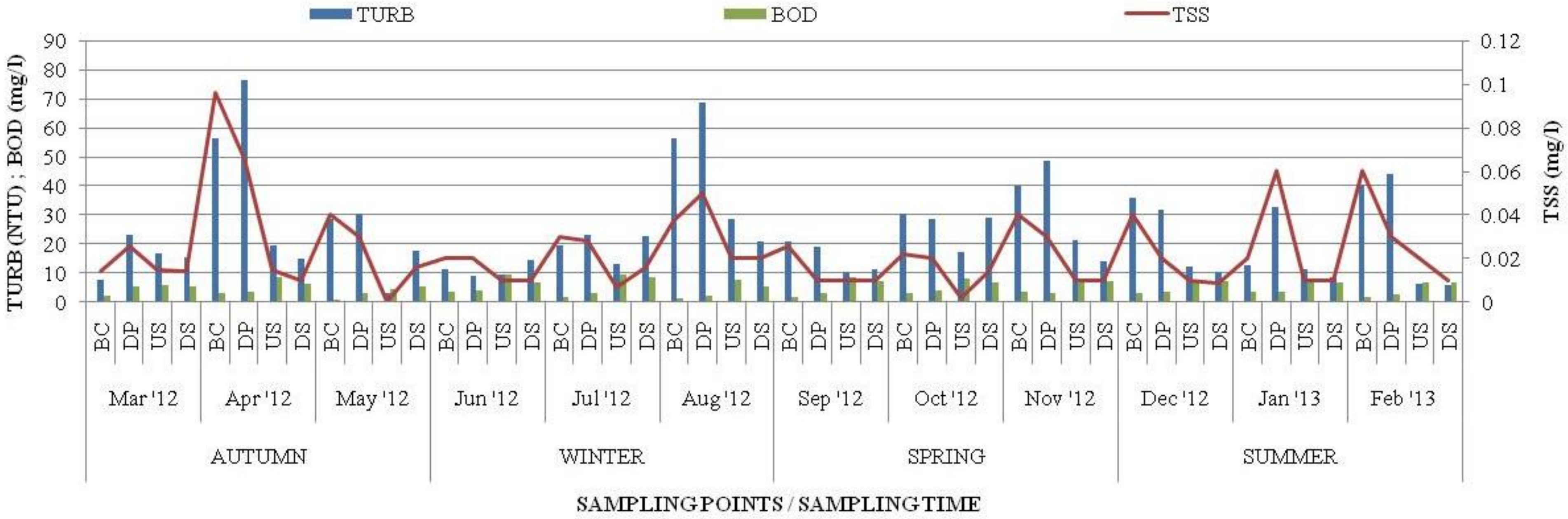


Figure 2.5: Monthly variations of turbidity, BOD and TSS of the NWWTP treated effluent and the receiving Umgeni River over the sampling period. Bars indicate the average of replicate samples (n = 3) whilst error bars show standard deviation. Turb: Turbidity; BOD: Biological Oxygen Demand; TSS: Total Suspended Solids; BC: Before Chlorination; DP: Discharge Point; US: Upstream; DS: Downstream.

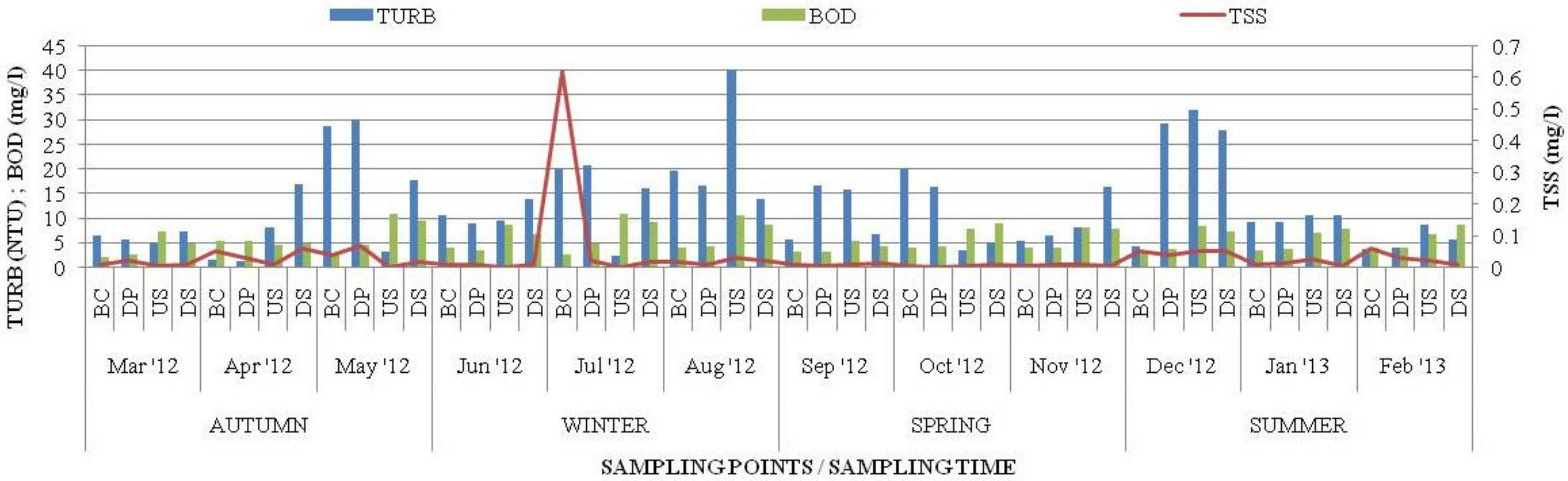


Figure 2.6: Monthly Variations of Turbidity, BOD and TSS of the NGTW treated effluent and the receiving Aller River over the sampling period. Bars indicate the average of replicate samples (n = 3) whilst error bars show standard deviation. Turb: Turbidity; BOD: Biological Oxygen Demand; TSS: Total Suspended Solids; BC: Before Chlorination; DP: Discharge Point; US: Upstream; DS: Downstream.

Variable nutrient levels were noted over the 12 month period at each sampling point with the nitrate levels for the final effluent and discharge point ranging between < 0.017 – 5.98 mg/l and < 0.017 – 3.92 mg/l for the NWWTP (Figure 2.7) and < 0.017 – 8.22 mg/l and < 0.017 – 2.35 mg/l for the NGTW (Figure 2.8). Increases in nitrate and phosphate levels at the discharge point were noted over several months for the NWWTP with the highest being noted during December (215.23%) for nitrate and September (12.21%) for phosphate (Figure 2.7). The receiving rivers exhibited varying nutrient levels over the study period with the upstream values for nitrate, phosphate and sulphate ranging from < 0.057 – 2.4 mg/l; < 0.025 – 2.173 mg/l and 0.092 – 0.816 mg/l for the NWWTP respectively. Similar results were noted for the NGTW with a 38.03% and 53.44% increase in nitrate and phosphate being observed at the discharge point relative to before chlorination during August whilst a reduction in nitrate was noted during June (47.07%) and September (97.18%). Nitrate, phosphate and sulphate levels within the receiving river ranged between < 0.017 – 2.65 mg/l; < 0.025 – 0.655 mg/l and 1.58 – 42.59 mg/l for the NGTW (Figure 2.8) respectively. Generally higher nutrient levels were noted downstream with the exception of June whereby higher levels of all nutrients were noted upstream for both the Umgeni and Aller river respectively. Significant positive correlations ($p \leq 0.05$) were observed upstream and downstream of the Umgeni river between temperature and BOD (r = 0.624) as well as turbidity (r = 0.537) and DO (r = 0.516) respectively (Table 2.4). Significant negative correlations were also observed between temperature and various other physicochemical parameters for the NGTW (Table 2.5) before chlorination (COD: r = -0.334), at the discharge point (DO: r = -0413; BOD: r = -0.362) and downstream of the Aller river (BOD: r = -0.345). Positive correlations ($p \leq 0.05$) were also observed between turbidity and temperature (r = 0.537) as well as TDS (r = 0.437) and TSS (r = 0.554) downstream of the Umgeni river and at the discharge point of the NWWTP respectively (Table 2.4). Positive correlations were also observed between turbidity and TSS (r = 0.691) as well as for TDS for final effluent within the NGTW and upstream of the Aller river (Table 2.5).

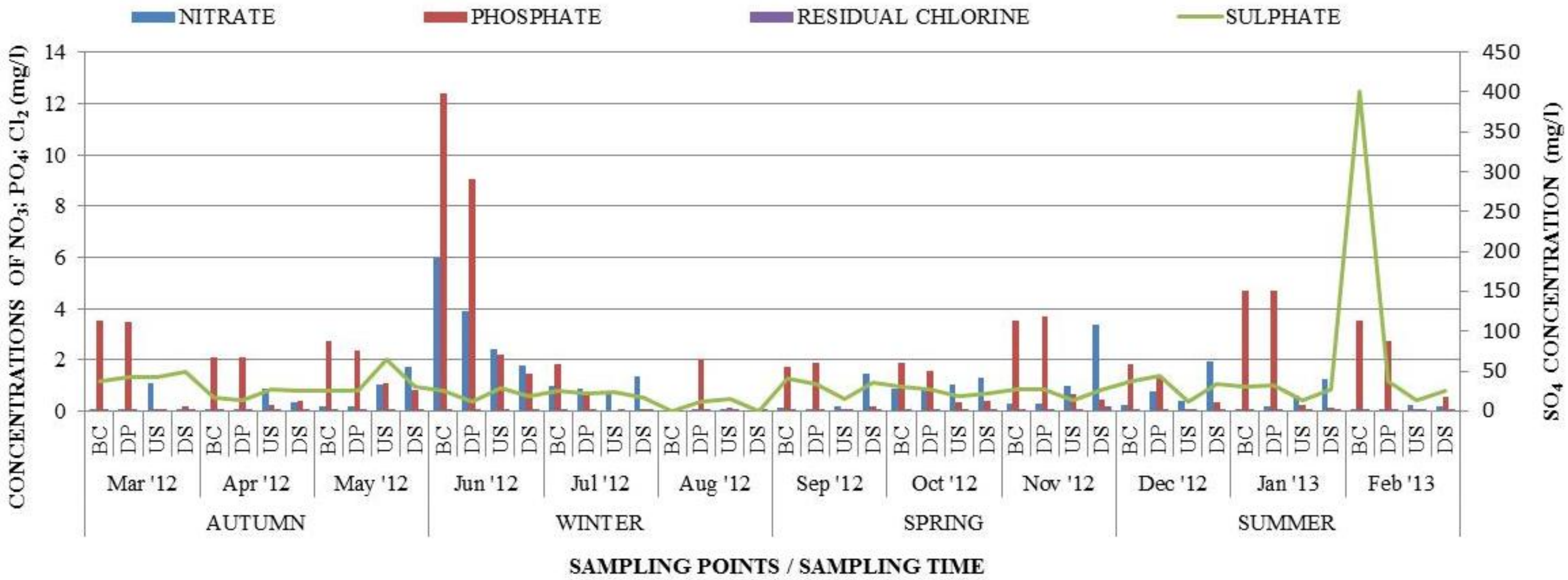


Figure 2.7: Monthly variations of Nitrate, Phosphate, Residual Chlorine and Sulphate concentrations of the effluent samples collected from the NWWTP and Umgeni River over the sampling period. Bars indicate the averge of replicate samples (n = 3) whilst error bars show the standard deviation. NO_3: Nitrate; PO_4: Phosphate; Cl_2: Residual Chlorine; SO_4: Sulphate; BC: Before Chlorination; DP: Discharge Point; US: Upstream; DS: Downstream.

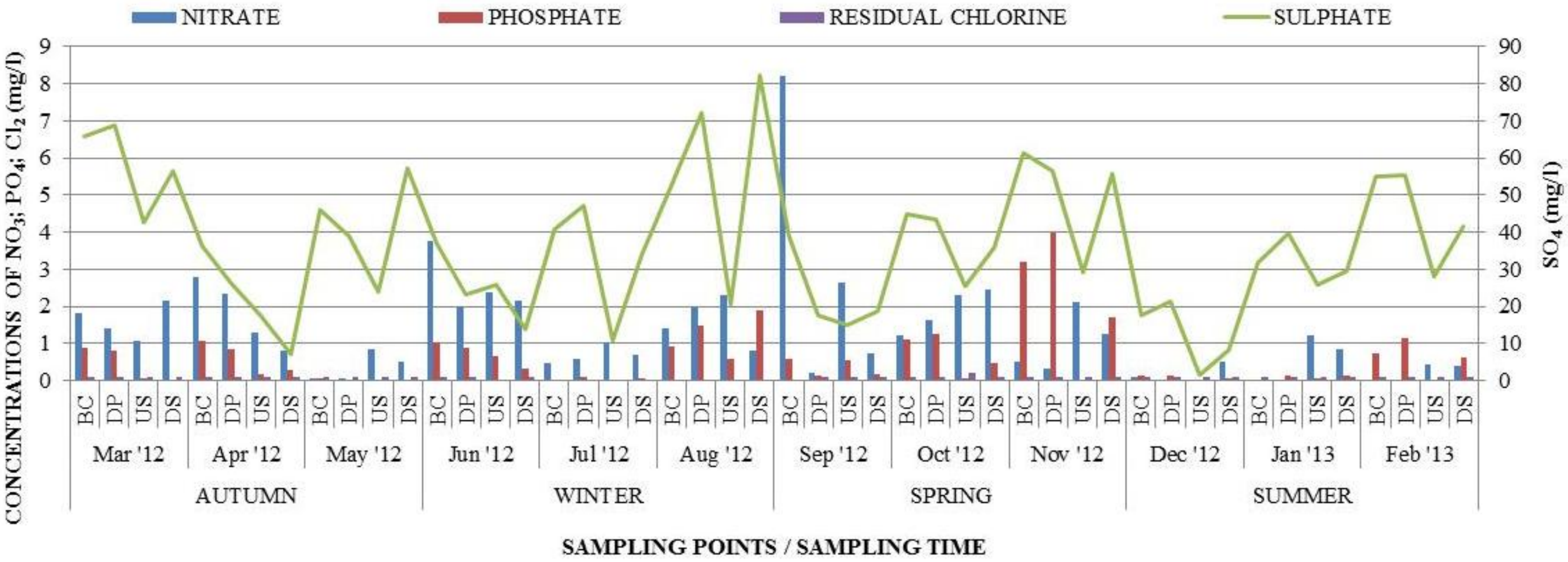


Figure 2.8: Monthly variations of Nitrate, Phosphate, Residual Chlorine and Sulphate concentrations of the effluent samples collected from the NGTW and Aller River over the sampling period. Bars indicate the average of replicate samples (n = 3) whilst error bars show the standard deviation. NO_3: Nitrate; PO_4: Phosphate; Cl_2: Residual Chlorine; SO_4: Sulphate; BC: Before Chlorination; DP: Discharge Point; US: Upstream; DS: Downstream.

Table 2.4: Correlation matrix between the physicochemical parameters obtained for the NWWTP effluent and receiving Umgeni River

	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	EC	RES
BEFORE CHLORINATION											
T	1										
TURB	.035	1									
TDS	-.664**	.160	1								
TSS	-.024	.691**	.124	1							
pH	.092	.121	-.208	.456**	1						
DO	.080	-.340*	-.420*	-.131	-.090	1					
BOD	.048	.099	.014	.183	-.161	.491**	1				
COD	.249	.424**	-.077	.149	.089	-.172	-.136	1			
Sal	-.658**	.149	.998**	.123	-.195	-.432**	.025	-.092	1		
EC	-.674**	.166	.996**	.120	-.226	-.403*	.018	-.063	.994**	1	
RES	.128	.021	-.426**	.006	-.092	.268	.209	.009	-.428**	-.399*	1

	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
DISCHARGE POINT											
T	1										
TURB	-.316	1									
TDS	-.482**	.437**	1								
TSS	-.130	.554**	.082	1							
pH	-.140	-.072	-.036	.107	1						
DO	-.018	-.577**	-.159	-.159	.099	1					
BOD	-.076	-.149	-.176	-.091	.409*	-.104	1				
COD	.130	.505**	-.044	.383*	-.024	-.528**	-.267	1			
EC	-.437**	.366*	.986**	.051	-.008	-.071	-.162	-.101	1		
Sal	-.451**	.332*	.983**	.032	.032	-.052	-.136	-.134	.996**	1	
RES	.231	-.130	-.124	-.161	-.281	.076	-.107	-.036	-.097	-.134	1

	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
UPSTREAM											
T	1										
TURB	.080	1									
TDS	.480**	.248	1								
TSS	-.322	.327	.082	1							
pH	.096	-.120	.331*	.120	1						
DO	.322	.023	.675**	-.023	.398*	1					
BOD	.624**	-.114	.058	-.250	-.001	.107	1				
COD	-.189	-.118	-.454**	-.045	.394*	-.237	.002	1			
EC	.480**	.249	1.000**	.082	.332*	.676**	.058	-.454**	1		
SAL	.455**	.143	.980**	.054	.291	.598**	.067	-.441**	.980**	1	
RES	-.492**	-.368*	-.962**	-.091	-.298	-.697**	-.031	.463**	-.963**	-.897**	1

	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
DOWNSTREAM											
T	1										
TURB	.537**	1									
TDS	-.084	-.104	1								
TSS	-.221	.037	-.018	1							
pH	.061	.059	-.791**	.006	1						
DO	.516**	.356*	-.627**	.275	.566**	1	.141				
BOD	.256	-.035	-.234	-.509**	.096	.141	1				
COD	-.196	-.031	-.388*	.129	.198	.079	.036	1			
EC	-.083	-.102	1.000**	-.017	-.791**	-.627**	-.233	-.393*	1		
SAL	-.075	-.109	.996**	-.017	-.790**	-.599**	-.219	-.424**	.997**	1	
RES	.196	-.074	-.323	-.081	.130	.282	.253	.194	-.325	-.333*	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

T: Temperature; TURB: Turbidity; TSS: Total Suspended Solids; DO: Dissolved Oxygen; BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; EC: Electrical Conductivity; SAL: Salinity; RES: Resistivity; HPC: Heterotrophic Plate Count; TC: Total Coliforms

Table 2.5: Correlation matrix between the physicochemical parameters obtained for the NGTW effluent and receiving Aller River

	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
BEFORE CHLORINATION											
T	1										
TURB	-.582**	1									
TDS	-.307	.474**	1								
TSS	-.004	-.163	.019	1							
pH	.181	-.231	.440**	.020	1						
DO	.042	.097	.142	-.103	.279	1					
BOD	-.254	.119	.089	.096	.107	.365*	1				
COD	-.334*	.300	.786**	-.076	.413*	.213	.027	1			
EC	-.326	.477**	.999**	.023	.423*	.124	.088	.778**	1		
SAL	-.305	.479**	.999**	.014	.434**	.144	.089	.783**	.998**	1	
RES	.304	-.447**	-.992**	-.034	-.428**	-.124	-.079	-.733**	-.995**	-.990**	1
	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
DISCHARGE POINT											
T	1										
TURB	-.399*	1									
TDS	-.372*	-.075	1								
TSS	.033	.020	-.011	1							
pH	.068	-.434**	.561**	.016	1						
DO	-.413*	-.011	.244	-.153	-.066	1					
BOD	-.362*	.309	.063	-.199	-.135	.171	1				
COD	.051	.341*	-.092	.046	-.192	-.036	.020	1			
EC	-.373*	-.078	1.000**	-.011	.560**	.245	.062	-.092	1		
SAL	-.365*	-.088	.999**	-.014	.565**	.234	.060	-.104	1.000**	1	
RES	.384*	.149	-.984**	.024	-.494**	-.317	-.039	.122	-.985**	-.984**	1
	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
UPSTREAM											
T	1										
TURB	.123	1									
TDS	-.034	.681**	1								
TSS	.162	-.183	-.157	1							
pH	.214	.076	-.052	-.053	1						
DO	-.150	-.655**	-.403*	.011	-.151	1					
BOD	-.230	-.362*	-.248	.035	-.093	.379*	1				
COD	-.011	-.499**	.000	-.071	-.158	.047	.041	1			
EC	-.033	.681**	1.000**	-.157	-.052	-.403*	-.247	.000	1		
SAL	-.062	.699**	.992**	-.161	-.036	-.423*	-.255	.003	.992**	1	
RES	-.034	-.660**	-.992**	.135	.048	.372*	.252	.016	-.992**	-.972**	1
	T	TURB	TDS	TSS	pH	DO	BOD	COD	EC	SAL	RES
DOWNSTREAM											
T	1										
TURB	-.391*	1									
TDS	-.707**	.179	1								
TSS	.001	.032	-.007	1							
pH	.017	-.379*	.461**	-.044	1						
DO	-.240	-.044	.362*	-.007	.220	1					
BOD	-.345*	.070	.204	-.096	.028	.103	1				
COD	-.420*	-.238	.501**	-.023	.236	.220	.261	1			
EC	-.708**	.176	1.000**	-.006	.462**	.359*	.204	.503**	1		
SAL	-.699**	.184	.999**	-.008	.460**	.358*	.195	.503**	.999**	1	
RES	.651**	-.077	-.975**	.007	-.589**	-.369*	-.217	-.567**	-.976**	-.975**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

T: Temperature; TURB: Turbidity; TSS: Total Suspended Solids; DO: Dissolved Oxygen; BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; EC: Electrical Conductivity; SAL: Salinity; RES: Resistivity; HPC: Heterotrophic Plate Count; TC: Total Coliforms

2.5 Discussion

In most developing countries, sewage treatment is often rudimentary, non-functional or absent. In South Africa, wastewater treatment plants are operational in almost all urban areas, however in many rural areas, sewage treatment is often non-existent (Samie *et al.*, 2009). Inefficient treatment has often led to the contamination of surrounding waterways with excessive nutrients and pathogenic microorganisms, resulting in severe outbreaks such as those previously reported within the provinces of both KwaZulu-Natal and Mpumalanga (Pillay *et al.*, 1997). Depending on the sewage origin and characteristics, as well as the socioeconomic status of the surrounding communities, different treatment plants will have different treatment technologies, with a lagooning system being stipulated as the minimum treatment requirements for those regions that cannot afford to integrate proper sewage treatment plants (Samie *et al.*, 2009; WHO, 1989).

In the present study, physico-chemical profiles of two independent WWTPs were monitored as well as their effect on the receiving watershed. Complex dynamic physico-chemical profiles within the waterway is related to a range of characteristics such as riverine flow, upwelling, atmospheric deposition, sewage discharges and various surrounding anthropogenic activities, with an increase in pollutants occurring during low flow when point sources dominate (Coetzee, 2003). The varying results obtained upstream and downstream of the receiving watersheds could be attributed to varying spatial heterogeneity leading to point specific local environmental conditions with respect to light, temperature, water discharge and changes in flow velocity, all of which change with time and channel form along the waterway (Pradhan *et al.*, 2009). Whilst tertiary treatment processes exhibited a limited impact on certain parameters such as temperature and pH, considerable variations were seen with other parameters such as turbidity, DO and BOD before chlorination and discharge point. The South African quality standard for wastewater effluent draining into any catchment or river states that the temperature of treated effluent shall not exceed a maximum of 25 °C. In particular, treated effluent at the discharge point exhibited temperature ranges of 12 – 25 °C for the NWWTP and 16.5 – 26 °C for the NGTW. Kantachote *et al.* (2009) reported that prolonged exposure of wastewater to sunlight results in a considerable effect on temperature and rate of photosynthesis, consequently affecting related parameters such as DO and pH levels. Within the independent receiving watersheds, temperature profiles upstream ranged between 12.7 – 26 °C and 13.5 - 25.5 °C whilst it ranged between 13.5 - 25.5 °C and 12 - 25.7 °C downstream of the Umgeni and Aller River, respectively. Temperature within catchments is often regarded as being an important water quality parameter, often influenced by a range of factors such as latitude, cloud cover, precipitation, time as well as local topography (Jaji *et al.*, 2007). In addition, water temperature, together with ionic charges influence a variety of chemical and biological reactions of organisms in the surrounding ecosystems, with increasing temperatures resulting in an increased rate of chemical, biological and metabolic reactions. Both macro- and microorganisms exhibit preference for temperature ranges that are optimal to their survival and which may fluctuate with season, life cycle and changes in surrounding environmental factors. Thus, changes in water temperature may lead to regulation of dissolved oxygen concentrations, changes in chemical equilibria as well as rates of photosynthesis, respiration and nutrient cycling within waterways and surrounding ecosystems leading to gross fish kills and ecosystem imbalances (Coetzee, 2003). Seasonal and point source fluctuations in river temperature may also occur due to changing air temperature, atmospheric changes, river origin, direction and velocity of flow, existing vegetation and available coverage as well as surrounding anthropogenic and land-use activities. In addition, climatic changes will ultimately result in the alteration of all aspects of the hydrological cycle, leading to changes in temperature, rainfall and evaporation. This will in turn cause additional distress on the regulation of daily and seasonal water quality and quantity within catchments nearby (DWAF, 1995a). Various reductions in temperature across the sampling period could be due to decreasing seasonal air temperature, excessive rainfall as well as the accumulation of run-off from surrounding informal settlements.

Natural processes like tidal flow and rainfall were noted over the sampling period with greater tidal impacts on measured parameters such as salinity and conductivity being experienced for the Umgeni River sampling points due to the river mouth being located nearby with higher salinity levels being recorded at high tide due to incoming sea water. Natural processes like excessive rainfall and tidal flow have also been known to affect the water quality and productivity of the current ecosystems along these waterways (Coetzee, 2003). The Umgeni River, being a large catchment divides into many branches, one of which is the Aller River, a smaller tributary located more inland and not subjected to tidal influences. However, various anthropogenic activities were noted along this tributary indicating contamination from various sources. Zhao *et al.* (2009) reported on the effects of surrounding vegetation with respect to watershed characteristics and water balance. Changes in surrounding riparian vegetation such as afforestation and deforestation all affect the response of runoff within a catchment. Previous studies however, have noted that larger catchments greater than 100 km^2 in size experience a variety of effects regarding surrounding vegetation due to heterogeneous geology and topography as well as varying anthropological activities along the watercourse (Wilk *et al.*, 2001). Rutherford *et al.* (1997) also highlighted the importance of surrounding riparian vegetation on stream temperature with greater vegetation resulting in greater absorbance of incoming shortwave radiation as well as affecting surrounding microclimatic conditions with regards to air temperature, humidity, wind speed, evaporation and ground and water temperature. Excessive vegetation coverage was noted downstream of the Aller River and may have contributed to increased shading thus reducing the maximum temperature of the watershed, hence lower temperatures were recorded downstream compared to upstream.

Manasrah *et al*. (2006) reported positive correlations between DO and temperature values measured in the upper water column of the Northern Gulf of Aqaba and attributed this to a higher photosynthetic rate since reaction rates are known to increase due to greater light penetration in shallow waters, ultimately resulting in increased oxygen concentrations. In addition, positive correlations between temperature, turbidity and DO could be attributed to increased particulate matter and greater scattering of light, resulting in increased adsorption of heat and ultimately increased photosynthetic rates as previously observed (Paaijmans *et al*., 2008). Negative correlations between temperature and turbidity (r = - 0.399), TDS (r = - 0.372) and BOD (r = - 0.362) at the NGTW discharge point observed in this study could however, be attributed to increased flow and velocity of wastewater discharge as well as the industrial nature of the effluent being discharged. El-Rehaili (1995) examined the behaviour of BOD, COD and TOC concentrations of secondary effluents treated with various chlorine concentrations and reported that the use of high chlorine concentrations generally results in alteration of the theoretical BOD and COD trends. In addition, their study also showed chlorine dosages above 10 mg/l which resulted in increased BOD and COD levels, with chlorine dosages above 30 mg/l almost doubling the resultant BOD and COD values. This has been attributed to alteration of the high organic matter present, making it more amenable to oxidation. In this study, extremely low chlorine concentrations (less 0.1 mg/l) were recorded thus indicating no serious alteration on BOD and COD concentrations.

Considerable negative correlations observed between temperature and DO, downstream of the Aller river could be attributed to coverage from overlying existing vegetation along the riverbed. In addition, the influx of surrounding organic and inorganic materials as well as periodic rainfall could serve as an additional source of DO. Abowei (2010) reported no significant correlation between water temperature and DO concentrations and attributed this to time of sampling as well as increasing photosynthetic reactions as the day progressed. The result also showed that measured DO values increased with subsequent progression downstream. Thus, considerable correlation variations in results obtained in this study could be characteristic of external factors such as date and time of sampling, nature of influent received, daily plant operational status and malfunctioning as well as the nature of treated effluent being discharged. Awobei (2010) reported higher DO values downstream, with similar results being obtained in this study downstream of the Aller river, with higher DO values being reported during March (8.63 mg/l), August (8.44 mg/l), October (8.50 mg/l), January (8.03mg/l) and February (7.94 mg/l). Pradhan *et al.* (2009) attributed low DO levels to mixing from surrounding polluted, low salinity water sources as well as improperly treated effluent whilst Sundaray *et al.* (2005) reported decreased DO levels due to large amounts of discharged acidic industrial effluents from nearby fertilizer industries. This could explain the influence of treated effluent high in industrial wastes on DO levels of receiving surface waters. Dissolved oxygen levels measured upstream and downstream of the Umgeni river varied with sampling time, daily temperature and rainfall as well as tidal flow. Higher DO values were observed upstream during March (8.22 mg/l), April (8.5 mg/l) and September (8.12 mg/l) when sampling had occurred during peak inflow indicating tidal influence. Higher DO values were also measured upstream during the spring months of October (7.7 mg/l) and November (7.63 mg/l) where higher levels of rainfall (17.6 and 0.6 mm) were also recorded (SAWS, 2013). In addition, lower DO levels were recorded within the receiving watershed during summer months when warmer temperatures and increased rainfall was experienced. Similar results were also reported by Venkatesharaju *et al.* (2010) who attributed minimum DO levels during summer to increased bacterial decomposition of organic matter present. In addition, increased rainfall may have resulted in increased run-off high in nutrients and organic matter from surrounding areas thereby further decreasing DO levels (Yisa and Jimoh, 2010).

pH is an important water quality parameter as it determines the suitability of the water for various purposes with lower pH waters being regarded as being more corrosive. Despite having no direct effect on human health, biochemical reactions are considered sensitive to changes in pH, thus a pH of 7 is generally considered ideal (Gupta *et al.*, 2009). In the present study, pH values obtained varied within a narrow range and fell within permissible guidelines. Neutral to slightly alkaline pH values were obtained upstream and downstream of the receiving rivers. These variations in pH could be due to the exposure of the receiving watershed to changing atmospheric conditions, biological activities and changes in temperature (Kumar and Bahadur, 2009). Changes in pH values are important to many aquatic organisms whereby the water sources become unsuitable at extremely low or high pH values such as 4.5 and 9.5. Very acidic waters may result in the release of heavy metals which can ultimately accumulate on the gills of fish reducing chances of survival. Boyd (1979) reported that adequate pH to support aquatic life should fall between a range of 6.5 – 7.5. The South African Water Quality Guidelines for Domestic Use stipulates a target water quality range (TWQR) of between 6.0 – 9.0 whilst the TWQR for Recreational Use stipulates a range of 6.5 – 8.5, whereby no harmful effects on human health will occur (DWAF, 1996a). The pH values obtained in the current study fell outside of the acceptable range for recreational use during May (6.42) and September (6.41) for the Umgeni River and during May (6.42), July (6.3), September (6.48) and December (6.47) for the Aller River thus disqualify these water sources for direct recreational activity. In addition, the WHO has set a standard of 7.0 – 8.5, whilst the EU has stipulated protection limits ranging between 6.0 – 9.0 for fisheries and aquatic life.

Clarity serves as a natural determinant of river health with increased turbidity being associated with suspended and colloidal matter such as clay, silt, organic and inorganic matter and microscopic microorganisms (Venkatesharaju *et al.*, 2010). Increased turbidity obtained at the discharge point of the NWWTP may be attributed to poor quality pipes through which the final treated effluent travels prior to discharge into the receiving Umgeni River. Poor sewage plant infrastructure in conjunction with other factors has been identified as a major source contributing to poor community health. In most instances, sewage pipes are outdated with resultant sediment deposits, biofilm build-up and pit formation occurring over extended periods of time. In addition, Valentukeviciene *et al.* (2011) reported that decreased flow may result in the stagnation of effluents and deposition of particulate matter over time. When flows increase again, settled particulate matter is flushed out, resulting in increased turbidity. Currently there is no standard for turbidity for effluent discharge in South Africa (Government Gazette, 1984). However, none of the receiving water bodies met the South African guideline of 0 – 1 NTU for turbidity of water used for domestic purposes thus disqualifying the receiving watershed for direct domestic use (DWAF, 1996a). Similar to this study, Samie *et al.* (2009) and Igbinosa and Okoh (2009) reported final effluent turbidity values as high as 159.06 NTU. Extremely high turbidity profiles noted at the discharge point for the NWWTP can be attributed to large amounts of black particulate matter being discharged by the plant itself, into the receiving watershed. Increases in turbidity indicate an increase in suspended particles within the watershed, resulting in an increase in the amount of heat adsorbed from sunlight. This ultimately results in increases in temperature which may result in proliferation of microbial growth and further deterioration of water quality. In addition, photosynthesis decreases due to less light penetration and may result in further reductions in oxygen content ultimately affecting the proliferation and survival of aquatic life (DWAF, 1998). In addition, excessive turbidity of the final effluent prior to tertiary treatment may affect plant purification processes such as flocculation and filtration which may result in increased treatment costs whilst trihalomethane precursor formation may increase when highly turbid waters are chlorinated. In addition, increased turbidity may result in the adsorption of heavy metals and other pollutants altering the overall quality of the water (DWAF, 1995b). Le

Roux *et al.* (2007) characterised the South African landscape as being highly susceptible to water erosion with sources of suspended sediment from surrounding agricultural land and mining industrial practises contributing to sediment loading within South African rivers. Furthermore, high levels of turbidity can serve as a means of protection to microorganisms within the water column from disinfection as well as stimulate the rate of growth of these microorganisms, thus increasing microbiological contamination (DWAF, 1996b). Barnes *et al.* (1981) reported that turbidity values should never exceed 100 NTU in order to maintain native fish populations as the presence of a high degree of suspended solids may clog fish gills, reduce growth rates, decrease resistance to disease as well as hamper egg and larval development. In addition, suspended sediment may settle at the bottom of the river bed, smothering fish eggs and aquatic insects as well as disrupting various microhabitats. Excessively high turbidity values obtained in this study indicate that whilst it may promote microbial growth, existing aquatic life may be negatively affected as well.

The COD profiles at the discharge point ranged between less than 10 – 311.11 mg/l and 54.11 - 310.44 mg/l for both plants with only measured values during March for the NWWTP (less than 10 mg/l) falling within the permissible 30 mg/l limit of the South African guideline for COD in effluents to be discharged into a receiving water body. COD and BOD levels serve as an indication of both the organic and inorganic pollution within the water source, thus serving as a useful indicator of potentially toxic conditions as well as the presence of biologically organic and inorganic resistant substances (Sawyer *et al.*, 2003). Extremely high levels of COD were observed upstream (311.89 mg/l; 306.78 mg/l) and downstream (239.22 mg/l; 257.56 mg/l) during October and November. The increased COD concentrations measured upstream could be due to increased run-off from the surrounding nearby informal settlements. In addition, the spring season was characterised by extremely high rainfall of 200.13 mm, which could increase run-off into the water body leading to overall contamination of both upstream and downstream of the Aller river. In addition, high levels of domestic activities carried out by the inhabitants of a nearby informal settlement along the upstream riverbanks may have further contributed to the organic loading of the water source. Leachate from domestic wastes dispersed along the river bank, pit latrine toilets and dumpsites may have also contributed to excessive organic loading. Nine of twelve months samples were characterised by an increase in COD values at the discharge point for the NGTW compared to measured values before chlorination indicating the discharge of effluent highly polluted with oxidizable organic and inorganic pollutants which may further contribute to the organic loading of the Aller River (Otukune and Biukwu, 2005). Strong positive correlations between EC, TDS and salinity were observed across all sampling points for both plants. EC serves as an indicator of the quantity of dissolved solids within the water source and varies with the salt and electrolyte concentration. Venkatesharaju *et al.* (2010) reported that increasing levels of conductivity and cations are the products of decomposition and mineralization of organic matter. Conductivity itself does not serve as a major human or aquatic health concern, however in terms of aesthetics; a large dissolved solid content may result in unpalatable, acrid tasting water sources, thus disqualifying them for drinking purposes (Kumar and Bahadur, 2009).

Nitrate and phosphate concentrations in the water serves as a means to monitor the biological activity of the water source with increasing concentrations leading to eutrophication (Venkatesharaju *et al.*, 2010). Temporal variations and seasonal patterns have been reported to occur within rivers, having both a direct and indirect effect on nutrient fluxes (Adeyemo *et al.*, 2008). Seasonal averages indicate the highest nitrate values upstream (2.36 mg/l) and downstream (0.557 mg/l) of the Aller River during spring which experienced the highest rainfall (200.13 mm) as well. The lowest nitrate values were measured during the warmer seasons of summer (0.557 mg/l) and autumn (1.07 mg/l). Similar results were reported by Venkatesharaju *et al.* (2010) who attributed their finding to excess run-off during the rainy season and increased utilization of nutrients by algae and surrounding aquatic plants during the warm season. The South African Guideline for treated effluent (Government Gazette, 1984) states that no discharge of effluent should occur if a nitrate and phosphate concentration of 1.5 and 1 mg/l, respectively is exceeded. De Villiers and Thiart (2007) reported on the nutrient status of South African Rivers between the 1970's to 2005 and attributed the most likely cause of increased nutrient enrichment to improperly treated effluent from poor-performing sewage plants. Concentrations measured at the discharge point of the NWWTP indicate that nitrate guidelines were grossly exceeded during the summer month of June by 161.33% whilst phosphate concentrations exceeded the 1.0 mg/l guideline for the entire sampling period except in July (0.751 mg/l). The results obtained from the NGTW discharge point indicate that nitrate guidelines were exceeded during April (2.35 mg/l), June (1.99 mg/l), July (0.513 mg/l), August (1.96 mg/l) and October (1.64 mg/l) whilst phosphate guidelines were exceeded during August (1.47 mg/l), October (1.26 mg/l), November (3.99 mg/l) and February (1.16 mg/l) respectively. These gross surpassing of these guidelines indicates that the improperly treated effluent being discharged from both these WWTPs may serve as a source of pollution to the receiving watershed. The South African Water Quality Guidelines for Domestic Use stipulates a TWQR of 0 – 6 mg/l for nitrate values in water bodies whereby no adverse effects on human health will be inferred, thus indicating compliance of the receiving watershed with recreational guidelines as well as safety for various recreational activities. Excessive nutrient enrichment may result in changing the balance between competitive plant species, allowing those tolerant to such high concentrations to prevail. This in turn may result in the degradation of important plant communities, indirectly affecting ecosystem functioning and modifications of existing habitats for current aquatic plant and animal species (De Villiers and Thiart, 2007). Nutrient loading may also lead to the proliferation of algal species ultimately leading to excessive eutrophication as well as depletion of oxygen resources and thus extensive invertebrate and fish kills.

Although the direct effect of tidal fluctuations were not monitored in this study, the observed changing tidal times, channel flow, velocity, water direction and depth during sampling may have influenced results obtained upstream and downstream of the Umgeni River due to the location of the river mouth nearby. This effect can be seen with the measured salinity whereby higher concentrations were recorded when sampling was conducted during peak inflow compared to sampling during peak outflow when lower salinity levels were measured. Tidal fluctuations caused by both spring and neap tides resulted not only in changes in water flow and direction but also changes in water levels which may have indirectly affected concentrations of suspended sediments, turbidity, nutrient fluxes, pH, DO and salinity levels measured. Wilson *et al.* (2004) monitored the effects of spring and neap tidal cycles in the Darwin Habour during the dry season and found varying concentrations of sediment, turbidity and nutrients over the tidal cycle with higher concentrations during high tide. In addition, they also reported a 10-fold increase in sediment and nutrient concentrations during spring tide and attributed this to higher channel velocities and higher water levels at nearby mangroves resulting in sediment uploading. Similar results were observed in this study with higher turbidity values measured upstream of the Umgeni River, which was closer to the river mouth, during March and April when there was a high tide. Similarly, low turbidity values were measured upstream during low tide in the months of May and February. The importance of tidal fluctuations and water quality constituent variability have been studied at varying scales (hourly, weekly, seasonally and annually) with results indicating a direct effect of changing tides on both the horizontal (point sources) and vertical gradients (depth) of water quality constituents (DiLorenzo *et al.*, 2004). In addition, tidal fluctuations may serve as a means of transportation to sediments and nutrients, resulting in the periodic displacement of both dissolved and suspended matter.

The results obtained in this study revealed that whilst both treatment plants monitored exhibited varying results across the sampling period, effluent produced at the discharge point met acceptable standards with certain parameters whilst falling short of others that are critical in ensuring safe clean water for both domestic, recreational and drinking water purposes. Thus, despite obtaining a provincial Green Drop Score of 82% in 2011, within the eThekwini municipality, approximately 7 plants are still regarded as low risk with an additional 10 plants being regarded as medium risk in 2012, indicating a need to further improve current management and surveillance of wastewater treatment plants within the Durban Area. In addition, results also revealed an adverse impact of selected physico-chemical characteristics such as turbidity on the receiving watershed as a result of improperly treated effluent thus indicating a significant health risk to those users who rely entirely on these surrounding rivers as their sole source of water as well as to existing ecosystem micro- and macro-fauna.

CHAPTER THREE

MICROBIAL PROFILES OF TREATED WASTEWATER EFFLUENT AND THE RECEIVING AQUATIC MILIEU IN DURBAN

3.1 Introduction

Water availability within South Africa is one of the key limitations to the countries development with existing water resources continuously being exploited and polluted due to increasing demographics, urbanization, afforestation, agriculture and power generation. Globally, the microbiological examination of water is used to monitor and control the quality and safety of various types of water sources to ensure safety for further usage (Barrell *et al.,* 2000). Within the urban areas of South Africa, water infrastructure is generally well developed, however the majority of rural communities still utilise poorly developed water distribution systems with some having none at all (Momba *et al.,* 2008). The eThekwini municipality receives wastewater from various surrounding domestic and industrial sources, which is treated prior to discharge via various river and oceanic outfalls. Approximately 83% of the total wastewater produced is of domestic origin with 220 Mℓ/d and 245 Mℓ/d being discharged to surrounding rivers and the sea, respectively. Approximately 64% of people within the eThekwini municipality have access to sufficient sanitation and wastewater treatment facilities, whilst a further 12% utilises pit latrines which are not connected to a sewer system. However, approximately 24% of households still lack access to basic sanitation facilities, thus resulting in an increased dependence on surrounding water bodies such as rivers and ponds for domestic and recreational activities as well as the increased use of treated effluent for a vast array of agricultural and industrial activities (Durban Metro, 2000; Bailey, 2004). Microbial-related diarrheal diseases such as gastroenteritis, salmonellosis and shigellosis serve as a major public health concern, more so, in continents such as Asia and Africa, where those most affected are either under the age of five or have the lowest financial resources and poorest hygienic facilities (Mara and Evans, 2011).

Ensuring efficient management of sewage systems and wastewater treatment plants within municipalities as well as efficient monitoring of collection, treatment and discharge, is imperative as it can serve as a huge health risk for both the communities utilising these water bodies as well as the ecosystems and environments fed by these water sources (Momba and Notshe, 2003; Momba *et al.*, 2006). Numerous studies have shown that improperly treated wastewater can serve as a source of microbiological contamination of receiving surface water, resulting in numerous outbreaks of salmonellosis, cryptosporidiosis and gastroenteritis (Ashbolt, 2004; Momba *et al.*, 2006). Furthermore, cholera epidemics previously recorded in both South Africa and Mozambique, have been linked to the discharge of inefficient sewage treatment plants (Dalsgaard *et al.*, 2001). A study conducted by Doughari *et al.* (2007) on the Gudu stream which serves as a major water source for the Gudu District, Abuja, attributed the observed contamination to a surrounding wastewater treatment plant with bacterial counts exceeding 1700 CFU/100 ml obtained in treated sewage. In addition, Samie *et al.* (2009) evaluated 14 sewage treatment plants in the Mpumalanga province and reported that only 14.2% of monitored plants produced treated effluent with a faecal coliform count of 0 CFU/100 ml. All treatment plants discharged final treated effluent into surrounding receiving rivers and the environment, thus indirectly serving as a danger to those relying on this water source.

The presence of pathogenic bacteria within the water environment tends to be sporadic, whilst the isolation and culturing of these bacteria is both time consuming and expensive. Therefore, routine water microbiological monitoring does not include the detection of individual pathogenic bacteria but rather of a group of representative indicator microorganisms. Commonly used indicators include total coliforms, faecal coliforms and enterococci, all of which are used as surrogates for human pathogens to assess the health risk and quality of the water (Barrell *et al.*, 2000). While these indicators may not be pathogenic themselves, numerous studies have shown them to correlate with poor water quality as well as the presence of other pathogenic bacteria. Recently, the use of indicator bacteria alone in assessing the quality of water sources has come under considerable review as these groups of bacteria may also originate from various sources other than warm-blooded animals. In addition, they tend to be poor indicators of viral contamination (Cabral, 2010). Hence, the need to incorporate additional indicators such as bacteriophages, which are more representative of viral contamination due to their similar size and structure. Thus, regular monitoring of the microbiological content present in discharged treated effluent will provide knowledge, not only of pathogenic microorganisms being discharged but also aid in providing a greater understanding in the epidemiological patterns of pathogen-related waterborne transmitted diseases. In addition, improvement of the operational status of sewage treatment plants as well individual treatment steps can be focused on (Samie *et al.*, 2009). The main focus of this chapter was to determine the microbial quality of discharged treated effluent from two independent WWTPs and their impacts on the respective receiving watersheds within the Durban area, KwaZulu-Natal, South Africa.

3.2 Materials and methods

Samples were collected from designated sites as described in sections 2.2.1 and 2.2.2 of Chapter 2 and were analysed within 48 hr of collection for bacterial indicators using standard microbiological methods (Standard Methods, 1998).

3.2.1 Detection and enumeration of bacterial pathogens

Presumptive total coliforms, faecal coliforms, faecal enterococci, faecal streptococci and *E. coli* populations in the water samples were enumerated using the standard membrane filtration technique. Prior to filtration, samples were diluted 10-fold with sterile distilled water. Fifty millilitres of the appropriate dilution of each sample was filtered through a sterile membrane filter (45 µm pore size, 47 mm diameter) (Millipore, Johannesburg, South Africa) using a vacuum pump. The membranes were placed grid-side up on respective selective agar plates (Table 3.1). The total heterotrophic bacterial population was determined using the spread plate technique whereby 0.1 ml of the appropriate dilution was plated. Plates were inverted and incubated at the appropriate conditions, aerobically (Table 3.1). After incubation, plates were examined and enumeration of colonies bearing the typical characteristics were conducted and expressed as colony forming units per millilitre (CFU/ml).

Table 3.1: Outline of the respective media and incubation conditions used for the enumeration and identification of each bacterial indicator

INDICATOR	SELECTIVE MEDIA	INCUBATION CONDITIONS	
		T (°C)	Time (h)
Total coliforms	Coli-Chromo agar	37	24
Faecal coliforms	mFC agar	44.5	24
Faecal streptococci	Oxolinic acid aesculin azide agar	42	48
Esherichia coli	Coli-Chromo Agar	37	24
Enterococci	Enterococcus selective Agar	37	24
Total heterotrophic bacteria	Nutrient Agar	37	24

3.2.2 Detection and Enumeration of Somatic and F-RNA bacteriophages

Enumeration of somatic and F-RNA bacteriophage populations in the collected water samples were carried out using the double agar layer plaque assay (EPA, 2001 – Method 1601 and 1602 with slight modifications) as described below.

3.2.2.1 Preparation of bacteriophage hosts

Escherichia coli strain WG5 and *Salmonella typhimurium* strain WG49 were used as the bacterial hosts to isolate somatic and F-RNA bacteriophages respectively. The bacterial host strains were grown overnight in nutrient broth (Merck), in a shaking incubator at 37 °C and 120 rpm. The *S. typhimurium* nalidixic acid and kanamycin resistant strain WG49 contains an *E. coli* plasmid which codes for sex pili production. Overnight growth allows for the development of F-pili onto which F-RNA bacteriophages attach prior to infection of the host. Bacterial host growth suspensions were standardised against a blank reference at 560 nm using a Spectrophotometer (Biochrom Libra S12) until an ideal absorbance between 0.1 – 0.5 nm was obtained. The host suspension was then maintained at 4 °C and used within 4 h. Ten-fold serial dilutions of each collected water sample were made in sterile lambda diluent containing 98.8 ml sterile double distilled water, 0.2 ml of 1 M sterile $MgCl_2$ and 1.0 ml of 1 M Tris-HCl, pH 8.

3.2.2.2 Preparation of bottom and top agar

Bottom agar plates contained 23 g nutrient agar supplemented with 5 g NaCl which were dissolved in 1 ℓ of distilled water and autoclaved at 121 °C for 15 min. The agar was allowed to cool before aseptically adding 10 ml of nalidixic acid stock solution. Twenty millilitres of the prepared media was poured into 90 mm petri dishes and allowed to solidify. Bacteriophage top agar was prepared using 8 g nutrient broth, 14 g bacteriological agar and 5 g NaCl dissolved in 1 ℓ distilled water, followed by sterilization by autoclaving at 121 °C for 15 min. After cooling, approximately 10 ml of a nalidixic acid stock solution was added aseptically.

3.2.2.3 Double agar layer plaque assay

To a sterile eppendorf tube, approximately 500 µl of log-phase grown bacterial host was mixed together with 500 µl of appropriate sample dilution and incubated at 37 °C for 15 min to allow the phage to attach to or penetrate the host. Following incubation, 3 ml of previously prepared top agar supplemented with NaCl and nalidixic acid were inoculated with appropriate host and sample mix followed by sufficient mixing using a vortex. The top-agar-host-sample mixture was then poured onto the bottom agar layer plates and allowed to solidify. This was followed by incubation in an inverted position at 37 °C for 16 – 24 h. Clearly visible plaques appearing through a lawn of host bacteria were then enumerated and expressed as plaque forming units (PFU/ml).

3.2.3 Statistical analyses

All statistical analyses were performed using The Statistical Package for Social Sciences Version 21.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.) All data were analyzed using descriptive statistical analysis (95% confidence limit). Means (± standard deviation) are presented for all continuous variables. Continuous variables were tested for normality prior to parametric testing. If skewed, data was normalized using the log transformation. The Pearson’s product-moment correlation coefficient matrix was calculated to determine the relationship between measured microbial indicators.

3.3 Results

3.3.1 Bacterial indicator profiles

Enumeration of bacterial indictors in the effluent samples before chlorination and at the discharge point was conducted to assess the efficiency of tertiary treatment for bacterial indicator removal and compliance with current guidelines. Enumeration of bacterial indicators both upstream and downstream of the receiving watershed was also carried out to further assess the impact of the treated effluent discharge on the receiving watersheds. Figures 3.1 – 3.6 show the different bacterial indicator populations enumerated over the one year period between March 2012 and February 2013. Variable trends were observed over the entire sampling period for both treatment plants and all indicators monitored with total coliforms being detected at the discharge point of both plants throughout the twelve month period. Bacterial counts in the final effluent before chlorination revealed high loads with a general reduction in population observed after chlorination, except for certain months. Seasonal averages of total coliform, *E. coli* and faecal coliform populations in the effluent samples before chlorination (Figures 3.1 and 3.3) were highest for all three indicators respectively during summer for the NWWTP (7.61×10^3 CFU/ml; 3.05×10^3 CFU/ml; 3.42×10^3 CFU/ml) and NGTW (56.14×10^2; 3.47×10^2; 19.27×10^2 CFU/ml).

Variable trends in bacterial indicator populations were observed throughout the sampling period at the discharge point for both plants (Figures 3.1 and 3.3). The percentage reduction of bacterial indicators at the discharge point compared to the counts before chlorination ranged between 0.52 – 100% across the sampling period with a 100% reduction in faecal coliform load obtained only during October 2012 for the NWWTP. For the NGTW, reduction at the discharge point ranged between 41.56 – 100% with a 100% reduction in faecal coliform load obtained in October 2012 and January 2013 only. However, higher levels of some indicator bacteria were observed at the discharge point at certain months when compared to counts before chlorination, with February 2013 samples exhibiting an increase for all bacterial indicators enumerated namely; total coliforms (21.73%), *E. coli* (72.14%), faecal coliforms (5.65%), faecal streptococci (100%) and enterococci (108.93%) for the NWWTP (Figure 3.1). A similar trend was observed for the NGTW (total coliforms (39.29%), *E. coli* (69.55%), faecal coliforms (137.80%), faecal streptococci (228.42%) and enterococci (39.26%)) during May 2012 (Figure 3.3). In addition, April (119.34%), June (48%), December (220%) and February (5.65%) were characterised by an increased faecal coliform load at the discharge point for the NWWTP (Figure 3.1) whilst the evaluation of the results obtained for the NGTW revealed a 137.8% and 16.47% increase in faecal coliform load during May and September 2012 respectively (Figure 3.3). Heterotrophic and total coliform populations (in CFU/ml) in treated effluent samples before chlorination ranged between 0.227×10^3 – 11.84×10^3 (TC) and 160×10^3 - 2026.67×10^3 (HPC) for the NWWTP (Figure 3.5) and 1.55×10^2 – 152.53×10^2 (TC) and 71.13×10^2 – 6026.67×10^2 (HPC) for the NGTW (Figure 3.6) respectively.

Seasonal averages indicate a higher heterotrophic bacterial population within the receiving watershed during winter, upstream (1128.89×10^3 CFU/ml) and downstream (1804.44×10^3 CFU/ml) of the Umgeni river (Figure 3.5) whilst a higher bacterial load was obtained upstream (3.502×10^5 CFU/ml) and downstream (2.74×10^5 CFU/ml) of the Aller River (Figure 3.6) during summer and spring respectively. Extremely low levels of all indicators were detected during March (0 – 0.017×10^2 CFU/ml), April (0 – 0.32×10^2 CFU/ml) and July (0 – 0.033×10^2 CFU/ml) for the Aller River whilst September revealed exceptionally high levels of all indicators (in CFU/ml) upstream and downstream of the Aller River (Figure 3.4) respectively (total coliforms (212.2×10^2; 120.5×10^2), *E. coli* (101×10^2; 31.8×10^2), faecal coliforms (122.7×10^2; 31.8×10^2), faecal streptococci (224×10^2; 6.93×10^2) and enterococci (290.7×10^2; 8.32×10^2). Seasonal averages revealed higher levels (in CFU/ml) of total coliforms (7.61×10^3; 25.85×10^3), *E. coli* (3.65×10^3; 4.16×10^3) and faecal coliforms (3.42×10^3; 1.73×10^3) in the final effluent and discharge point, respectively during summer for the NWWTP. Similarly, higher levels (in CFU/ml) of *E. coli* (3.47×10^2; 4.64×10^2) and faecal coliforms (19.27×10^2; 3.97×10^2) were observed during summer in the final effluent and autumn at the discharge point. The faecal coliform to faecal streptococci ratio (FC/FS) ranged between 0 – 13.79 and 0 - 33 at the discharge point for the NWWTP and NGTW, respectively whilst a ratio of 0 – 51 and 0 – 115.58 was obtained for the receiving Umgeni River and Aller River respectively. Fifty-eight percent (7/12) and 50% (6/12) of before chlorination and discharge point samples had a FC:FS ratio of greater than 4. Similarly for the NGTW, 42% (5/12) and 17% (2/12) of samples exhibited a FC:FS ratio of greater than 4.

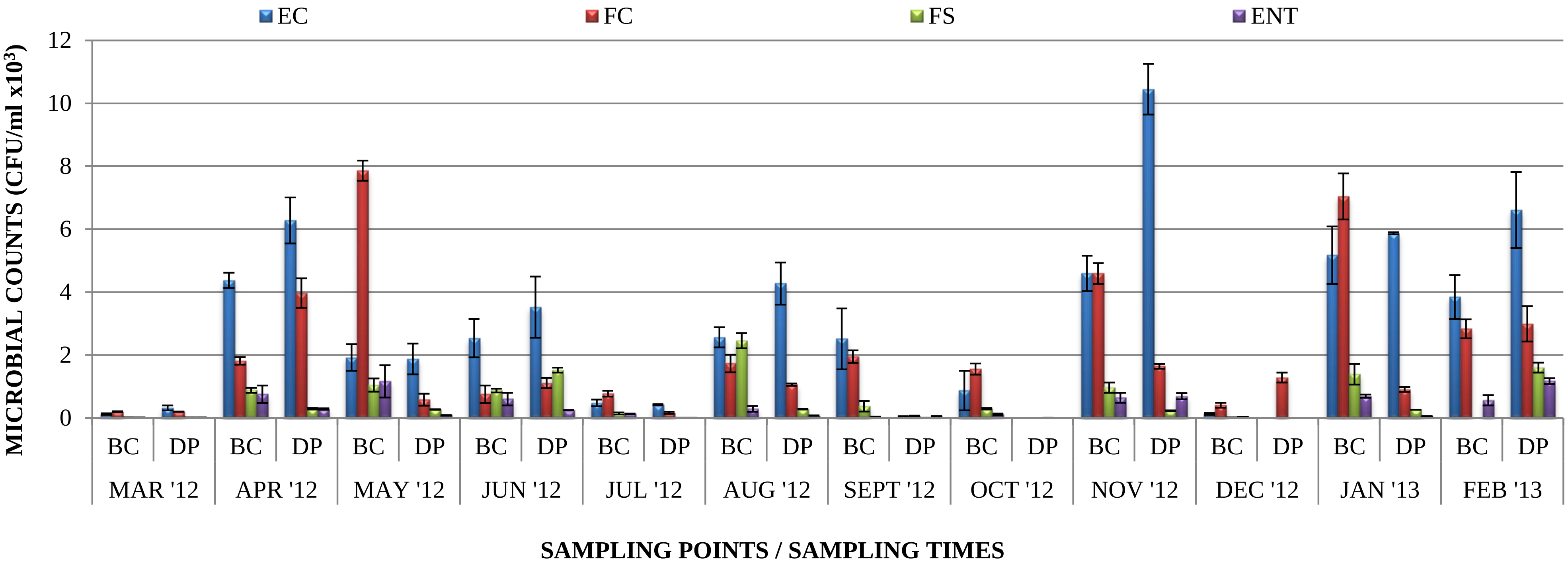


Figure 3.1: Presumptive *E. coli* (EC), faecal coliform (FC), faecal streptococci (FS) and enterococci (ENT) load in NWWTP effluent samples before chlorination (BC) and at discharge point after chlorination (DP) between March 2012 and February 2013. All bars represent average (n=3) values ± standard deviation.

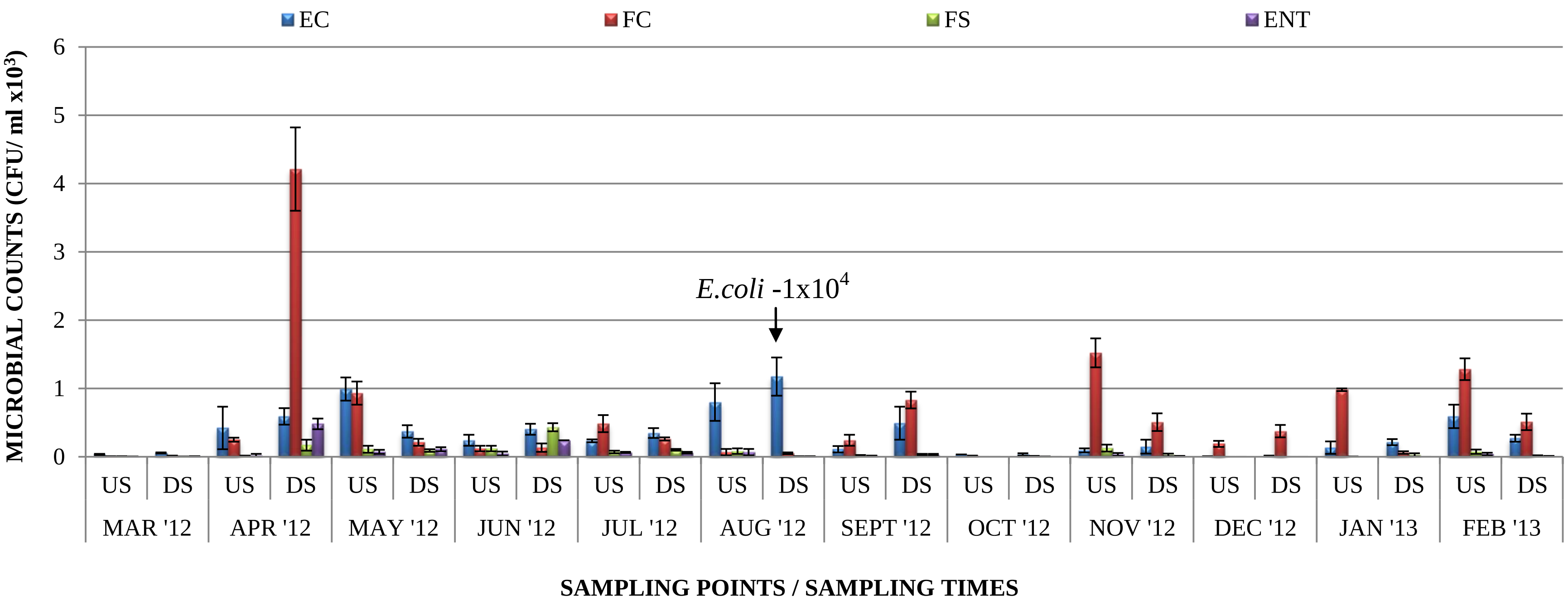


Figure 3.2: Presumptive *E. coli* (EC), faecal coliform (FC), faecal streptococci (FS) and enterococci (ENT) population detected upstream (US) and downstream (DS) of the Umgeni River between March 2012 and February 2013. All bars represent average (n = 3) values ± standard deviation at a CFU/ml as indicated however *E.coli* population detected downstream during August 2012 is represented as $x10^4$ CFU/ml.

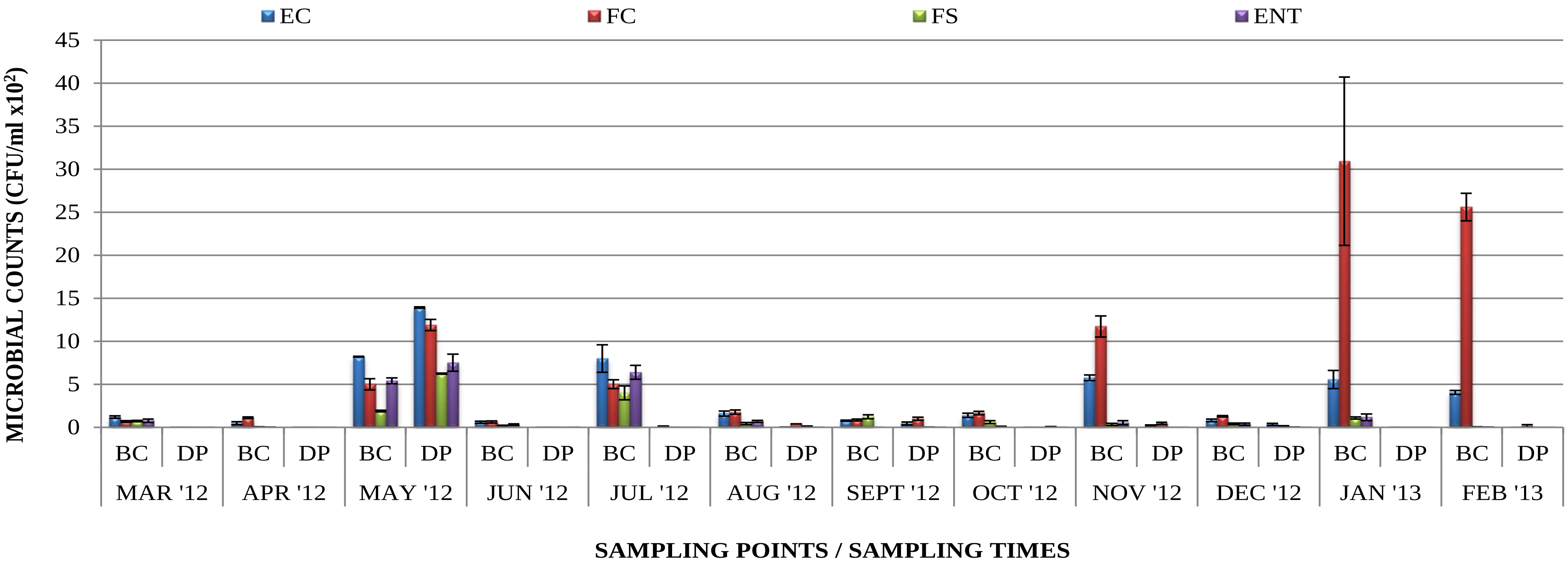


Figure 3.3: Presumptive *E. coli* (EC), faecal coliforms (FC), faecal streptococci (FS) and enterococci (ENT) load detected in NGTW effluent samples before chlorination (BC) and at the discharge point after chlorination (DP) between March 2012 and February 2013. All bars represent average (n=3) values ± standard deviation at a CFU/ml as indicated.

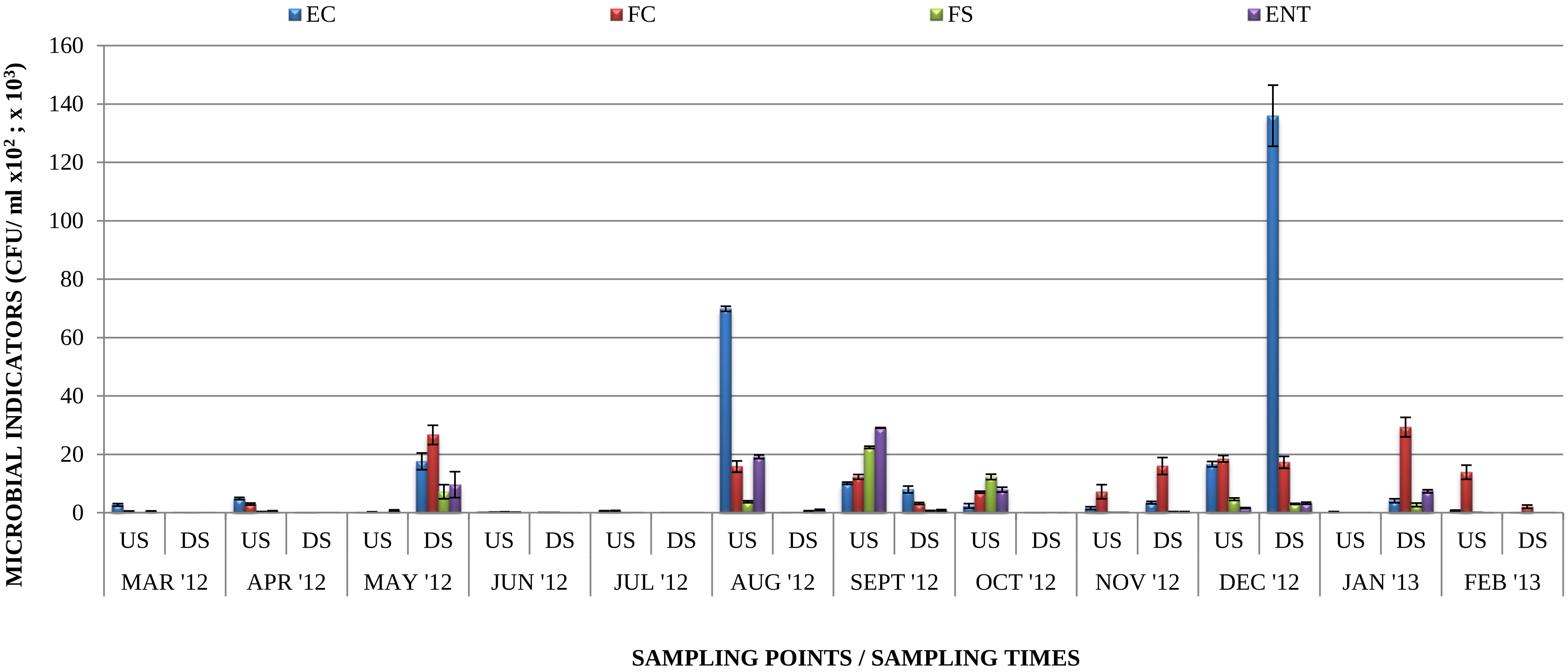


Figure 3.4: Presumptive *E. coli* (EC), faecal coliform (FC), faecal streptococci (FS) and enterococci (ENT) populations detected upstream (US) and downstream (DS) of the Aller River between March 2012 and February 2013. All bars represent average (n = 3) values ± standard deviation at a CFU/ml as indicated however *E.coli* population detected downstream during August 2013 as well as all indicators detected during September 2013 are represented as $x10^3$ CFU/ml.

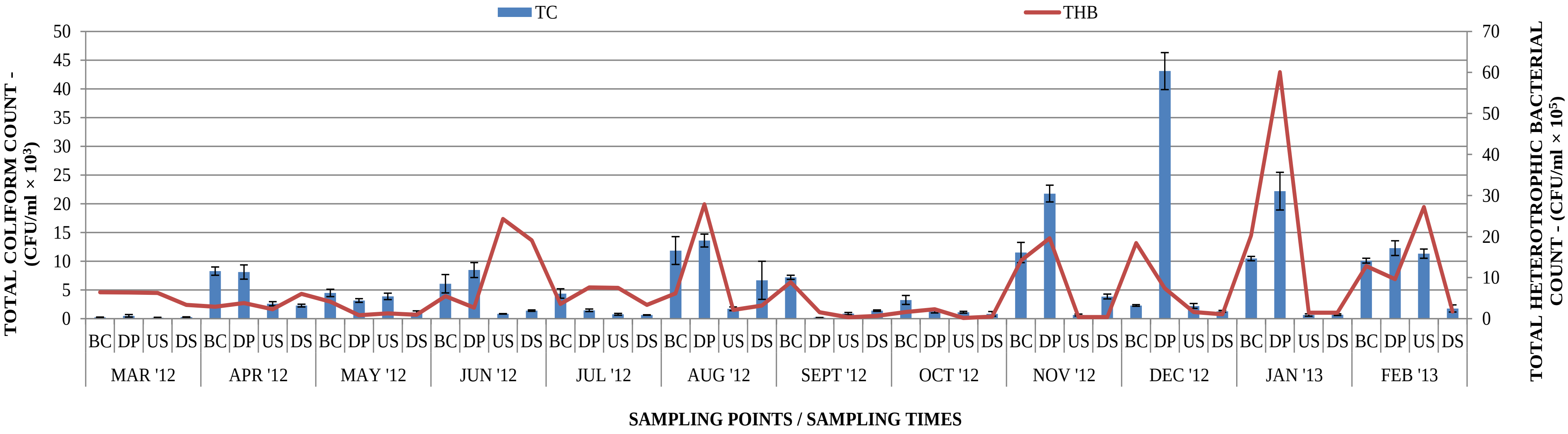


Figure 3.5: Total coliform (TC) and total heterotrophic bacterial (THB) population enumerated before chlorination (BC) and after chlorination (AC) at NWWTP as well as upstream (US) and downstream (DS) of the Umgeni River between March 2012 and February 2013. Values represent averages (n = 3) ± standard deviation at a CFU/ml as indicated, however, the total coliform population detected downstream during August 2012 is represented as x10^4 CFU/ml.

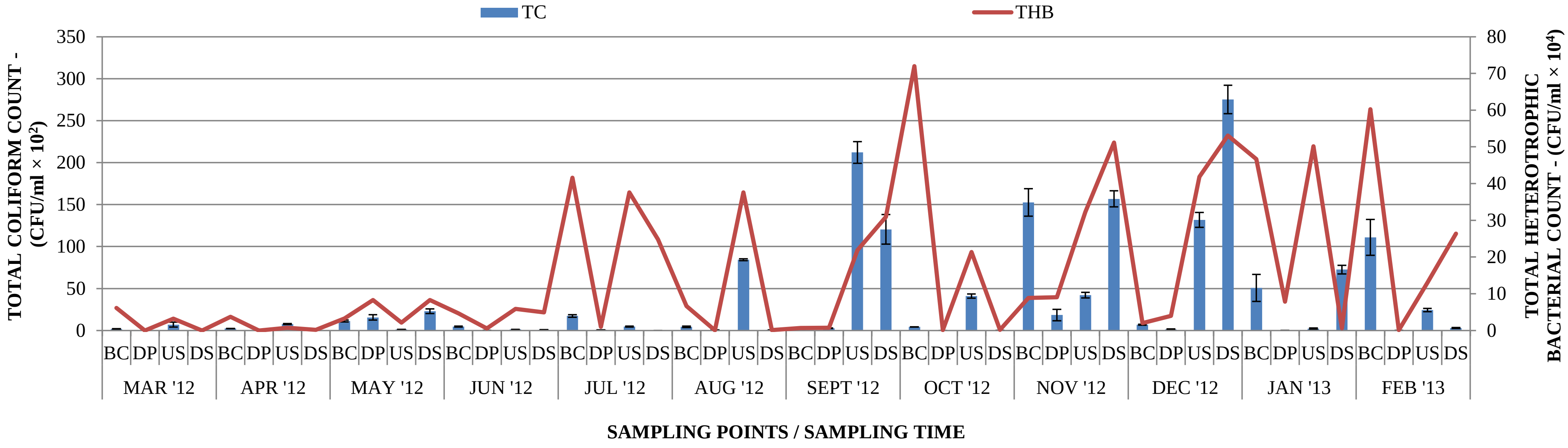


Figure 3.6: Total coliform (TC) and total heterotrophic bacterial (THB) population enumerated before chlorination (BC) and after chlorination (AC) at the NGTW as well as upstream (US) and downstream (DS) of the Aller River between March 2012 and February 2013. Values represent averages (n = 3) ± standard deviation at a CFU/ml as indicated, however, the total coliform population detected upstream (US) during August 2012 is represented as $x10^3$ CFU/ml.

3.3.2 Somatic and F-RNA coliphage indicators

Somatic and F-RNA bacteriophages were detected during May, June and January in all samples collected for the NWWTP (Table 3.2). Higher levels of somatic bacteriophages were detected at the discharge point during April (106.67 PFU/ml), May (309.33 PFU/ml), June (346.67 PFU/ml) and August (126.67 PFU/ml) compared to before chlorination whilst higher levels of F-RNA bacteriophages were detected only during June for the NWWTP. Similar trends were observed for the NGTW (Table 3.3) with higher levels of somatic bacteriophages being detected at the discharge point during May (490.67 PFU/ml) and September (34.67 PFU/ml) whilst higher levels of F-RNA bacteriophages were detected during April (701.33 PFU/ml) and September (61.33 PFU/ml) compared to effluent samples before chlorination. Extremely high levels of somatic bacteriophages were detected upstream of the Aller River during September (2453.53 PFU/ml), while November (624 PFU/ml) revealed the highest levels of F-RNA bacteriophages downstream. Similarly for the Umgeni River, fairly high levels of both phages were detected upstream during autumn and downstream during summer with the highest levels detected downstream during April (1440 PFU/ml) and January (429.33PFU/ml) for somatic and F-RNA coliphages respectively.

Table 3.2: Coliphage counts for all samples collected for the NWWTP and receiving Umgeni River

	SOMATIC COLIPHAGE				F-RNA COLIPHAGE			
	BC	**DP**	**US**	**DS**	**BC**	**DP**	**US**	**DS**
MAR	-	-	-	-	-	-	-	-
APR	76.00 ± 8.00	106.67 ± 31.07	0	1440.00 ± 787.97	0	0	97.33 ± 56.76	209.33 ± 55.47
MAY	165.33 ± 20.13	309.33 ± 16.65	740.00 ± 626.42	453.33 ± 394.63	74.67 ± 72.15	69.33 ± 6.11	156.0 ± 38.16	88.00 ± 4.00
JUN	65.33 ± 18.90	15.33 ± 8.08	626.67 ± 128.58	125.33 ± 77.7	94.67 ± 23.09	129.33 ± 32.58	4.00 ± 1.00	48.00 ± 26.23
JUL	274.67 ± 77.70	346.67 ± 234.38	0	38.33 ± 33.83	0	0	0	0
AUG	89.33 ± 78.42	126.67 ± 122.66	93.33 ± 83.27	82 ± 75.18	0.67 ± 0.58	0	0	0
SEPT	0	0	0	0	0	0	0	1.00 ± 1.00
OCT	0	0	0	1.00 ± 1.00	0	0	0	0
NOV	0	0	88.00 ± 78.69	1.00 ± 1.00	11.00 ± 6.08	0	0	0
DEC	76.00 ± 14.42	0	100.00 ± 21.17	288.00 ± 48.66	138.67 ± 76.04	0	216.00 ± 117.85	424.00 ± 96.99
JAN	400.00 ± 34.87	378.67 ± 134.9	101.33 ± 47.72	222.67 ± 88.21	213.33 ± 20.13	58.67 ± 56.19	108.00 ± 97.08	429.33 ± 72.15
FEB	272.00 ± 16.00	194.67 ± 28.10	0	146.67 ± 39.46	202.67 ± 48.88	173.33 ± 99.38	66.67 ± 39.46	112.00 ± 36.66

Values represent averages of triplicate results ± standard deviation

Table 3.3: Coliphage counts for all samples collected for the NGTW and receiving Aller River

	SOMATIC COLIPHAGE				**F-RNA COLIPHAGE**			
	BC	**DP**	**US**	**DS**	**BC**	**DP**	**US**	**DS**
MAR	-	-	-	-	-	-	-	-
APR	6.67 ± 1.15	1.00 ± 1.00	317.33 ± 75.61	258.67 ± 36.07	0	0	701.33 ± 107.43	0
MAY	226.67 ± 20.13	490.67 ± 40.27	61.33 ± 15.14	477.33 ± 75.59	0	44.00 ± 12.00	0	17.33 ± 6.11
JUN	0	0	0	0	0	0	0	0
JUL	197.33 ± 16.65	6.67 ± 0.58	144.00 ± 28.84	41.33 ± 24.44	0	0	0	0
AUG	0	0	85.33 ± 16.65	0	0	0	0	0
SEPT	29.33 ± 0	34.67 ± 6.11	2453.33 ± 468.76	320.00 ± 56.00	0	0	61.33 ± 9.24	48.00 ± 8.00
OCT	0	0	8.67 ± 2.52	6.67 ± 2.08	0	0	0	0
NOV	36.00 ± 4.00	0	176.00 ± 110.85	365.33 ± 108.03	325.33 ± 272.63	0	0	624.00 ± 154.30
DEC	0	0	0	0	0	0	0	21.33 ± 2.31
JAN	0	0	1.67 ± 1.15	0	0	0	0	2.67 ± 1.53
FEB	272.00 ± 16.00	194.67 ± 28.10	0	146.67 ± 39.46	202.67 ± 48.88	173.33 ± 99.38	66.67 ± 39.46	102.00 ± 26.15

Values represent averages of triplicate results ± standard deviation

3.3.3 Statistical Analyses

Tables 3.4 and 3.5 show the Pearson's Product Moment Correlation matrices for some physicochemical parameters of the water samples and all bacterial indicators analysed in this study. Significant positive correlations were observed between THB and turbidity in samples collected before chlorination (r = 0.501) and at the discharge point (r = 0.458) for the NWWTP as well as at the discharge point (r = 0.527) and upstream (r = 0.356) for the NGTW. Within the receiving watershed, positive correlations were observed upstream of the Umgeni river between faecal streptococci and *E. coli* (r = 0.443) as well as faecal coliforms (r = 0.539), whilst strong positive correlations were observed upstream and downstream of the Aller River between faecal streptococci and *E. coli* (US: r = 0.639; DS: r = 0.822) as well as faecal coliforms (US: r = 0.777; DS: r = 0.912). Positive correlations were also observed between total coliforms and BOD at the before chlorination point (r = 0.465) for the NWWTP and at the discharge point (r = 0.386) for the NGTW.

Table 3.4: Correlation matix between physicochemical and microbial parameters for the NWWTP and Umgeni River

	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	*E. coli*	FC	FS	ENT	TC	THB
BEFORE CHLORINATION															
T	1														
TURB	.035	1													
TDS	-.664**	.160	1												
TSS	-.024	.691**	.124	1											
pH	.092	.121	-.208	.456**	1										
DO	.080	-.340*	-.420*	-.131	-.090	1									
BOD	.048	.099	.014	.183	-.161	.491**	1								
COD	.249	.424**	-.077	.149	.089	-.172	-.136	1							
SAL	-.658**	.149	.998**	.123	-.195	-.432**	.025	-.092	1						
E. coli	.112	.303	.147	.339*	.175	.048	.283	-.042	.136	1					
FC	.082	.066	.331*	.097	-.119	-.173	.083	-.393*	.326	.672**	1				
FS	.431**	.293	-.346*	.074	-.222	.147	-.033	-.051	-.371*	.533**	.519**	1			
ENT	.236	.124	.007	.281	.330*	.120	.076	-.300	-.001	.623**	.720**	.516**	1		
TC	-.301	.276	.341*	.356*	.000	.028	.465**	-.235	.334*	.588**	.310	.087	.211	1	
THB	.244	.501**	.067	.296	.069	-.252	.100	.158	.054	.820**	.568**	.634**	.451**	.427**	1
	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	*E. coli*	FC	FS	ENT	TC	THB
DISCHARGE POINT															
T	1														
TURB	-.316	1													
TDS	-.482**	.437**	1												
TSS	-.130	.554**	.082	1											
pH	-.140	-.072	-.036	.107	1										
DO	-.018	-.577**	-.159	-.159	.099	1									
BOD	-.076	-.149	-.176	-.091	.409*	-.104	1								
COD	.130	.505**	-.044	.383*	-.024	-.528**	-.267	1							
SAL	-.451**	.332*	.983**	.032	.032	-.052	-.136	-.134	1						
E. coli	-.181	.506**	.270	.467**	.036	-.244	-.113	.462**	.285	1					
FC	-.173	.554**	.357*	.510**	.265	-.103	-.143	.356*	.386*	.714**	1				
FS	.072	-.168	-.262	.044	.664**	.130	.147	.090	-.153	.392*	.477**	1			
ENT	-.394*	.319	.305	.119	.361*	-.204	-.005	.323	.354*	.737**	.693**	.653**	1		
TC	.038	.426**	.339*	.391*	-.214	-.127	-.304	.250	.346*	.596**	.685**	.249	.371*	1	
THB	-.175	.458**	.265	.432**	-.028	-.107	-.232	.522**	.247	.590**	.442**	.184	.376*	.649**	1
	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	*E. coli*	FC	FS	ENT	TC	THB
UPSTREAM															
T	1														
TURB	.080	1													
TDS	.480**	.248	1												
TSS	-.322	.327	.082	1											
pH	.096	-.120	.331*	.120	1										
DO	.322	.023	.675**	-.023	.398*	1									
BOD	.624**	-.114	.058	-.250	-.001	.107	1								
COD	-.189	-.118	-.454**	-.045	.394*	-.237	.002	1							
SAL	.455**	.143	.980**	.054	.291	.598**	.067	-.441**	1						
E. coli	.193	.030	.490**	.387*	.185	.118	.150	-.301	.554**	1					
FC	.049	-.257	-.090	.099	-.063	-.238	.161	.185	.035	.306	1				
FS	.449**	-.009	.357*	.144	.236	.064	.103	-.263	.394*	.443**	.539**	1			
ENT	.474**	.062	.554**	.127	.286	.167	.222	-.228	.578**	.571**	.327	.618**	1		
TC	-.090	-.431**	-.057	.174	.141	-.206	.154	.146	.043	.597**	.488**	.147	.270	1	
THB	.103	-.530**	.351*	.217	.661**	.312	-.009	.041	.390*	.430**	.178	.331*	.382*	.448**	1
	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	*E. coli*	FC	FS	ENT	TC	THB
DOWNSTREAM															
T	1														
TURB	.537**	1													
TDS	-.084	-.104	1												
TSS	-.221	.037	-.018	1											
pH	.061	.059	-.791**	.006	1										
DO	.516**	.356*	-.627**	.275	.566**	1									
BOD	.256	-.035	-.234	-.509**	.096	.141	1								
COD	-.196	-.031	-.388*	.129	.198	.079	.036	1							
SAL	-.075	-.109	.996**	-.017	-.790**	-.599**	-.219	-.424**	1						
E. coli	.296	.263	-.079	-.136	.125	.220	-.059	.334*	-.076	1					
FC	.078	-.152	.156	-.199	.147	-.289	-.017	-.169	.138	-.065	1				
FS	.561**	.097	-.426**	-.110	.557**	.606**	.290	-.390*	-.395*	-.051	.186	1			
ENT	.380*	.082	-.265	-.070	.489**	.293	.014	-.324	-.256	-.013	.742**	.714**	1		
TC	.213	.226	.034	-.244	-.010	.020	.056	.335*	.032	.930**	-.013	-.120	-.060	1	
THB	.427**	.021	-.503**	.080	.589**	.651**	-.065	.212	-.490**	.624**	.069	.531**	.461**	.462**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

T: Temperature; TURB: Turbidity; TDS: Total dissolved solids; TSS: Total Suspended Solids; pH; DO: Dissolved Oxygen; BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; SAL: Salinity; FC: Faecal Coliforms; FS: Faecal Streptococci; ENT: Enterococci; TC: Total Coliforms; THB: Total Heterotrophic Bacteria

Table 3.5: Correlation matix between physicochemical and microbial parameters for the NGTW and Aller River

	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	*E. coli*	FC	FS	ENT	TC	HPC
BEFORE CHLORINATION															
T	1														
TURB	-.582**	1													
TDS	-.307	.474**	1												
TSS	-.004	-.163	.019	1											
pH	.181	-.231	.440**	.020	1										
DO	.042	.097	.142	-.103	.279	1									
BOD	-.254	.119	.089	.096	.107	.365*	1								
COD	-.334*	.300	.786**	-.076	.413*	.213	.027	1							
SAL	-.305	.479**	.999**	.014	.434**	.144	.089	.783**	1						
E. coli	-.237	.508**	.543**	.138	-.264	-.347*	.008	.225	.551**	1					
FC	.182	-.004	.243	.210	-.016	-.444**	.085	-.141	.244	.667**	1				
FS	-.289	.603**	.227	-.138	-.561**	-.164	-.034	.151	.234	.624**	.091	1			
ENT	-.480**	.708**	.542**	-.021	-.291	-.105	-.091	.492**	.545**	.705**	.024	.772**	1		
TC	.052	-.058	.262	.333*	.049	-.542**	.081	-.133	.263	.647**	.907**	-.018	.070	1	
HPC	.030	.084	.354*	.060	.159	-.471**	-.113	-.017	.348*	.515**	.751**	.133	.137	.685**	1

	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	*E. coli*	FC	FS	ENT	TC	HPC
DISCHARGE POINT															
TEMP	1														
TURB	-.399*	1													
TDS	-.372*	-.075	1												
TSS	.033	.020	-.011	1											
pH	.068	-.434**	.561**	.016	1										
DO	-.413*	-.011	.244	-.153	-.066	1									
BOD	-.362*	.309	.063	-.199	-.135	.171	1								
COD	.051	.341*	-.092	.046	-.192	-.036	.020	1							
SAL	-.365*	-.088	.999**	-.014	.565**	.234	.060	-.104	1						
E.coli	-.344*	-.176	.991**	-.016	.577**	.279	.049	-.088	.992**	1					
FC	-.193	.533**	.461**	.025	-.055	.047	.319	.114	.460**	.395*	1				
FS	-.215	.566**	.434**	.031	-.002	.144	.277	-.042	.431**	.361*	.931**	1			
ENT	-.200	.535**	.517**	.031	.035	.101	.239	.074	.513**	.445**	.956**	.980**	1		
TC	-.153	.326	.363*	-.051	-.198	-.319	.340*	-.026	.369*	.317	.703**	.537**	.583**	1	
HPC	-.114	.527**	.211	.003	-.215	-.409*	.386*	.036	.217	.135	.563**	.469**	.496**	.777**	1

	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	E.coli	FC	FS	ENT	TC	HPC
UPSTREAM															
T	1														
TURB	.123	1													
TDS	-.034	.681**	1												
TSS	.162	-.183	-.157	1											
pH	.214	.076	-.052	-.053	1										
DO	-.150	-.655**	-.403*	.011	-.151	1									
BOD	-.230	-.362*	-.248	.035	-.093	.379*	1								
COD	-.011	-.499**	.000	-.071	-.158	.047	.041	1							
SAL	-.062	.699**	.992**	-.161	-.036	-.423*	-.255	.003	1						
E. coli	-.047	.719**	.817**	-.310	-.108	-.370*	-.232	.040	.849**	1					
FC	.034	.578**	.529**	-.336*	-.188	-.531**	-.332*	.200	.525**	.697**	1				
FS	-.053	.397*	.620**	-.217	-.295	-.187	-.207	.093	.585**	.639**	.777**	1			
ENT	-.133	.455**	.761**	-.213	-.224	-.227	-.175	.202	.758**	.828**	.721**	.895**	1		
TC	-.121	.651**	.750**	-.428**	-.109	-.491**	-.312	.187	.767**	.864**	.876**	.713**	.761**	1	
HPC	-.361*	.356*	.389*	-.323	-.327	-.465**	-.186	.166	.396*	.417*	.553**	.346*	.275	.688**	1

	T	TURB	TDS	TSS	pH	DO	BOD	COD	SAL	E.coli	FC	FS	ENT	TC	HPC
DOWNSTREAM															
T	1														
TURB	-.391*	1													
TDS	-.707**	.179	1												
TSS	.001	.032	-.007	1											
pH	.017	-.379*	.461**	-.044	1										
DO	-.240	-.044	.362*	-.007	.220	1									
BOD	-.345*	.070	.204	-.096	.028	.103	1								
COD	-.420*	-.238	.501**	-.023	.236	.220	.261	1							
SAL	-.699**	.184	.999**	-.008	.460**	.358*	.195	.503**	1						
E.coli	.071	.442**	-.237	.012	-.662**	-.613**	-.144	-.269	-.230	1					
FC	.099	.140	-.126	-.002	-.590**	-.550**	-.104	-.168	-.122	.807**	1				
FS	-.013	.202	-.070	-.003	-.609**	-.387*	-.133	-.164	-.067	.822**	.912**	1			
ENT	-.046	.189	-.048	-.004	-.597**	-.346*	-.028	-.145	-.045	.785**	.911**	.965**	1		
TC	.152	.386*	-.252	.011	-.558**	-.761**	-.129	-.263	-.242	.865**	.855**	.740**	.708**	1	
HPC	-.116	.283	.052	-.030	-.167	-.679**	.169	.064	.046	.575**	.530**	.425**	.394*	.651**	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

T: Temperature; TURB: Turbidity; TDS: Total dissolved solids; TSS: Total Suspended Solids; pH; DO: Dissolved Oxygen; BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; SAL: Salinity; FC: Faecal Coliforms; FS: Faecal Streptococci; ENT: Enterococci; TC: Total Coliforms; THB: Total Heterotrophic Bacteria

3.4 Discussion

South Africa has continuously been defined as a water scarce country with return flows forming an imperative part of the countries freshwater supply. The National Water Act (1998) states that all treated effluent is required to flow back into some form of surface water source or into the ocean directly (DWAF, 2004). Despite many urban areas possessing good sewage treatment plants, many rural areas still lack efficient treatment resulting in severe contamination of surrounding rivers, streams and oceanic water bodies (Samie *et al.*, 2009). Municipal wastewater contains a mixture of domestic waste, suspended solids and debris as well as a variety of chemical and pesticide wastes originating from surrounding domestic, industrial and agricultural activities (Schaper *et al.*, 2002). Numerous past studies have indicated the failure of South African WWTPs to produce effluent of suitable bacteriological quality (Dungeni *et al.*, 2010; Olaniran *et al.*, 2012; Samie *et al.*, 2009). Samie *et al.* (2009) conducted a study involving the examination of 14 WWTP's within the Mpumalanga Province and reported the presence of numerous pathogenic bacteria such as *Salmonella* sp., *Shigella* sp. and *Vibrio* sp. in discharged chlorinated effluents. Another study conducted by Okoh and Igbinosa (2010) confirmed the presence of pathogenic *Vibrio* sp. within treated effluents of some WWTPs in the Eastern Cape.

In order to ensure that effluent discharged by WWTPs do not serve as an additional source of contamination to receiving watersheds, national and international guidelines have been set by departmental authorities which treatment facilities are required to comply with. In addition, improved treatment processes and stringent monitoring policies are generally devised by individual treatment plants to ensure suitable quality control of treated effluent. In 2008, the Department of Water Affairs in South Africa initiated a regulation program as a means to monitor and maintain efficient wastewater treatment and management. The initiation of the Green Drop and Blue Drop monitoring program allowed for the complete assessment of all municipalities within the country as well as assessment of both wastewater and drinking water compliance and quality. The Green Drop report produced in 2011 indicated a total wastewater treatment design capacity of 6614 Mℓ/d and an actual received flow of 5258 Mℓ/d, leaving a space capacity of 1356 Mℓ/d. In addition, despite only 33 systems receiving a Green Drop score in 2009, approximately 40 systems received a green drop score in 2011 showing a 21% increase in the number of complying WWTPs over the two years.

Variable trends in bacterial indicator profiles were observed over the entire sampling period for both treatment plants. Microbial indicators showed both seasonal and monthly variations within the study period and were often statistically related to abiotic variables such as temperature, turbidity and pH (Table 2.2; Table 2.3; Figure 2.5; Figure 2.6). The NWWTP is one of the larger treatment plants within the eThekwini Municipality, designed to receive an inflow of approximately 70 mega litres daily. Previous Green Drop Reports have reported a microbiological compliance of 42% with the highest plant risk area being the effluent quality (DWA, 2012). Generally higher levels of all indicators were observed in effluent samples before chlorination for both the NWWTP and NGTW respectively with a reduction in indicator populations after chlorination being observed at the discharge point for certain months only. The tertiary treatment step within a WWTP is imperative to ensure that final effluent of adequate quality is returned to a receiving watershed with the main aim of disinfection being to ensure the removal of pathogenic microorganisms. Poor sewage plant infrastructure coupled with inefficient treatment has been identified as a major factor contributing to the proliferation of microbial growth after chlorination and at the discharge point. Dungeni *et al.* (2010) stated that the presence of residual chlorine in water inactivates certain indicator bacteria such as *E. coli* whilst leaving other pathogenic microorganisms unaffected for extended periods of time. It is therefore not surprising that high populations of faecal coliforms, faecal streptococci and enterococci were observed in some chlorinated effluent samples tested in this study despite low levels of *E. coli*.

Being one of the larger plants within the Durban area, the discharge pipe of the NWWTP transporting treated effluent to the receiving river is situated approximately two kilometres away and may also be old, thus, may have contributed to the microbial load of the treated effluent. Vreeburg *et al.* (2010) reported that outdated sewage pipes often have increased sediment deposits and biofilm build-up over time. This coupled with fluctuating daily volumes may serve as one such factor contributing to fluctuating microbial loads detected at the discharge point, more so when increased flows are experienced. In addition, other factors such as plant size, capacity, varying monthly influent volumes and characteristics as well as operational status are also known to affect levels of indicator populations. These were found to fluctuate drastically at the discharge point for both plants on a month to month basis during the course of this study.

The presence of varying levels of pathogenic indicator bacteria such as faecal coliforms, faecal streptococci and faecal enterococci within the receiving watershed, and throughout the sampling period suggest that the water may be unfit for human consumption and further recreational uses involving activities with a high degree of water contact such as swimming, canoeing and angling. According to the current domestic and recreational guidelines (DWAF, 1996a; DWAF, 1996b), the target water quality range of faecal coliforms is 0 CFU/100ml and 0 - 130 CFU/100ml, respectively thus indicating that the receiving watershed was unfit for both domestic and recreational activities. This may be due to poor sanitation and hygiene practices from surrounding rural settlements as well as animal and other environmental runoff in conjunction with poorly treated effluent being discharged. Rainfall runoff carries a variety of pollutants from surrounding communities, industries and informal settlements as well as agricultural runoff including pesticides, plant and animal wastes (Taiwo *et al.*, 2012). This could explain the observed higher levels of indicators within the receiving watershed after periods of increased precipitation. Previous studies have also noted increases in measured water quality parameters such as turbidity and suspended solids after periods of intense rainfall which may further contribute to the proliferation of microorganisms (Taiwo *et al.*, 2012). In addition, high levels of total coliforms, *E. coli*, faecal coliforms, faecal streptococci and faecal enterococci were detected during the summer months of December and January. This may be attributed to increased rainfall levels of 124.2 mm and 165.8 mm, respectively recorded in these months as well as warmer temperatures which may further lead to microbial proliferation. Consequently, higher seasonal averages of total coliform, *E. coli* and faecal coliform populations obtained in the effluent samples before chlorination during summer at both WWTPs could be due to increased precipitation and increased influent volumes and storm water received by the treatment plants resulting in overloading, overflow and increased pressure to ensure efficient treatment. Venkatesharaju *et al.* (2010) also reported that microbial contamination in flowing watersheds may vary with climatic and seasonal changes in parameters such as temperature, salinity and rainfall, thus indirectly influencing the distribution and survival of certain pathogenic microorganisms. Changes in weather, such as increased rainfall and subsequent flooding may further lead to increased runoff and elevated levels of pathogenic microorganisms within the receiving rivers, ultimately contributing to increased levels of community illness. In addition, the re-suspension of sediments may consequently result in the reintroduction of sediment-associated pathogens into surface waters further leading to a poor water quality.

The South African guidelines for treated effluent being discharged into any receiving watershed state that treatment plants should comply with a 0 CFU/100 ml load for faecal coliforms. Results obtained throughout the sampling period indicate that these guidelines were exceeded 92% and 58% of the time for the NWWTP and NGTW respectively, with compliance being met only during October 2012 for the NWWTP. Gross exceedence of these guidelines indicates the contribution of these treatment plants to the poor water quality detected within the receiving watershed. Plant location forms a major factor in determining the contribution of sewage plants to the water quality within a receiving watershed. A range of additional factors need to be taken into consideration when considering plant location, such as surrounding communities and industries which determine the quality and volume of influent received as well as flood protection during periods of intense precipitation as this may lead to excessive overflows and plant infrastructure damage. The discharge point of the NWWTP is located approximately four kilometres away from the Umgeni river mouth, thus indicating the effect of tidal influences near the discharge point. Thus, tidal variation during the sampling period may have affected the levels of microbial indicator populations detected, with higher levels of indicators coinciding with a lower tidal flow as previously reported (Lipp *et al.*, 2001). In addition, after intense periods of rainfall, enumeration of higher levels of certain indicators may be attributed to the dislodging of sediment and increased turbidity. Previous studies have also indicated the presence of higher levels of bacterial indicators such as *C. perfringens* within sediment compared to the water column (Ferguson *et al.*, 1996). Gerba and Mcleod (1976) suggested that these higher indicator levels on sediment may be due to organic rich sediments which serve as a reservoir of pathogenic indicator bacteria.

Compared to the NWWTP, the NGTW is a much smaller plant, located more inland and with a design capacity of approximately 7 Mℓ/d. Previous Green Drop reports have reported a microbiological compliance of 67% and an operational capacity of approximately 10.9% (DWA, 2012). Treated effluent is discharged into the Aller River, which forms a smaller tributary of the Umgeni River and due to its inland location, was not subjected to any tidal influence. Effluent compliance with regards to faecal coliform levels was met during June, July, August, October and January whereby a count of 0 CFU/ 100 ml was recorded. Increases in all bacterial indicators observed during May, September and December may be attributed to inefficient treatment and plant malfunctioning. During sampling in September, a chlorine leak was noted resulting in the cessation of all chlorination treatment whilst no chlorination process was observed during sampling in December. Thus, both months resulted in the discharge of poor quality effluent into the receiving Aller River, consequently resulting in higher levels of all indicators downstream of the receiving river during these months. Extremely high levels of all bacterial indicators noted upstream of the Aller River throughout the sampling period may be attributed to the presence of a large informal settlement located on the banks of the Aller River. Direct discharge of untreated domestic waste containing faecal matter as well as overflowing pit latrine toilets and open defecation along the sides of the river bank from the surrounding settlement were noted throughout the sampling period, which may have contributed to the high microbial loads upstream.

The faecal coliforms to faecal streptococci (FC:FS) ratio has been proposed as one such method to differentiating between human and animal sources of contamination as faecal streptococci concentrations in human faeces are generally lower than that of faecal coliform concentrations. Cabral (2010) reported that ratios greater than 4 suggest human pollution whilst ratios less than 0.7 may suggest contamination from animal sources. Calculated FC:FS ratios indicate predominately human pollution both upstream and downstream of both the Aller and Umgeni River. However, previous microbial source tracking studies have also shown a shift in the ratio with time and distance from the source of pollution, indicating that this may serve as an unreliable means to identify and characterize the source of pollution (Sargeant, 1999).

Monitoring of bacteriophage populations in conjunction with bacterial indicators is imperative as many studies have shown their importance in serving as an additional faecal pollutant indicator as well as a means for enteric viral monitoring. Previous studies conducted by Armon *et al.* (1997) revealed the presence of somatic coliphages, F-RNA coliphages and bacteriophages infecting *Bacteroides fragilis* in drinking water in the absence of faecal coliforms. Similar trends were observed in this study during July, whereby no faecal coliforms were detected, yet a somatic coliphage population of 41.33 PFU/ml was recorded. Of the 96 samples tested, higher levels of somatic and F-RNA coliphages were obtained in 46.9% and 17.7% of the samples respectively. Skraber *et al.* (2002) stated that whilst somatic coliphage populations tend to be lower in wastewater than thermotolerant coliforms, a reverse relationship is noted in river water. Also, some coliform bacteria closely related to *E. coli* such as *Klebsiella* sp. may support the replication of somatic coliphages within freshwater environments. In addition to the dilution effect, additional environmental factors such as flow rate and water temperature may affect bacteriophage survival and proliferation. Previous studies conducted by Grabow *et al.* (1995) have shown somatic coliphages to outnumber F-RNA phages in wastewater by a factor of approximately 5 and cytopathogenic human viruses by about 500 whilst F-RNA phages outnumber cytopathogenic enteric viruses by a factor of 100. Whilst a similar ratio was observed within this study across certain months (Table 3.2 and Table 3.3), a range of variables have been shown to affect phage replication and survival within the water environment thus making it difficult to predict phage behaviour (Grabow 2001). Factors affecting the numbers and behaviour of phages within the water environment include the densities of both host bacteria and phages, the presence of organic matter, temperature and the concentration and type of ions (Havelaar and Hogeboom, 1983). Organic compounds such as humic and fulvic acids present within the water environment may interfere with phage attachment, while the presence of cations, such as calcium and magnesium can promote phage adsorption to the host bacterium. In addition, replication of phages within the water environment is dependant on the presence of the respective host bacteria. At low levels of host bacteria, the probability of a phage encountering a susceptible host is low, thus infection may not occur. Thus, factors affecting the survival and proliferation of host bacteria within the water column are important in determining if bacteriophage replication and proliferation will occur (Goyal *et al.*, 1987). In addition, temperature plays an important role for F-RNA coliphages which can only infect host bacteria at temperatures above 30 °C (Grabow, 2001). Previous studies have shown somatic coliphages to be resistant to commonly used disinfectant levels whilst inactivation of somatic and F-RNA coliphages by chlorine tends to be dose dependent rather than residual dependent (Grabow, 2001; Grabow *et al*., 1995) which may account for the high levels of bacteriophages enumerated at the discharge point during May, June, January and February (Table 3.2 and Table 3.4).

The above results obtained in this study provide an overall indication of treatment efficiency of the NWWTP and NGTW. With the increasing demands being placed on WWTPs to reduce their risk of contamination coupled with public health concerns, ensuring efficient operation and compliance to current legislation is imperative. Furthermore, results from this study clearly indicate that both plants fail to maintain a long-standing efficient operational status and may contribute to the poor quality of the surrounding watersheds into which the treated effluent is discharged. Variable bacterial indicator populations observed throughout the sampling period (Figures 3.1 – 3.6) further indicate a need to enforce the use of both bacterial and bacteriophage indicators to ensure a more accurate determination of water quality as previously suggested (Nwachcuku and Gerba, 2004), in conjunction with a continuous monitoring program of both WWTPs and surrounding surface waters.

CHAPTER FOUR

DETECTION OF HUMAN ADENOVIRUSES AND ENTEROVIRUSES IN TREATED WASTEWATER EFFLUENT AND RECEIVING WATERSHEDS IN DURBAN, SOUTH AFRICA

4.1 Introduction

Traditionally, bacterial indicator organisms have been used to determine the microbial quality of water; however, numerous studies have revealed the presence of enteric viruses in surface water sources which conform to current bacterial guidelines (van Heerden *et al.*, 2005; Pusch *et al.*, 2005). In developing countries, the prevalence of poor health care practices and inefficient sanitation and hygiene results in approximately 13 million deaths annually from gasteroenteric diseases due to the consumption of contaminated water (Theron and Cloete, 2002). Whilst sufficient knowledge regarding the role of water in the transmission of pathogenic enteric bacteria exists, that which is related to enteric viruses is less understood due to the difficulties associated with detecting these disease-causing agents (Bosch *et al.*, 2011). Waterborne diseases are often underdiagnosed with inadequate and expensive diagnostic technologies limiting efficient enteric viral detection (Bosch *et al.*, 2011). Enteric viruses are generally introduced into the aquatic environment via a range of activities such as leaking sewage and septic systems, urban runoff, agricultural runoff, sewage outfalls, broken pipelines as well as contaminated surface-, well-, ground- and borehole waters (Fong and Lipp, 2005). Despite current microbiological water quality standards including a range of bacterial indicators such as total coliforms, faecal coliforms and *E. coli*, often these standards are not adequate to indicate the presence of viral contamination (Pusch *et al.*, 2005; Cho *et al.*, 2000; Hot *et al.*, 2003).

Exposure to waterborne enteric viruses may result from the consumption of shellfish grown in contaminated water; food crops irrigated with contaminated wastewater or fertilized with sewage sludge as well as from sewage polluted recreational facilities. Despite being present at low concentrations, enteric viruses may cause a range of asymptomatic infections as well as a range of more serious diseases such as hepatitis, meningitis, paralysis and encephalitis in more immuno-compromised individuals and young children leading to high morbidity and mortality in both developed and developing countries (Okoh *et al.*, 2010). Despite a relatively low infectious dose, these viruses are often shed in extremely high numbers in the faeces of infected individuals with numbers ranging between $10^5 – 10^{11}$ viral particles per gram of stool. Also, these viruses are transmitted via diverse routes ranging from direct or indirect person to person contact, food, water as well as poor sanitation and hygiene practices (Bosch *et al.*, 1998; Wyn-Jones *et al.*, 2011). Human adenoviruses and enteroviruses are two of the most commonly studied viruses within the water environment, with numerous studies suggesting them as possible viral pollution indicators (Puig *et al.*, 1994; Hovi *et al.*, 2006; WHO, 2003b). Enteroviral infections are often regarded as being mild or asymptomatic, however, in certain instances they may be fatal (Muir *et al.*, 1998). These viruses are often associated with a range of respiratory illnesses, meningitis, myocarditis and neonatal multi-organ failure with large enteroviral outbreaks observed in Japan, Germany, France, Switzerland and Israel (Caro *et al.*, 2001; Akasu, 1997; Chambon *et al.*, 1999; Schumacher *et al.*, 1999 and Handsher *et al.*, 1999). Human adenoviruses are the only enteric virus with a DNA genome and have been associated with a range of gasteroenteric and respiratory diseases, haemorrhagic cystitis and conjunctivitis (Okoh *et al.*, 2010).

Whilst current wastewater treatment processes such as the activated sludge process, oxidation ponds, filtration, flocculation and disinfection may be highly effective against pathogenic bacteria, previous studies have shown these processes to only eliminate between 50% - 90% of viruses present (Theron and Cloete, 2002). Also, whilst physical processes may aid in the removal of viruses associated with large particles, smaller particles may still pass through to the disinfection process, which if not effective may lead to their discharge in surrounding water sources (Okoh *et al.*, 2010). In addition, the level of chlorination and disinfection time has proven to be inadequate in effectively removing many waterborne viral pathogens due to their stability and association with solids such as sludge (Theron and Cloete, 2002). Consequently, this may result in their accumulation in surrounding sediments, ultimately resulting in resuspension and contamination at later periods.

A variety of techniques have been described for viral recovery including adsorption onto electropositive or electronegative cartridges and membranes, gauze pads and glass powder. However, no single method has been considered superior, as the efficiency, consistency of performance, robustness, cost and complexity need to be taken into consideration when deciding on the method of choice (Bosch *et al.*, 2011). Meanwhile, viral recovery via glass-wool adsorption-elution has proven to be a cost effective alternative for viral concentration from large volumes of water and has been successfully applied to a range of water sources within South Africa (Van Heerden *et al.*, 2005; Ehlers *et al.*, 2005). Glass wool is held together by a binding agent and coated with mineral oil to create both hydrophobic and electropositive sites on its surface, thus aiding adsorption of negatively charged potential viral particles at neutral pH (Lambertini *et al.*, 2008). Apart from the cost effectiveness, this method has proven to be extremely simple, allowing non-expert laboratories to maintain a simple cost effective set-up (Bosch *et al.*, 2011). Thus, the main aim of this chapter was to detect the presence of human adenoviruses and enteroviruses in treated wastewater effluent of two WWTPs in Durban and the receiving surface water sources using a cost effective glass wool adsorption-elution procedure and PCR technique.

4.2 Materials and methods

4.2.1 Collection of water samples

Twenty five litre samples were collected seasonally from the final effluent and discharge point of the NWWTP and NGTW, as well as upstream and downstream of the respective receiving rivers. Samples were transported to the Microbiology Laboratories at the University of KwaZulu-Natal (Westville) and processed within 24 hr.

4.2.2 Viral recovery and secondary concentration

Human enteric viruses were recovered from the collected water samples using a glass wool adsorption-elution procedure according to Van Heerden *et al.* (2005). Perspex columns containing 10 g of compressed sodocalcic glass wool (Figure 4.1) were used for the recovery of potential enteroviruses and human adenoviruses. Twenty five litres of each sample were filtered through positively charged glass wool columns with an internal diameter of 25 mm and a length of 20 cm. The negatively charged viruses which adsorb to the positively charged glass wool were subsequently eluted with 100 ml of glycine beef extract buffer (pH 9.5) which reverses the ionic charge of the viruses and releases them from the glass wool. Immediately after elution, the pH of the eluate was neutralized to pH 7 using 1 M HCl followed by the addition of 14 g of polyethylene glycol (PEG) 6000 and 1.17 g of sodium chloride to the neutralised eluate. This was followed by gentle shaking and overnight flocculation at 4°C. Following this, the flocculated eluate was subjected to centrifugation at 3000 rpm for 30 min at 4°C. The resulting pellet was then re-suspended in 10 ml of phosphate buffer saline followed by vortexing and sonication for 30 sec. Subsequently, 2 ml of chloroform was added followed by centrifugation at 3000 rpm for

10 min at 4°C. The resulting supernatant was then transferred to a new collection tube followed by removal of the chloroform layer and storage at - 70°C until nucleic acid extraction.

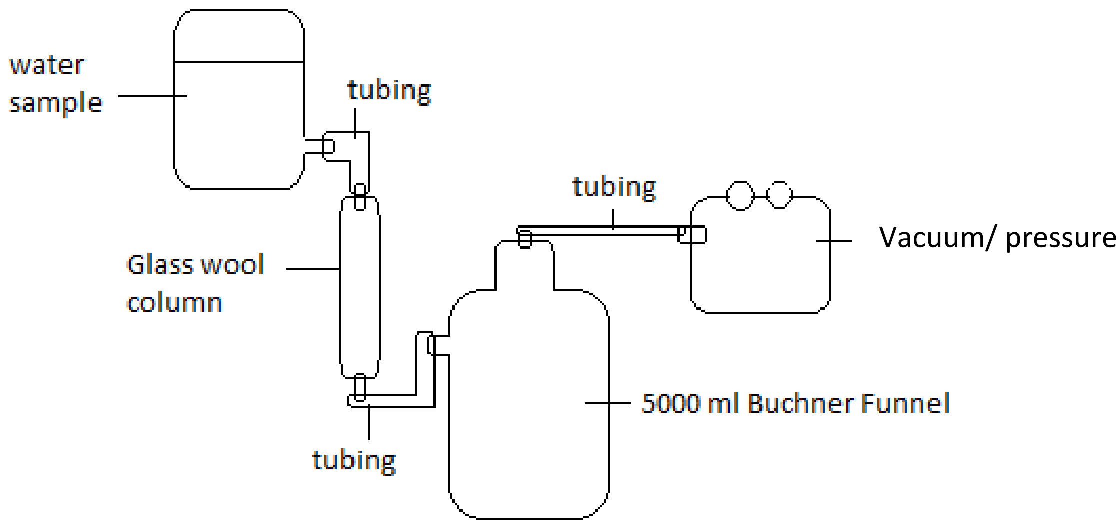


Figure 4.1: Set-up for the recovery of human enteric viruses using a glass-wool adsorption elution method (Van Heerden *et al.*, 2005)

4.2.3 Nucleic acid extraction

4.2.3.1 RNA Extraction

Extraction of RNA was carried out according to the TRIZOL Reagent technical insert (Invitrogen). One millilitre of previously concentrated water sample was centrifuged at 13 000 rpm for 10 min. Following centrifugation, pelleted cells were lysed in TRIzol Reagent (Invitrogen) by repetitive pipetting according to the manufacturer's instructions. Homogenized cells were incubated for 5 min at 25 °C to allow for complete dissociation of nucleoprotein complexes. Two hundred microliters of chloroform was added followed by vigorous shaking for 15 sec and incubation at 25 °C for 2 - 3 min. Samples were then centrifuged at 12 000 x g for 15 min at 4 °C. Following centrifugation, the mixture separated out into 3 layers namely, a lower red phenol-chloroform phase, an interphase and a colourless upper aqueous phase with the RNA remaining exclusively in the upper aqueous phase. The upper aqueous phase was then transferred to a fresh tube for RNA precipitation whilst the lower organic phase was retained for DNA isolation. The RNA was precipitated from the aqueous phase by mixing with 0.5 ml isopropyl alcohol. Samples were incubated at 25 °C for 10 min followed by centrifugation at 12 000 x *g* for 10 min at 4 °C. The RNA precipitate which was invisible before centrifugation subsequently formed a gel-like pellet on the side of the tube. The RNA wash involved decanting the supernatant, followed by washing of the invisible pellet once with 1 ml of 75% ethanol. The sample was mixed by vortexing followed by centrifugation at 7500 x *g* for 5 min at 4 °C and subsequently air dried for 10 min. The RNA pellet was redissolved in 10 µl of RNase-free water by repetitive pipetting followed by incubation for 10 min at 55 °C. RNA concentrations were determined on the NanoDrop 2000c (Thermo Scientific) using 1 µl of RNA sample. All samples were stored at – 70 °C until further use.

4.2.3.2 DNA Extraction

After the complete removal of the aqueous phase as required by the RNA isolation procedure, DNA from the interphase and phenol phase was isolated from the initial homogenate. The DNA was precipitated using 0.3 ml of ethanol and samples were mixed by inversion. Samples were then stored at 25 °C for 3 min and DNA was sedimented via centrifugation at 2000 x *g* for 5 min at 4 °C. The phenol-ethanol supernatant phase was then removed and the resulting DNA pellet was washed twice in a solution containing 0.1 M sodium citrate in 10% ethanol. One millilitre of the sodium-citrate-ethanol solution was used per 1 ml of TRIzol used for initial homogenization. During each wash, the DNA pellet was stored in the washing solution for 30 min at 25 °C and was mixed by inversion periodically, followed by centrifugation at 2000 x *g* for 5 min at 4 °C. The DNA pellet was washed three times and following these washes, the DNA pellet was suspended in 1.5 – 2 ml of 75% ethanol. This suspended DNA was stored for 15 min at 25 °C with periodic mixing followed by centrifugation at 2000 x *g* for 5 min at 4 °C. Subsequently DNA was air-dried for 10 min in an open tube and dissolved in 100 µl of 8 mM NaOH followed by centrifugation at 12 000 x *g* for 10 min. The supernatant containing DNA was then transferred to a new tube. For long term storage, samples were adjusted with HEPES buffer to pH 7 – 8 according to the manufacturer's instructions.

4.2.4 Viral detection

4.2.4.1 Enteroviruses

cDNA was generated from extracted RNA using the Revert Aid H Minus First Strand cDNA Synthesis Kit (ThermoScientific). Extracted RNA (1 µl) was mixed with 1 µl of 100 µm random hexamer primers and 10 µl of sterile double distilled water. This mixture was subjected to an initial denaturation heating step at 65 °C for 5 min followed by cooling on ice for 2 min. To this tube containing the template-primer mix, 8 µl of the RT-PCR was added. The RT-PCR mix consisted of 4 µl of 5x buffer, 1 µl of Ribolock RNase Inhibitor, 2 µl of 10 mM dNTPs and 1 µl of Revert Aid H Minus RT. The reaction mixture was then incubated at 25 ºC for 5 min, 42 ºC for 60 min followed by inactivation at 70 ºC for 5 min and the resultant cDNA stored at -70 °C until PCR amplification. Detection via PCR was performed using the BioRad T100 Thermal Cycler. PCR amplification of the 5 non-coding region was carried out, which is the most constant genome region in human enteroviruses. PCR mixes were prepared with a LightCycler Taqman Master Kit (Roche) according to Furhman *et al.* (2005). The Taqman reaction mixture consisted of a 20 µl reaction consisting of 5 µl cDNA, 4 µl master mix, 0.5 µl Primer EntV2 (10 µM), 0.5 µl Primer EntV1 (10 µM) (Table 4.1) and 10 µl dH_2O. Amplification reactions began with a pre-incubation activation step for 15 min at 95 ºC followed by 45 cycles of 15 s at 95 ºC, 30 s at 60 ºC and 30 s at 65 ºC followed by cooling at 40 °C for 30 s.

4.2.4.2 Human adenoviruses

A nested PCR protocol described by Van Heerden *et al.* (2005) was used for Human Adenoviral DNA amplification. The primers used for the first and second round PCR amplification were specific for the detection of the hexon protein coding region of the human adenoviral genome (Table 4.1). A 50 µl reaction volume was prepared for the first round containing 28.5 µl nuclease-free water, 5 µl 10x buffer, 8 µl 25mM $MgCl_2$, 2 µl 10 mM dNTP mix, 0.5 µl primer Adhex1F (100 µM), 0.5 µl primer Adhex2R (100 µM), 2.5 U *Taq* polymerase and 5 µl of extracted DNA. Cycling conditions were as follows: initial denaturation at 94 °C for 2 min, followed by 30 cycles of denaturation at 93 °C for 1 min, annealing at 50 °C for 1 min and extension at 72 °C for 1 min followed by a final extension at 72 °C for 6 min. Subsequently 1 µl of the first round PCR was transferred to a nested PCR mixture containing 33 µl sterile distilled water, 5 µl 10x PCR buffer, 8 µl of 25 mM $MgCl_2$, 1.5 µl 10 mM dNTP mix, 0.5 µl primer Adhex2F (100 µM), 0.5 µl primer Adhex1R (100 µM) and 2.5 U *Taq* polymerase. Cycling conditions were as follows: initial denaturation at 94 °C for 2 min followed by 30 cycles of denaturation at 93 °C for 1 min, annealing at 55 °C for 1 min and extension at 72 °C for 1 min, followed by a final extension step at 72 °C for 6 min.

Table 4.1: PCR Primers used for the detection of Enteroviruses and Human Adenoviruses

VIRUS	PRIMER	SEQUENCE (5´-3´)	PRODUCT SIZE (bp)	REFERENCE
Enterovirus	EV2 F EV1 R	GCCCCAGTGGTCTTACATGCACATC GCCACGGTGGGGTTTCTAAACTT	128	Furhman *et al.* (2005)
Adenovirus	ADHEX1F ADHEX2R	AACACCTAYGASTACATGAAC KATGGGGTARAGCATGTT	473	Van Heerden *et al.* (2005)
	ADHEX2F ADHEX1R	CCCMTTYAACCACCACCG ACATCCTTBCKGAAGTTCCA	168	

4.2.5 Staining and visualization

All PCR products were analysed on a 2% electrophoresis grade agarose gel (Whitehead Scientific) and visualised with ultraviolet illumination using the ChemiGenius BioImaging System followed by analysis using the SynGene GeneSnap 6.08 Software (Cambridge, England).

4.2.6 Sequencing and phylogenetic analysis

All amplicons obtained after PCR were sequenced at Inqaba Biotech (South Africa). Obtained sequences were compared with all nucleotide sequences present in the GenBank database by using the PubMed National Centre for Biotechnology Information BLAST program (www.ncbi.nlm.nih.gov/BLAST). Sequence editing and analysis was done using BioEdit Sequence Alignment Editor Version 7.0.9.0. (Hall, 1999) followed by sequence alignment using Clustal X for Windows Version 2.1. Phylogenetic trees were constructed using MEGA5 with tree topology being inferred using the neighbour-joining algorithm. Bootstrap analysis was done using 500 replicates.

4.3 Results

4.3.1 Detection of human adenoviruses and enteroviruses

Sixteen water samples (4 collected before chlorination, 4 at the discharge point and 8 samples upstream and downstream of the respective receiving rivers) were collected from each treatment plant across the seasons making a total of 32 water samples collected and analysed for the presence of enteroviruses and human adenoviruses over a one year period. Conventional PCR revealed the presence of enteroviruses in 100% (8/8) of unchlorinated final effluent samples, 87.5% (7/8) of chlorinated final effluent and 93.75% (15/16) of receiving river samples (Table 4.2). Within the NWWTP, enteroviruses were detected in samples collected before chlorination and at discharge points throughout the sampling period except during autumn. Similarly for the NGTW, all samples collected before chlorination and at the discharge point tested positive for enteroviruses throughout the sampling period. No enteroviruses were detected upstream of the Umgeni River during winter whilst all other samples tested positive. All samples collected from the Aller River tested positive for enteroviruses throughout the sampling period. Amplicon sequencing followed by BLAST analysis revealed a 91 – 99% similarity of the enteric viruses detected in these samples to previously identified enteroviral or coxsackievirus strains. For example, enterovirus detected in water samples collected before chlorination from the NWWTP during autumn was found to be 98% similar to the Human enterovirus 71 strain (Accession Number: KC570453.1).

Variable results were obtained for human adenoviral detection throughout the sampling period. On numerous occasions, the first round PCR failed to give visible bands on an agarose gel. However, conventional nested PCR revealed detection of human adenoviruses in 50% of the final effluent samples before chlorination, 62.5% in samples collected at the discharge point and 62.5% of river water samples (Table 4.2). Human adenoviruses were detected at the discharge point of the NWWTP during spring and autumn, whilst discharge point samples collected for the NGTW tested positive during spring, summer and autumn. All river samples (upstream and downstream) of the Umgeni and Aller River collected during summer tested positive whilst human adenovirus was detected downstream of the rivers during spring, summer and autumn. Sequencing of the PCR products of the adenovirus amplified in the water samples followed by BLAST analysis revealed a 91 – 99% similarity to previously identified Human Adenovirus strains. For example, adenovirus detected in the discharge point sample of NWWTP was found to be 98% similar to Human adenoviral C strain ADV (Accession Number: GU048702.1).

Table 4.2: Seasonal detection of human adenovirus and enterovirus in water samples collected from the NWWTP and NGTW and receiving rivers

		NWWTP		NGTW	
SEASON	**SAMPLING POINT**	**ENTERO**	**ADENO**	**ENTERO**	**ADENO**
AUTUMN	**BC**	+	+	+	+
	DP	-	+	+	+
	US	+	-	+	-
	DS	+	+	+	+
WINTER	**BC**	+	-	+	-
	DP	+	-	+	-
	US	-	-	+	+
	DS	+	-	+	-
SPRING	**BC**	+	+	+	-
	DP	+	+	+	+
	US	+	+	+	+
	DS	+	+	+	+
SUMMER	**BC**	+	+	+	-
	DP	+	-	+	+
	US	+	+	+	+
	DS	+	+	+	+

BC: Before chlorination; DP: discharge point; US: upstream; DS: downstream; (+): virus present; (-): no virus detected

4.3.2 Phylogenetic analysis of detected human adenoviruses and enteroviruses

The evolutionary relationships of enteroviruses detected in the treated effluent of NWWTP and the receiving Umgeni River is depicted in Figure 4.2, while those of the NGTW and receiving Aller River is shown in Figure 4.3. Enteroviral isolates detected in samples collected before chlorination during spring clustered together with isolates detected at the discharge point during winter and summer for the NWWTP whilst isolates detected upstream of the Umgeni River during spring and downstream during autumn clustered closely together (Figure 4.2). Similarly, enteroviral isolates detected downstream of the Aller river during autumn clustered closely with isolates at the discharge point for the NGTW during autumn as well, whilst isolates detected at the before chlorination sampling point during autumn and winter clustered together for the NGTW (Figure 4.3).

Evolutionary relationships of Human adenoviruses detected in the treated effluent of the NWWTP and the receiving Aller River is depicted in Figure 4.4, whilst those of the NGTW and receiving Aller River is shown in Figure 4.5. Human adenoviral isolates detected upstream and downstream of the Umgeni River for the NWWTP during summer clustered closely with isolate detected at the NWWTP discharge point during autumn (Figure 4.4). Similarly isolates detected upstream and downstream of the Aller River during summer clustered closely together (Figure 4.5).

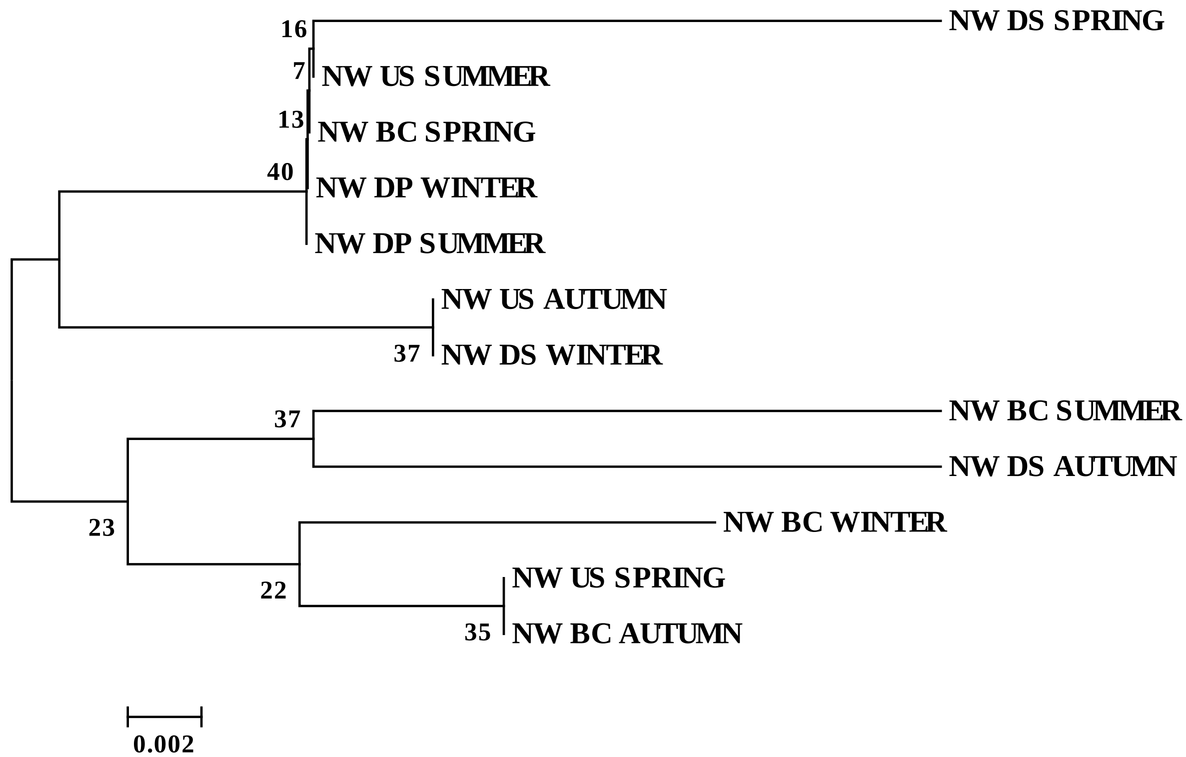


Figure 4.2: Evolutionary relationships of enteroviral taxa sequenced from NWWTP and receiving Umgeni River across all seasons. The evolutionary history was inferred using the Neighbour-Joining method (Saitou and Nei, 1987). The bootstrap consensus tree inferred from 500 replicates is taken to represent the evolutionary history of the taxa analysed. Branches corresponding to partitions reproduced in less than 50% bootstrap replicates are collapsed. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (500 replicates) are shown next to the branches (Felsenstein, 1985). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Jukes-Cantor method (Jukes and Cantor, 1969) and are in the units of the number of base substitutions per site. The analysis involved 12 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 60 positions in the final dataset. Evolutionary analyses were conducted in MEGA5 (Tamura *et al*., 2011).

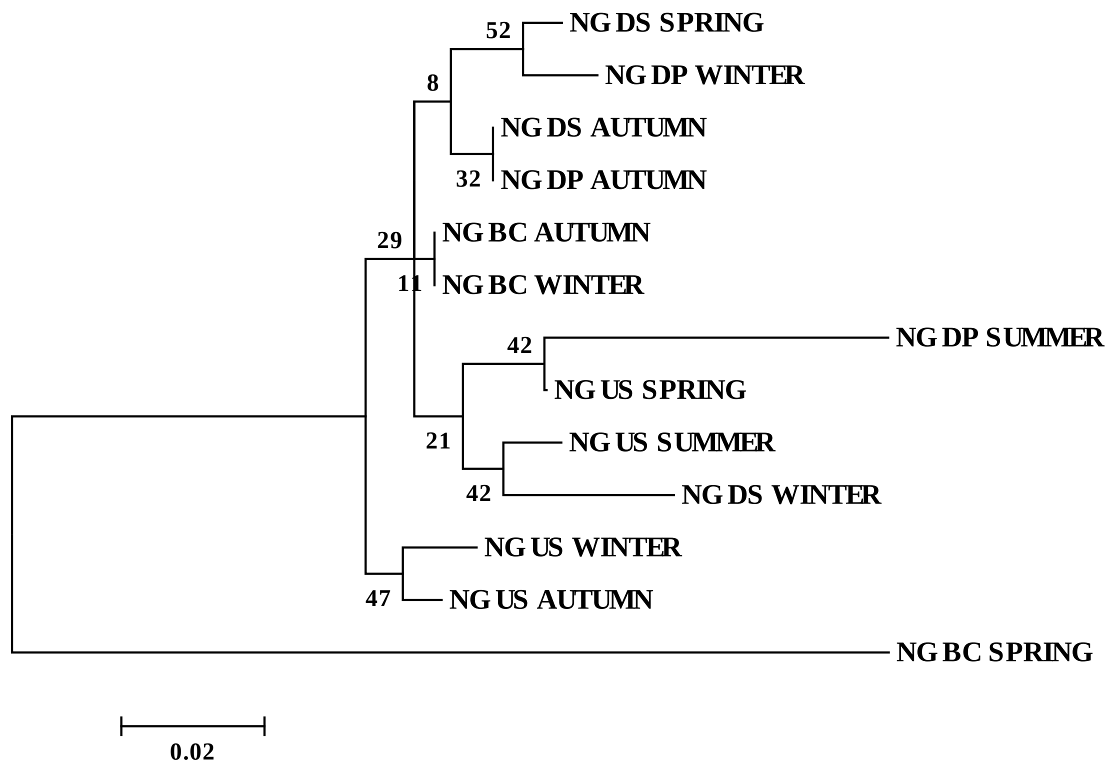


Figure 4.3: Evolutionary relationships of enteroviral taxa sequenced from NGTW and receiving Aller River across all seasons. The evolutionary history was inferred using the Neighbour-Joining method (Saitou and Nei, 1987). The bootstrap consensus tree inferred from 500 replicates is taken to represent the evolutionary history of the taxa analysed (Felsenstein, 1985). Branches corresponding to partitions reproduced in less than 50% bootstrap replicates are collapsed. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (500 replicates) are shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Jukes-Cantor method and are in the units of the number of base substitutions per site (Jukes and Cantor, 1969). The analysis involved 13 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 64 positions in the final dataset. Evolutionary analyses were conducted in MEGA5 (Tamura *et al.*, 2011).

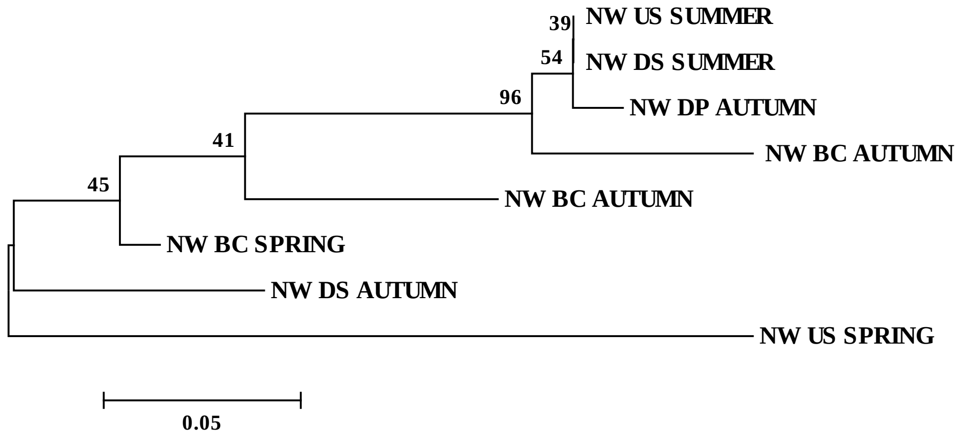


Figure 4.4: Evolutionary relationships of adenoviral taxa sequenced from NWWTP and receiving Umgeni River across all seasons. The evolutionary history was inferred using the Neighbour-Joining method (Saitou and Nei, 1987). The bootstrap consensus tree inferred from 500 replicates is taken to represent the evolutionary history of the taxa analysed (Felsenstein, 1985). Branches corresponding to partitions reproduced in less than 50% bootstrap replicates are collapsed. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (500 replicates) are shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Jukes-Cantor method and are in the units of the number of base substitutions per site (Jukes and Cantor, 1969). The analysis involved 8 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 79 positions in the final dataset. Evolutionary analyses were conducted in MEGA5 (Tamura *et al*., 2011).

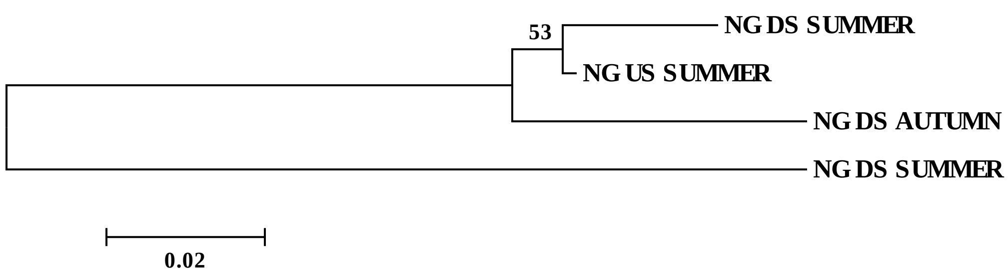


Figure 4.5: Evolutionary relationships of adenoviral taxa sequenced from NGTW and receiving Aller River across all seasons. The evolutionary history was inferred using the Neighbour-Joining method (Saitou and Nei, 1987). The optimal tree with the sum of branch length = 0.22952000 is shown. The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (500 replicates) are shown next to the branches (Felsenstein, 1985). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Jukes-Cantor method and are in the units of the number of base substitutions per site (Jukes and Cantor, 1969). The analysis involved 4 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 96 positions in the final dataset. Evolutionary analyses were conducted in MEGA5 (Tamura *et al*., 2011).

4.4 Discussion

Surface water sources may be contaminated with a range of enteric viruses from a variety of sources such as raw sewage, wastewater discharges as well as domestic and animal run-off with the most commonly reported enteric viruses being adenovirus, enterovirus, norovirus, rotavirus and hepatitis A and E viruses (Wong *et al.*, 2012). The main aim of this chapter was to recover and detect the presence of two important enteric viruses commonly implicated in waterborne diseases, namely enteroviruses and human adenoviruses, in treated wastewater effluent of two WWTPs and receiving river water sources in the Durban area using a glass wool adsorption-elution method and a PCR assay. Numerous methods have been developed in order to evaluate and monitor the microbiological quality of surface water sources as well as the efficacy of treatment plant processes with the majority of emphasis being placed on pathogenic bacterial contamination. The traditional method for human pathogenic viral detection is cell culture, however it has proven to be costly, time consuming and impractical for continuous monitoring. Thus, numerous methods have been developed and whilst there has been an increase in the number of studies investigating the presence of human enteric viruses in wastewater within South Africa, the absence of sufficient expertise and knowledge of a viral concentration method that is cost effective and operates well with high recovery efficiency is one of the main reasons for the low detection and report rates of human enteric viral contamination (Chigor and Okoh, 2012). Thus, there is a growing demand for more rapid, cost effective and more robust method that will aid in the detection of viruses from environmental samples. Previous studies have highlighted the efficiency of glass wool as a cost effective and simple means to recover and concentrate viruses, however; the effectiveness depends on the type of virus, water pH and water constituents present (Gantzer *et al.*, 1997). Lambertini *et al*. (2008) reported glass wool recovery efficiencies to be significantly affected by water pH with recovery efficiencies decreasing at pH's greater than 7.5. Thus, the method should be optimised based on the isoelectric points and adsorptive behaviours of individual viral types being detected (Lambertini *et al.*, 2008).

Although most molecular-based methods fail to distinguish between infectious and non-infectious viral particles, the presence of viral nucleic acid in contaminated water sources suggests the presence of infective viral particles as the survival of naked nucleic acids is usually low within the water environment (Lambertini *et al.,* 2008). In addition, the glass wool adsorption-elution method has been found to be more effective in retaining infectious intact viral particles rather than naked viral nucleic acid, thus only viral capsids adsorb to the glass wool whilst naked DNA passes through the columns during filtration. Hence, the enteric viruses detected in this study were probably intact and infectious, thus indicating their potential threat to those utilising these water sources for direct domestic and recreation use. The detection of both viral types at the discharge point (Table 4.2) indicates both, the resistance of these viruses to currently used chlorination treatment as well as inefficient chlorination procedures noted within the treatment plant itself. This corroborates previous studies that have highlighted the resistance of these viruses to common conventional tertiary treatments with no correlation between viral loads and the reported high removal efficiency of commonly used bacterial indicators (Le Cann *et al.,* 2004; Meleg *et al.,* 2006). In addition, numerous studies have highlighted the stability of human adenoviruses compared to other commonly detected enteric viruses when subjected to UV irradiation (Bofill-Mas *et al.* 2006; Eischeid *et al.* 2009; Lee and Shin 2011; Nwachuku *et al.* 2005). In this study however, human adenoviruses were detected in 62.5% of all samples collected for both plants whilst enteroviruses were detected in 100% and 87.5% of samples collected at the NGTW and NWWTP respectively (Table 4.2).

Analysis of adenoviral sequences revealed a 91 – 99% similarity to previously confirmed human adenoviral isolates in the GenBank database with phylogenetic analysis indicating isolates detected upstream and downstream of the receiving Umgeni river during summer as well as those detected at the discharge point during autumn being closely related and clustering together (Figure 4.4). Similarly, human adenoviral isolates confirmed in the upstream and downstream samples of the Aller river during summer exhibited the closest similarity (Figure 4.5). Previous studies have confirmed the specificity of human adenoviral strains, with only human waste and infected individuals serving as a source of these strains (Motes *et al.*, 2004). Also, human adenoviral infections are known to occur throughout the year with the infection rate being more common in late winter, spring and early summer which may be due to increased rainfall and hence increased run-off from surrounding areas (Fong *et al.*, 2010). In addition, these viral agents are generally associated with nosocomial infections, with type 40 and 41 being considered the most important cause of childhood gastrointestinal illnesses (Magwalivha, 2009). Thus the lack of seasonal variability associated with human adenoviral detection in this study indicates that the occurrence of human adenoviruses within the aquatic environment is most likely due to contamination with untreated or improperly treated human sewage (Hang, 2006).

Viral distribution within water systems depends on a range of factors such as temperature, pH, humidity and season with previous studies indicating enteroviral loads of approximately 2 - 500 PFU/l with loads as high as 5600 PFU/l recorded during disease outbreaks and epidemics (Kocwa-Haluch, 2001). Analysis of enteroviral sequences showed isolate similarity (99%, 98% and 97%) to that of Human Enterovirus 90 isolate 01421 (Accession Number: KC570453.1), Human Enterovirus 71 strain (Accession Number: JX390655.1) and the Human coxsackievirus

A20 strain CVA20a (Accession Number: EF015021.1) amongst others (Figure 4.2 and 4.3). Detection of these viruses throughout the sampling period and within the receiving watershed indicates that these viruses are frequently excreted and relatively resistant not only to tertiary treatments but also to natural inactivation processes within surface water resources (Hundesa *et al.*, 2006). Phylogenetic analysis was used to determine similarities between viral isolates detected at the different sampling points with the results obtained for enteroviral isolates from the NWWTP and receiving Umgeni River (Figure 4.2) indicating that those isolates detected upstream and at the discharge point during summer, those detected before chlorination and downstream sampling point during spring as well as those at the discharge point during winter clustering together and are thus closely related. Generally, filtration of large volumes of water may result in the concentration of high levels of PCR inhibitors such as humic acids which may inhibit downstream detection assays (Kocwa-Haluch, 2000). Thus, failure to detect human adenoviruses at the NGTW in samples collected before chlorination whilst discharge point samples tested positive could be attributed to high concentrations of inhibitors which may have affected the PCR assay.

Overall, the data obtained in this study confirm the effectiveness of a more economical method for viral recovery and concentration, namely the glass wool adsorption-elution procedure. In addition, the results have also indicated that tertiary treatment processes within the two treatment plants monitored, whilst possibly effective for currently monitored bacterial indicators, it is not effective for the removal of enteroviruses and human adenoviruses. This further emphasises the need to incorporate viral indictors into the current water quality guideline as the treated effluent discharge from these WWTPs could further contaminate the receiving surface water and pose a serious threat to the end users of these surface water resources.

CHAPTER FIVE

GENERAL DISCUSSION AND CONCLUSION

5.1 Research in perspective

Water scarcity in South Africa together with poor spatial distribution of rainfall and increasing demographics, have accelerated the demands on water resources. In addition, increasing global energy demands coupled with increasing agricultural needs has resulted in the mobilisation of extensive nutrient resources, all of which have contributed to the water quality problem (Elser and Bennett, 2011). Future predictions indicate that by 2100, the loss of biodiversity and resultant downstream effects on surrounding communities will be greater for aquatic ecosystems than for terrestrial ones (Sala *et al.*, 2000). Whilst rivers serve as a vital indispensable freshwater resource, globally their importance is underestimated as they serve as the main resources for a range of domestic, industrial and agricultural activities with their declining quality hindering the overall productivity and long term sustainability (Faith, 2006; Venkateharaju *et al.*, 2010). Variations in water quality occur as a result of natural variability, societal development and pollutant discharges. In addition, seasonal and geographical variations exert an additional effect on water quality leading to the accumulation of pollutants in certain environments even when there is no point source pollution present. This together with constant industrial and urban development, coupled with agricultural runoff contributes to the deterioration of water quality resulting in poor physico-chemical and microbial profiles. Thus, ensuring the overall long term understanding of river health is critical to implement adequate plans to manage, maintain and restore good water quality.

Despite numerous reports on the poor physicochemical and microbial quality of treated effluents from wastewater treatment plants and receiving watersheds in other South African provinces (Samie *et al.*, 2009; Igbinosa and Okoh, 2009; Preez *et al.*, 1987), the efficiency of wastewater treatment plants and the impact of treated effluent discharge on the quality of surface waters, particularly within the Umgeni River, Durban has not been adequately investigated. Hence, the main focus of this study was to determine the microbiological and chemical quality of treated final effluent being discharged from two independent wastewater treatment plants into receiving water bodies in the Durban area and to ascertain if these plants contribute significantly to the poor quality of the receiving aquatic milieu. The results obtained in this study revealed that whilst the independent treatment plants monitored, exhibited effluent qualities that met acceptable standards for some parameters such as pH and temperature, the effluent quality fell short of other standard requirements such as turbidity, orthophosphate, nitrate, COD and faecal coliforms, with values as high as 76.43 NTU, 3.99 mg/l, 8.22 mg/l, 313.89 mg/l and 3.97×10^3 CFU/ml obtained respectively. From the results presented in chapter two, it is clear that tertiary treatment processes exhibited a limited impact on certain physico-chemical parameters such as turbidity, whereby an increase in turbidity at the discharge point was observed 66.7% of the time throughout the sampling period relative to before chlorination. Similarly, increases in nutrient levels were also noted at the discharge point over several months with a 215.23% increased nitrate and a 12.21% increased phosphate concentration observed in December and September, respectively. In addition, point and diffuse sources of pollution coupled with a range of peripheral factors such as changing tides, atmospheric deposition and surrounding industrial and anthropogenic activities may have further contributed to the fluctuating physical, chemical and nutrient profiles observed within the receiving watershed.

Similarly, results presented in chapter three and four highlighted the increased levels of microbial indicators, poor reduction efficiencies and the presence of faecal coliforms and enteric viruses at the discharge point, indicative of health and environmental risk. Higher levels of certain indicator bacteria were observed at the discharge point compared to before chlorination across various months with February 2013 exhibiting increases for all enumerated indicators namely, total coliforms (21.73%); *E. coli* (72.14%), faecal coliforms (5.65%), faecal streptocci (100%) and enterococci (108.93%) for the NWWTP. In addition, despite the South African guideline for treated effluent stipulating that no faecal coliforms should be present in treated effluent being discharged into any receiving water body, this guideline was only met in October 2012 for the NWWTP. Similarly, high counts of both somatic and F-RNA coliphages were detected at the discharge point throughout the sampling period with coliphages being detected during July in the absence of faecal coliforms indicating the need for a combination of indicators.

Despite the long term use of bacteria as indicators of water quality, numerous studies have reported on their inadequacy to accurately determine the presence of enteric viruses or protozoa, with more research being required on currently monitored indicators (Gironez *et al.*, 2010). Hence, chapter four focused on determining the presence of enteroviruses and human adenoviruses which have been commonly implicated in disease outbreaks in South Africa. Results obtained indicated the presence of both viruses within collected samples, with human adenovirus being detected in 62.5% of all samples collected for both plants and enteroviruses in 100% and 87.5% of samples collected from NWWTP and NGTW respectively. Similar to other findings, results presented in chapters three and four of this study revealed that whilst detected bacterial indicators provided an overall indication of the water quality within the receiving watersheds, there was no link between the presence of bacterial indicators monitored and that of coliphages and enteric viruses in certain months. This further confirmed the possible need for the use of coliphages as indicators of faecal contamination, reinforcing their potential to serve as a valuable model for predicting the presence of enteric viruses in contaminated water due to the many similarities between the two groups (Grabow, 2001).

In order for sewage treatment plants to meet national and international standards, there is a growing need to improve current treatment processes and to adopt more rigid methods for monitoring final effluent being discharged into any receiving water body. The design and implementation of affordable and suitable equipment and wastewater technologies in conjunction with adequate training of workforce within treatment plants will further aid management and treatment efficiencies, especially in developing countries. In addition, the privatization of treatment plants as well as the inclusion of suitable penalties such as the 'polluter-pays' principle together with a bottom-up approach involving community education and involvement may further aid the overall improvement and prevention of further contamination of existing water bodies (Doughari *et al.*, 2007). Accurate and timeous information on the quality of water is necessary to develop a sound public policy and to ensure the implementation of efficient water quality improvement programmes. In addition, ensuring effective societal communication measures through the introduction of simple easy to understand water quality indices will allow for ease of understanding regarding water quality trends. Ensuring rigorous water quality monitoring is imperative for the provision of reference data that will aid policy development as well as the protection and management of existing water resources (Varunprasath and Daniel, 2010). Therefore, more stringent monitoring of wastewater treatment plants is required to ensure compliance with current guidelines. In addition, current legislation should be enforced and industries discharging toxic wastes should be registered according to the effluent they discharge with toxic chemicals being used in agriculture and industry being monitored and intensely studied. Without an adequate water supply of good quality, surrounding communities as well as further agricultural developments will suffer and the overall economy affected.

5.2 Potential for future developments

Results presented in the current study indicate that utilising a single indicator to predict water quality is grossly insufficient and inaccurate. Thus, the development of a water quality monitoring program utilising a range of bacterial indicators in conjunction with both coliphage and enteric viruses requires additional investigation. Whilst the presumptive enumeration of bacterial indicators is a more cost effective method, these methods combined with the use of molecular-based techniques can successfully lead to more conclusive results regarding faecal contamination of water. In addition, whilst monitoring the surface water sources may provide an overview of the current status of the water body, the quality and quantity of surrounding sediments within the watershed often poses an indirect effect on the ecological quality of the water body, reflecting the long term profile in conjunction with current point sources of pollution (Stronkhorst *et al.*, 2004). Numerous pollutants may be accumulated within sediments over extended periods of time and re-suspended at later periods affecting the overall physico-chemical and microbial quality of the water body (Adeyemo *et al.*, 2008). Thus, monitoring the quality of the surface water in conjunction with sediment quality is imperative for a more accurate understanding of the health status of the watershed.

Whilst the glass-wool adsorption elution method offers a promising cost effective alternative to viral recovery and concentration, its effectiveness depends on the water quality and type of virus being recovered. Previous studies have indicated varying recovery efficacies ranging between 14 – 90% for different enteric viral types, thus further optimisation of the glass wool adsorption procedure based on the isoelectric point of respective viruses would aid the recovery and detection process (Lambertini *et al.*, 2008). In addition, the inclusion of an internal control will aid in determining the overall recovery efficiencies. Previous studies have indicated that extremely low viral numbers are required for disease outbreak and infection, thus quantifying the relative viral loads within the monitored sites will provide a more accurate indication of the overall quality and disease risk. In this study, whilst conventional PCR was utilised to detect the presence of enteroviruses and human adenoviruses, it merely served as a qualitative procedure with the degree of contamination not being determined. Thus, quantitative real-time PCR will serve as one such alternative to quickly detect and enumerate enteric viruses in a one-step reaction within collected samples. The utilisation of specific probes will result in increased sensitivity, coupled with a less time-consuming procedure due to the elimination of confirmation with gel electrophoresis. In addition, the entire assay is carried out in a closed system thereby reducing the potential for cross contamination (Fong and Lipp, 2005). Further quantification of viral copy numbers present within the watershed will provide greater information regarding the potential for human infection and disease outbreak.

Previous clinical studies have indicated that a diverse range of enteric viral genera colonize the gastrointestinal tract of humans with the most important being rotaviruses, adenoviruses, noroviruses, enteroviruses as well as Hepatitis A and E viruses (Okoh *et al.*, 2010). In addition, the USEPA has listed adenoviruses, caliciviruses, coxsackieviruses and echoviruses on the

Candidate Contaminant List which poses a risk to drinking water systems (Nwachcuku and Gerba, 2004). Due to the complexities associated with testing for individual viral genera, it has become impractical to monitor the presence of every enteric viral genera known to occur within a contaminated water body. Thus, whilst reliance on bacterial indicator organisms has proven to be unsuccessful, previous studies have suggested poliovirus as a model indicator strain for enteric viral pollution (Bosch, 1998). However, evidence has also shown that whilst it does not resemble the behaviour of commonly detected human enteric viruses, such as hepatitis A virus or rotaviruses, the establishment of a single viral indicator is difficult due to varying viral characteristics in different water environments. Globally, numerous studies have identified both rotavirus and norovirus, amongst others as being important enteric viral pathogens that cause gasteroenteritis. Rotavirus has been implicated as one of the leading causes of global childhood diarrhoea, more so in developing countries with more than 0.6 million deaths under the age of 5 being attributed to rotaviral infections (Hashuzume *et al.*, 2008). In addition, whilst the first South African noroviral outbreaks were documented in 1993, limited knowledge of circulating genotypes exists with the lack of sufficient noroviral outbreak monitoring and reporting systems having resulted in the underestimation of contamination and impact of infections. Thus, it is imperative to characterize and quantify other important viral pathogens of human concern in the water samples.

Whilst bacteriophages have been identified as a potential indicator of poor water quality, numerous studies have highlighted the need for future research into their beneficial properties (Withey *et al.*, 2005). With the increasing antibiotic resistance in bacteria, numerous studies have raised interest in the bacteriocidal properties of bacteriophages, with reported phage treatments against a range of enteric bacterial pathogens (Sulakvelidze *et al.*, 2001; Chanishvili *et al.*, 2001). In addition, previous reports have further highlighted the possible use of bacteriophages in wider environmental applications such as in the control of cyanobacterial blooms, phage-induced bacterial lysis of biological warfare bacteria such as *Bacillus anthracis* as well as in improving wastewater treatment processes (Thomas *et al.*, 2002). Thus, future research focusing on characterisation of bacteriophages obtained in this study for possible discovery of novel bacteriophages that could be applicable in wastewater treatment and other important applications is imperative for greater insight into the beneficial applications of bacteriophages.

In conclusion, it is a well-known fact that man has dominated the planet for decades and with the constant increasing population, hydrological variability and rapid urbanization coupled with the urgency for greater socio-economic development, man will continue to play an ever increasing dominant role. Twenty years after the Rio Earth Summit highlighted the seriousness of the global water situation, considerable improvements have been made to safe guard this precious resource. However, it has become increasingly difficult to obtain a global perspective of surface water quality as different nations struggle with different environmental pressures. Whilst further progress is possible, one of our generation's greatest challenges is building a meaningful connection between science and society that will aid in combating this crisis.

REFERENCES

Abowei, J. F. N. 2010. Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. Advance Journal of Food Science and Technology. **2:**16-21.

Adeyemo, O. K., O. A. Adedokun, R. K. Yusuf, E. A. Adeleye. 2008. Seasonal Changes In Physico-Chemical Parameters And Nutrient Load Of River Sediments In Ibadan City, Nigeria. Global Nest Journal. **10:**326-336.

African Ministers' Council on Water (AMCOW). 2012. Status report on the application of integrated approaches to water resources management in Africa.

Akasu, Y. 1997. Outbreak of aseptic meningitis due to ECHO- 9 in northern Kyushu island in the summer of 1997. Kurume Medical Journal. **46:**97–104.

Alexiou, G. E. and Mara, D.D. 2003. Anaerobic wastewater stabilization ponds: a low cost contribution to a sustainable wastewater reuse cycle. Applied biochemistry and biotechnology. **109:**241 – 252.

Angulo, F.J., S. Tippen, D. J. Sharp, B. J. Payne, C. Collier, J. E. Hill, T. J. Barett, R. M. Clark, E. E. Geldrich, H. D. Donnell Jr. and D. L. Swerdlow. 1997. A community waterborne outbreak of salmonellosis and the effectiveness of a boil water order. American Journal of Public Health. **87:**580–584.

APHA. 1998. Standard methods for the examination of water and wastewater. 20th edition. American public health association. Washington D.C.

Armon, R., Araujo, R., Kott, Y., Lucena, F., and Jofre, J. 1997. Bacteriophages of enteric bacteria in drinking water, comparison of their distribution in two countries. Journal of Applied Microbiology. **83:** 627–633.

Ashbolt, N. J., W. O. K. Grabow and M. Snozzi. 2001. Indicators of Microbial Quality. Water Quality: Guidelines, Standards and Health. World Health Organization (WHO). Edited by Lorna Fewtrell and Jamie Bartram. Published by IWA Publishing, London, UK. ISBN: 1 900222 28 0.

Ashbolt, N. J. 2004. Microbial contamination of drinking water and disease outcomes in developing regions. Toxicology. **198:**229–238.

Asiedu, K. 2001. Evaluationg biological treatment systems - Moving Bed Biofilm Reactor Versus Biological Aerated Filtration And Sulfide-Induced Corrosion In Anaerobic Digester Gas Piping. Department of Civil and Environmental Engineering. Blacksburg, Virginia.

Barnes, B., P. J. Bliss, B. W. Gould and H. R. Vallentine. 1981. Water and Wastewater Engineering Systems. Pitman Publishing, London.

Barrell, R. A. E., P. R. Hunter and G. Nichols. 2000. Microbiological standards for water and their relationship to health risk. Communicable Disease and Public Health. **3:**8-13.

Benko, M. and B. Harrach. 2003. Molecular evolution of adenoviruses. Current Topics in Microbiology and Immunology. **272:**3-35.

Bidawid, S., J. M. Farber and S. A. Sattar. 2001, Survival of hepatitis A virus on modified atmosphere-packaged (MAP) lettuce. Food Microbiology. **18:**95–102.

Bigas, H. (Ed.), 2012. The Global Water Crisis: Addressing an Urgent Security Issue. Papers for the InterAction Council, 2011-2012. Hamilton, Canada: UNU-INWEH.

Blacklow, N R. Norwalk Virus and Other Caliciviruses. In: Baron S, editor. Medical Microbiology. 4th edition. Galveston (TX): University of Texas Medical Branch at Galveston; 1996. Chapter 65. Available from: http://www.ncbi.nlm.nih.gov/books/NBK8545/

Bofill-Mas, S., N. Albinana-Gimenez, P. Clemente-Casares, A. Hundesa, J. Rodriguez-Manzano, A. Allard, M. Calvo and R. Girones. 2006. Quantification and stability of human adenoviruses and polyomavirus JCPyV in wastewater matrices. Applied and Environmental Microbiology. **72:**7894-7896.

Borchardt, M. A., P. D. Bertz, S. K. Spencer and D. A. Battigelli. 2003. Incidence of Enteric Viruses in Groundwater from Household Wells in Wisconsin. Applied and environmental microbiology. **69:**1172-1180.

Bosch, A. 1998. Human enteric viruses in the water environment: a minireview. International Microbiology. **1:**191–196.

Bosch, A., F. Lucena, R. Girones, and J. Jofre. 1986, Survey of viral pollution in Besos River. Journal of the Water Pollution Control Federation. **58:**87–91.

Bosch, A., G. Sánchez, M. Abbaszadegan, A. Carducci, S. Guix, F. S. Le Guyader, R. Netshikweta, R. M. Pintó, W. H. M. van der Poel, S. Rutjes, D. Sano, M. B. Taylor, W. B. van Zyl, D. Rodríguez-Lázaro, K. Kovač and J. Sellwood. 2011. Analytical methods for virus detection in water and food. Food Analytical Methods. **4:**4-12.

Bosch, A., R. M. Pintó and F. X. Abad. 2006. Survival and Transport of Enteric Viruses in the Environment. Food Microbiology and Food Safety. pp151-188. DOI: 10.1007/0-387-29251-9_6.

Boyd, C. E. 1979. Water Quality in Warm Water Fish ponds. Agricultural Experiment Station. Auburn University. Alabama. p359.

Cabral, J. P. S. 2010. Water Microbiology. Bacterial Pathogens and Water. International. Journal of Environmental. Research and Public Health. **7:**3657-3703. DOI:10.3390/ijerph7103657.

Caro, V., S. Guillot, F. Delpeyroux, R. Crainic. 2001. Molecular strategy for ‘‘serotyping’’ of human enteroviruses. Journal of General Virology. **82:**79–91.

Carter, M. J. 2005. Enterically infecting viruses: Pathogenicity, transmission and significance for food and waterborne infection. Journal of Applied microbiology. **98:**1354-1380.

Chambon, M., J.L. Bailly, A. Beguet, C. Henquell, C. Archimbaud, J. Gaulme. 1999. An outbreak due to echovirus type 30 in a neonatal unit in France in 1997: usefulness of PCR diagnosis. Journal of Hospital Infections. **43:**63–68.

Chanishvili, N, T. Chanishvili, M, Tediashvili and P.A. Barrow. 2001. Phages and their application against drug resistant bacteria. Journal of Chemical Technology and Biotechnology. **76:** 689-699.

Charles, P., C. P. Gerba, C. Wallis and J. L. Melnick. 1975.Viruses in water: the problem, some solutions. Environmental Science and Technology. **9:**1122-1126.

Chaudhary, D. S., S. Vigneswaran, H. Ngo,W. G. Shim and H. Moon. 2003. Biofilter in Water and Wastewater Treatment. Korean Journal of Chemical Engineering. **20:**1054-1065.

Chigor, V. N. and A. I. Okoh. 2012. Quantitative detection and characterization of human adenoviruses in the Buffalo River in the Eastern Cape Province of South Africa. Food and Environmental Virology. **4:**198-208.

Cho, H. B., S. H. Lee, J. C. Cho and S. J. Kim. 2000. Detection of adenoviruses and enteroviruses in tap water and river water by reverse transcription multiplex PCR. Canadian Journal of Microbiology. **46:**417–424.

CIDWT: Decentralized Wastewater Glossary. 2009. Second Edition. Available online at: http://www.onsiteconsortium.org/glossary.html. Climates of Developing Countries. World Technical Paper Number 7.

Coetzee, M. A. S. 2003. Water pollution in South Africa: its impact on wetland biota. Centre for water in the environment. Department of botany. University of the Witwatersrand.

Croci, L., D. De Medici, C. Scaslfaro, A. Fiore, and L. Toti. 2002,The survival of hepatitis A virus in fresh produce. International Journal of Food Microbiology. **73:**29–34.

Dalsgaard, A., A. Forslund, D. Sandvang, L. Arntzen and K. Keddy. 2001. Vibrio cholerae O1 outbreak isolates in Mozambique and South Africa in 1998 are multiple-drug resistant, contain the STX element and the aadA2 gene located on Class 1 Integrons. Journal of Antimicrobial Chemotherapy. **48:**827–838.

De Flora, S., G. De Renzi, and G. Badolati. 1975, Detection of animal viruses in coastal seawater and sediments. Applied and Environmental Microbiology. **30:**472–475.

De Villiers, S. and C. Thiart. 2007. The nutrient status of South African rivers: concentrations, trends and fluxes from the 1970s to 2005. South African Journal of Science. **103:**343–349.

Dilorenzo, J. L., R. J. Filadelfo, C. R. Surak, H. S. Litwack, V. K. Gunawardana.And T. O. Najarian. 2004. Tidal Variability in the Water Quality of an Urbanized Estuary. Esturine Research Federation. **27:**851-860.

Divizia, M., P. De Filippis, A. Di Napoli, A. Venuti, B. Peres and A. Pana. 1989. Isolation of wild type hepatitis A virus from the environment. Water Research. **23:**1155–1160.

Doughari, J. H., J. S. Dodo and F. A. Mbhu. 2007. Impact of effluent from Gudu District Sewage Treatment Plant on Gudu Stream in Abuja, Nigeria. Journal of Applied Sciences and Environmental Management. **11:**7983.

Dungeni, M., R. R. van der Merwe and M. N. B. Momba. 2010. Abundance of pathogenic bacteria and viral indicators in chlorinated effluents produced by four wastewater treatment plants in the Gauteng Province, South Africa. Water SA. **36:** 607-614.

DWAF. 1995a. South African Water Quality Management Series. Procedures To Assess Effluent Discharge Impacts. Water Research Commission Wrc Report No Tt 64/94. First Edition.

DWAF. 1995b. The South African Water Quality Guidelines for Coastal Marine Waters. Department of Water Affairs and Forestry. Pretoria. RSA.

DWAF. 1996a. The South African Water Quality Guidelines. Volume 1: Domestic Water Use. Second Edition. Department of Water Affairs and Forestry. Pretoria. RSA.

DWAF. 1996b. The South African Water Quality Guidelines. Volume 2: Recreational Use. Department of Water Affairs and Forestry. Pretoria. RSA.

DWAF. 1998. Quality Of Domestic Water Supplies. Assessment Guide 1 (2nd Edition). Department Of Water Affairs and Forestry. Department of Health and Water Research Commission.

DWAF. 2003. Water Quality Management Series. Sub-Series No. MS11. Towards a Strategy for a Waste Discharge Charge System. First Edition. Pretoria.

DWAF. 2004. Water Quality Management Series Sub-Series. Operational policy for the disposal of land-derived water containing waste to the marine environment of South Africa: Guidance on Implementation. Edition 1. Department of Water Affairs. Pretoria.

DWA. 2011. Green drop handbook. Version 1. Department of Water Affairs. Pretoria. RSA.

DWA. 2012. Green drop handbook. Version 1. Department of Water Affairs. Pretoria. RSA.

Ehlers, M. M., W. O. K. Grabow and D. N. Pavlov. 2005. Detection of enteroviruses in untreated and treated drinking water supplies in South Africa. Water Research. **39:**2253 - 2258.

El-Rehaili, A. M. 1995.Response Of BOD, COD and TOC Of Secondary Effluents To Chlorination. Water Research. **29:**1571-1577.

Elser, J and **E. Bennett. 2011.** A broken biogeochemical cycle. Nature. 478.

Environmental Protection Agency. 1997. Wastewater treatment manuels – primary, secondary and tertiary treatment.

Environmental Protection Administration, R.O.C. (Taiwan). 2007. Taiwan. Water: Domestic Wastewater and Pollution. Update：2010/03/31. http://www.epa.gov.tw/en/epashow.aspx?list=102&path=135&guid=c4b6ad0f-13e5-4259-be98-8356037dc862&lang=en-us

Felsenstein, J. 1985. Confidence limits on phylogenies: An approach using the bootstrap. Evolution. **39:**783-791.

Ferguson, C. M., B. G. Coote, N. J. Ashbolt, And I. M. Stevenson. 1996. Relationships between indicators, pathogens and water quality in an estuarine system. Water Research **30:** 2045–2054.

Finance, C., M. Brigaud, F. Lucena, M. Aymard, A. Bosch and L. Schwartzbrod. 1982, Viral pollution of seawater at Barcelona. Zentralbl Bakteriol. Mikrobiol. Hyg. **176:**530–536.

Fiore, A. E. 2003. Hepatitis A Transmitted by Food. Clinical Infectious Diseases. **38:**705–15.

Fong T. T., M. S. Phanikumar, I. Xagoraraki and J. B. Rose. 2010. Quantitative Detection of Human Adenoviruses in Wastewater and Combined Sewer Overflows Influencing a Michigan River. Applied Environmental Microbiology. **76:**715–723.

Fong, T. T. and E. K. Lipp. 2005. Enteric Viruses of Humans and Animals in Aquatic Environments: Health Risks, Assessment Tools Detection, and Potential Water Quality. Microbiology and Molecular Biology Reviews. **69:**357-371.

FUCHS Clean Solutions. Aerated lagoons for the treatment of municipal wastewater. 2011. www.fuchs-germany.com.

Furhman, J. A., X. Liang and R. T. Noble. 2005. Rapid Detection of Enteroviruses in Small Volumes of Natural Waters by Real-Time Quantitative Reverse Transcriptase PCR. Applied and Environmental Microbiology. **71:**4523–4530.

Gantzer, C., S. Senouci, A. Maul, Y. Levi and L. Schwartzbrod. 1997. Enterovirus genomes in wastewater: concentration on glass wool and glass powder and detection by RT-PCR. Journal of Virological Methods. 65: 265-271.

Gerba, C. P. and J. S. Mcleod. 1976. Effect of sediments on the survival of Escherichia coli in marine waters. Applied and Environmental Microbiology **32:** 114–120.

Gerba, C. P., S. M. Goyal, R. L. LaBelle, I. Cech, and G. F. Bodgan. 1979. Failure of indicator bacteria to reflect the occurrence of enteroviruses in marine waters. American Journal of Public Health. **69:**1116–1119.

Girones, R., M. A. Ferrus, J. L. Alonso, J. Rodriguez-Manzano, B. Calgua, A. de Abreu Corre, A. Hundesa, A. Carratala and S. Bofill-Mas. 2010. Molecular detection of pathogens in water - the pros and cons of molecular techniques. Water Research. **44:**4325 – 4339.

Government Gazette. 1984. No. 9225. Requirements For The Purification Of Waste Water Or Effluent. General And Special Standards. Minister Of Environment Affairs And Fisheries.

Goyal, S. M., and C. P. Gerba. 1979, Comparative adsorption of human enteroviruses, simian rotavirus, and selected bacteriophages to soils. Applied and Environmental Microbiology. **38:**241–247.

Goyal S. M., C. P. Gerba and G. Bitton. 1987. Phage Ecology. John Wiley And Sons, New York. pp321.

Grabow, W. 2001. Bacteriophages: Update on application as models for viruses in water. Water SA. **27:**251-268.

Grabow, W. O. K. 1990. Microbiology of drinking water treatment: reclaimed wastewater. In: McFeters GA (ed.) Drinking Water Microbiology - Progress and Recent Developments. Springer Verlag, New York. pp185-203.

Grabow, W. O. K. 2001. Bacteriophages: Update on application as models for viruses in water. Water SA. **2:** 251-268.

Grabow, W. O. K. 2002. Enteric hepatitis viruses. In Guidelines for drinking-water quality: Second Edition, World Health Organization, pp 18-39.

Gross, M. and K. Farell-Poe. 2004. University Curriculum Development for Decentralized Wastewater Management –Disinfection. University Curriculum Development for Decentralized Wastewater Management.

Gupta, D. P., Sunita and J. P. Saharan. 2009. Physico-chemcial analysis of groundwater of selected area of Kaithal city (Haryana) India. Researcher. **2:**1-5.

HACH. 2007. Biochemical oxygen demand protocol. Method 8043. (Adapted from standard methods for the examination of water and wastewater and from Klein, R.L.,Gibbs, C. Journal of Water Pollution Control Federation, 1979, 51:2257).

Hall, T. A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids. Symposium Series. **41:**95-98.

Handsher, R., L.M. Shulman, B. Abramovitz, I. Silberstein, M. Neuman, M. Tepperberg-Oikawa, T. Fisher, E. Mendelson. 1999. A new variant of echovirus 4 associated with a large outbreak of aseptic meningitis. Journal of Clinical Virology **13:**29–36.

Hang, S. C. 2006. Human adenoviruses in water: occurrence and health implications: A critical review. Environmental Science and Technology. **40:**7132-7140.

Hartman, P. and J. Cleland. 2007. Wastewater Treatment Performance and Cost Data to Support an Affordability Analysis for Water Quality Standards. Montana Department of Environmental Quality.

Hashizume, M., B Armstrong, Y Wagatsuma, A. S. G. Faruque, T. Hayashi and D. A. Sack. 2008. Rotavirus infections and climate variability in Dhaka, Bangladesh: a time-series analysis. Epidemiology and Infection. **136:**1281–1289.

Havelaar A. H. and W. M. Hogeboom. 1983. Factors affecting the enumeration of coliphages in sewage and sewage polluted waters. Antoine van Leeuwenhoek. **49:**387-397.

Hot, D., O. Legeay, J. Jacques, C. Gantzer, Y. Caudrelier, K. Guyard, M. Lange, L. Andreoletti. 2003. Detection of somatic phages, infectious enteroviruses and enterovirus genomes as indicators of human enteric viral pollution in surface water. Water Research. **37:**4703–4710.

Hovi, T. 2006. Surveillance of poliovirus. Biologicals. **34:**123– 126.

http://www.deq.state.mt.us/wqinfo/Standards/PDF/Nutrient%20Treatment%20Cost%20Data_053107.pdf

Hugues, B., A. Cini, M. Plissier, and J. R. Lefebre. 1980, Recherche des virus dans le milieu marin à partir d'échantillons de volumes différents. *Eau. Ouetec.***13:**199–203.

Hundesa, A., C. M. de Motes, S. Bofill-Mas, N. Albinana-Gimenez and R. Gironez. 2006. Identification of human and animal adenoviruses and polyomaviruses for determination of sources of faecal contamination in the environment. Applied and Environmental Microbiology. **72:**7886-7893.

Igbinosa E. O. and A. I. Okoh. 2009. Impact of discharged wastewater effluents on the physicochemical qualities of a receiving watershed in a typical rural community. International Journa ofl Environmental Science and Technology. **6:**175-182.

Jackson, R. B., S. R. Carpenter, C. N. Dahm, D. M. Mcknight, R. J. Naiman, S. L. Postel, And S. W. Running. 2001. Issues In Ecology. Water In A Changing World. 2001. Ecological Applications. **11:**1027–1045.

Jägerskog, A. and T. Jønch Clausen. (eds.) 2012. Feeding a Thirsty World – Challenges and Opportunities for a Water and Food Secure Future. Report Nr. 31. SIWI, Stockholm.

Jaji, M. O., Bamgbose, O., Odukoya, O. O. and Arowlo, T. A. 2007. Water quality assessment of Ogun River, South West Nigeria. Environmental Monitoring and Assessment. **133:**447-482**.**

Jiang, S. C. 2006. Human Adenoviruses in water: occurrence and health implications: a critical review. Environmental Science and technology. **40:**7132-7140.

Joshi, D. M., A. Kumar and N. Agrawal. 2009. Studies on physicochmcial parameters to assess the water quality of river ganga for drinking purpose in Haridwar District. RASAYAN Journal of Chemistry. **2:**195-203.

Jukes, T. H. and C. R. Cantor. 1969. Evolution of protein molecules. In Munro HN, editor, Mammalian Protein Metabolism, pp. 21-132, Academic Press, New York.

Kadu, P. A. and Y. R. M. Rao. 2012. A Review of Rotating Biological Contactors System. International Journal of Engineering Research and Applications. **2:**2149-2153.

Kantachote, D., K. Dangtago and C. Siriwong. 2009. Treatment efficiency in wastewater treatment plant of Hat Yai Municipality by quantitative removal of microbial indicators. Songklanakarin Journal of Science and Technology. **31:**567-576.

Kitajima, M., E. Haramoto, C. Phanuwan and H. Katayama. 2011. Genotype Distribution of Human Sapoviruses in Wastewater in Japan. Applied and Environmental Microbiology. DOI:10.1128/AEM.00088-11.

Kocwa-Haluch, R. 2001. Waterborne Enteroviruses as a Hazard for Human Health. Polish Journal of Environmental Studies. **10:**485-487.

Kocwa-Haluch, R. and B. Zalewska. 2002. Presence of Rotavirus hominis in Sewage and Water. Polish Journal of Environmental Studies. **11:**751-755.

Kumar, A. and Bahadur, Y. 2009. Physicochemical studies on the pollution potential of river Kosi at Rampur (India). World Journal of Agricultural Sciences. **5:**1-4.

Lambertini, E., S. K. Spencer, P. D. Bertz, F. J. Loge, B. A. Kieke and M. A. Borchardt. 2008. Concentration of enteroviruses, adenoviruses and noroviruses from drinking water by use of glass wool filters. Applied and Environmental Microbiology. **74:**2990-2996.

Lazarova V., P.Savoye, M L Janex, E R Blatchley III and M Pommepuy. 1999. Advanced wastewater disinfection technologies: state of the art and perspectives. Water Science and Technology. **40:**203-213.

Le Bris, J. M., S. Billaudel, P. Bertrand, G, Loukou and A. L. et Courtieu. 1983, Recherche des virus et des salmonelles dans la Loire par une method d'adsorption-élution sur filtres en microfibre de verre. *Tech. Sci. Munic. L'Eau.* **6:**303–306.

Le Cann, P., S. Ranarijaona, S. Monpoeho, F. Le Guyader, V. Ferré. 2004. Quantification of human astroviruses in sewage using real-time RT-PCR. Research in Microbiology. **155:**11-15.

Le Roux, J. J., T. S. Newby and P. D. Sumner. 2007. Monitoring soil erosion in South Africa at a regional scale: review and recommendations South African Journal of Science. **103:**7-8.

Lee, S. H., and S. J. Kim. 2002. Detection of infectious enteroviruses and adenoviruses in tap water in urban areas in Korea. Water Research. **36:**248–256.

Magwalivha, M. 2009. The molecular characterisation of human adenoviruses from human species and environmental samples. Master of Science Dissertation. Medical Virology. Department of Medical Virology. Faculty of Health Science. University of Pretoria.

Mahvi, A.H. 2008. Sequencing batch reactor: A promising technology in wastewater treatment. Iranian Journal of Environmental Health Science & Engineering **5**:79-90.

Manasrah, R., M. Raheed and M. I. Badran. 2006. Relationships between water temperature, nutrients and dissolved oxygen in the northern Gulf of Aqaba, Red Sea. OCEANOLOGIA, **48:**237–253.

Mara, D. 2004. Domestic wastewater treatment in developing communities. Earthscan. ISBN: 1-84407-019-0. Chapter 1**.**

Mara, D. and B. Evans. 2011. Sanitation and water supply in low income countries. Ventus Publishing ABS. ISBN 978-87-7681-866-1.

Meleg, E., F. Jakab, B. Kocsis, K. Bányai, B. Melegh, G. Szucs. 2006. Human astroviruses in raw sewage samples in Hungary. Journal of Applied Microbiology. **101:**1123-1129.

Melnick, J. L. 1992. Properties and classification of hepatitis A virus. Vaccine. **10:**24-26.

Mendoza-Espinosa, L. and T. Stephenson. 1999. A review of biological aerated filters (BAFs) for wastewater treatment. Environmental Engineering Science. **16:**201-216.
Microbiological agents in drinking water. Geneva,World Health Organization, pp.119–142.

Momba M. N. B., and Notshe T. 2003. The effect of long storage and household containers on the microbiological quality of drinking water in rural communities of South Africa. Journal of Water Supply: Reseasrch & Technology.-AQUA. **52:** 67-76.

Momba, M. N. B., B. O. Abong'o and J. N. Mwambakana. 2008. Prevalence of enterohaemorrhagic Escherichia coli O157:H7 in drinking water and its predicted impact on diarrhoeic HIV/AIDS patients in the Amathole District, Eastern Cape Province, South Africa.Water SA. **34:** 365-372.

Momba, M. N. B., V. K. Malakate and J. Theron. 2006. Abundance of pathogenic *Escherichia coli*, *Salmonella typhimurium* and *Vibrio cholerae* in Nkonkobe drinking water sources. Journal of Water & Health. **4:** 289-296.

Morrison, G., O. S. Fatoki, L. Persson and Ekberg, A. 2001. Assessment of the impact of point source pollution from the Keiskammahoek Sewage Treatment Plant on the Keiskamma RiverpH, electrical conductivity, oxygen demanding substance (COD) and nutrients. Water SA., **27:**475-480.

Mounts, A. W., T. Ando, M. Koopmans, J. S. Bresee, J. Noel and R. I. Glass. 2000. Cold weather seasonality of gastroenteritis associated with Norwalk-like viruses. The Journal of Infectious Diseases. **2:**284-287.

Muir, P., U. Kammerer, K. Korn, M. N. Mulders, T. Poyry, B. Weissbrich, R. Kandolf, G. M. Cleator, A. M. van Loon. 1998. Molecular typing of enteroviruses: current status and future requirements. Clinical Microbiology Reviews. **11:**202–227.

Nataro, J. P. and J. B. Kaper. 1998. Diarrhaegenic *Escherichia coli.* Clinical Microbiology Reviews. 11: 142-201.

NHMRC, NRMMC. 2011. Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

Nilsson, C. and Renofalt B. M. 2008. Linking Flow Regime and Water Quality in Rivers: a Challenge to Adaptive Catchment Management.

Norton, A., S. Björnberg, D. Kibirige and A. B. Raja. 2012. Wastewater Treatment – Treatment Ponds. VVAN01 Spring. LTH.

Nwachcuku, N. and C. P. Gerba. 2004. Emerging waterborne pathogens: can we kill them all? Current Opinion in Biotechnology. **15:** 175–180.

Okoh, A. I., T. Sibanda and S. S. Gusha. 2010. Inadequately Treated Wastewater as a Source of Human Enteric Viruses in the Environment. International Journal of Environmental Research and Public Health. **7:**2620-2637.

Okoh, A. I. and E. O. Igbinosa. 2010. Antibiotic susceptibility profiles of some *Vibrio* strains isolated from wastewater final effluents in a rural community of the Eastern Cape Province of South Africa. BMC Microbiology. **10:**1-6.

Olaniran, A. O., S. Naidoo and B. Pillay. 2012. Surveillance of invasive bacterial pathogens and human enteric viruses in wastewater final effluents and receiving water bodies – a case study from Durban, South Africa. Clean – Soil, Air, Water. **40:**1-11.

Otukune, T. V. and C. O. Biukwu. 2005. Impact of Refinery Influent on Physico-chemical properties of a water body on Niger Delta. Journal of Applied Ecology and Environmental Research. **3:**61-72.

Paaijmans K. P., W. Takken, A. K. Githeko and A. F. Jacobs. 2008. The effect of water turbidity on the near-surface water temperature of larval habitats of the malaria mosquito Anopheles gambiae. **8:**747-53.

Park, S. H., E. J. Kim, T. H. Yun, J. H. Lee, C. K. Kim, Y. H. Seo, S. A. Oh, S. S. Choi, S. J. Cho, M. S. Kim, G. Y. Han, M. Y. Kim, H. S. Jeong, D. S. Cheon and H. S. Kim. 2010. Human Enteric Viruses in Groundwater. Food and Environmental Virology. **2:**69–73.

Phadhan, U. K., P. V. Shirodkar and B. K. Sahu. 2009. Physicochemical characteristics of the coastal water off Devi estuary, Orissa and evaluation of its seasonal changes using chemometric techniques. Current Science. **96:**1203-1209.

Pillay DG, Karas AJ, Sturm AW. 1997. An Outbreak of Shiga Bacillus Dysentery in KwaZulu/Natal. South African Journal of Epidemiology and Infection. **34:**107-111.

Pradhan, U. K., P. V. Shirodkar and B. K. Sahu. 2009. Physicochemical characteristics of the coastal water off Devi estuary, Orrisa and evaluation of its seasonal changes using chemometric techniques. Current Science. **96:**1203-1209.

Puig, M., J. Jofre, F. Lucena, A. Allard, G. Wadell, and G. Girones. 1994. Detection of adenoviruses and enteroviruses in polluted waters by nested PCR amplification. Applied Environmental Microbiology. **60:**2963–2970.

Purcell, R. H. and S. U. Emerson. 2001. Animal Models of Hepatitis A and E. Institute for Laboratory Animal Research. **42:**161-177.

Pusch, D., D. Y. Oh, S. Wolf, R. Dumke, U. Schroter-Bobsin, M. Hohne, I. Roske and E. Schreier. 2005. Detection of enteric viruses and bacterial indicators in German environmental waters. Archives of Virology. **150:**929–947. DOI 10.1007/s00705-004-0467-8.

Rosenwinkel, K. H., U. Austermann-Haun and H. Meyer. 2005. Industrial Wastewater Sources and Treatment Strategies. Environmental Biotechnology. Concepts and Applications. Edited by H.-J. Jördening and J. Winter. Copyright © 2005 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. ISBN: 3-527-30585-8.

Rutherford, J., S. Blackett, C. Blackett, L. Saito and R. Davies –Colley. 1997. Predicting the effects of shade on water temperature in small streams. New Zealand Journal of Marine and freshwater Research. **31:** 707-721.

Saitou, N. and M. Nei. 1987. The neighbour-joining method: A new method for reconstructing phylogenetic trees. Molecular Biology and Evolution. **4:**406-425.

Sala, O. E., F. S. III Chapin, J. J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L. F. Huenneke, R. B. Jackson, A. Kinzig, R. Leemans, D. M. Lodge, H. A. Mooney, M. Oesterheld, H. L. Poff, M. T. Sykes, B. H. Walker, M. Walker and D. H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science. **287:**1770-1774.

Samie, A., C. L. Obi, J.O. Igumbor and M. N. B. Momba. 2009. Focus on 14 sewage treatment plants in the Mpumalanga Province, South Africa in order to gauge the efficiency of wastewater treatment. African Journal of Biotechnology. **8:** 3276-3285.

Sawyer, C. N., P. L. McCarty and G. F. Parkin. 2003. Chemistry for Environmental Engineering and Science, 5th edition,Tata McGraw-Hill, pp. 625-630.

Schaper, M., J. Jofre, M. Uys and W. O. K. Grabow. 2002. Distribution of genotypes of F-specific RNA bacteriophages in human and non-human sources of faecal pollution in South Africa and Spain. Journal of Applied Microbiology. **92:**657–667.

Sargeant D. 1999. Fecal Contamination Source Identification Methods in Surface Water. A department of Ecology Report. Washington State Department of Ecology. Ecology report: 99-345.

Schumacher, J. D., C. Chuard, F. Renevey, L. Matter and C. Regamey. 1999. Outbreak of echovirus 30 meningitis in Switzerland. Scandinavian Journal of Infectious Diseases. **31:**539–542.

Shattuck, L. 1850. The Shattuck Report: General Plan for the Promotion of Public and Personal Health. The Sanitary Survey of 1850. Public Health Museum in Massachusetts.

Simpson, J. M., J. W. Santodomingo and D. J. Reasoner. 2002. Microbial Source Tracking: State Of The Science. Environmental Science & Technology. **36:**5279 5288.

Skraber, S., C. Gantzer, A. Maul and L. Schwartzbrod. 2002. Fates of bacteriophages and bacterial indicators in the Moselle river (France). Water Research **36:** 3629–3637.

Smith, A. H., E. O. Lingas and M. Rahman. 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bulletin of The World Health Organization. **78:**1093-103.

Sonune, A. and Ghate, R. 2004. Developments in wastewater treatment methods. Desalination **167:**55-63.

SOPAC. 1999. Small scale wastewater treatment plant project. Report on project criteria, guidelines and technologies. Technical Report 288.

South African River Health Programme (RHP). State of the Rivers Report. 2011. Umgeni River and Neighbouring Rivers and Streams.

South African Weather Service (SAWS). 2013. Rainfall Data provided.

Staggemeier, R., S. E. M. Almeida and F. R. Spilki. 2012. Methods of virus detection in soils and sediments. Virus Reviews and Research. Sociedade Brasileira de Virologia. 17:1-7.

Standard Methods for the examination of water and wastewater. 1998. 20th edition. Edited by Clesceri, L.S., A.E. Greenburg and A.D. Eaton. American public health association. American water works association. Water environmental federation, USA.

Stronkhorst, J., J. Brils, J. Batty, M. Coquery, M. Gardner, J. Mannio, C. O'Donnell, J. Steenwijk and P. Frintrop. 2004. Discussion document on sediment monitoring guidance for the EU Water framework directive. Version 2. EU Water Framework Directive expert group on analysis and monitoring of priority substances.

Sulakvelidze, A., Z. Alavidze and JRG Morris. 2001. Bacteriophage Therapy. **43:** 649-659.

Sundaray, S. K., U. C. Panda, B. B. Nayak and D. Bhatta. 2005. Behaviour and distribution pattern of nutients in river-esturine waters of Mahanadi, Orissa, india. J. water. Environ. Pollut. **2:**77-84.

Sundram, A., N Jumanlal and M. M. Ehlers. 2005. Genotyping of F-RNA coliphages isolated from wastewater and river water samples. Water SA. **32:**65-70.

Taiwo, A. M., O. O. Olujimi, O. Bamgbose and T. A. Arowolo. 2012. Surface water quality monitoring in Nigeria: Situational Analysis and Future Manageent Strategy, Water Quality Monitoiring and Assessment. Dr. Voudouris (Ed.). ISBN: 978-953-51-0486-5.

Tamura, K., D. Peterson, N. Peterson, G. Stecher, M. Nei and S. Kumar. 2011. MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. Molecular Biology and Evolution (In Press).

Theron, J., and T. E. Cloete. 2002. Emerging waterborne infections: contributing factors, agents, and detection tools. Critical Reviews in Microbiology. **28:**1-26.

Thomas, J. A, Soddell J A and Kurtboke D I. Fighting foam with phages? Wat Sci Tech 2002; 46:511-553.

Tiekotter, K. L. and H. W. Ackermann. 2009. High-quality virus images obtained by transmission electron microscopy and charge coupled device digitial camera technology. Journal of virological methods. DOI: 10.1016/j.viromet.2009.03.004.

Trajkovic S., S. Brankovic and M. Gocic. 2008. Analysis of biological water quality treatment parameters of the river Nisava upstream of water treatment plant Mediana. BALWOIS. **27:**1-5.

UNICEF and WHO. 2008. A Snapshot of Drinking Water and Sanitation in Africa. Joint Monitoring Programme for Water Supply and Sanitation. Cairo, Egypt.

UNICEF and World Health Organization. 2012. Progress on Drinking Water and Sanitation. 2012 Update- Joint Monitoring Programme for Water Supply and Sanitation.

United Nations Water Global Annual Assessment of Sanitation and Drinking Water (GLAAS). 2012. The challenge of extending and sustaining services. World Health Organization.

United Nations Environmental Programme. 2012. Division of Technology, Industry and Economics. Freshwater Management Series No. 1. Biosolids, Management and Environmentally sound approach for managing sewage treatment plant sludge. http://www.unep.or.jp/ietc/publications/freshwater/fms1/2.asp

USEPA. 1999a. Wastewater Technology Fact Sheet - Sequencing Batch Reactors. Office of Water Washington, D.C. EPA 832-F-99-073

USEPA. 1999b. United States. Wastewater Technology Fact Sheet - Ultraviolet Disinfection. Office of Water Washington, D.C. EPA 832-F-99-064.

USEPA. 1999c. Wastewater Technology Fact Sheet – Chlorine disinfection. Office of water Washington D.C. EPA 832-F-99-062.

USEPA. 2000. Wastewater Technology Fact Sheet - Trickling Filters. Office of Water. Washington, D.C. EPA 832-F-00-014.

USEPA. 2001. Method 1601: Male specific (F+) and somati coliphage in water by two-step enrichment procedure. Office of Water, Washington DC 20460.

USEPA. 2002. Wastewater Technology Fact Sheet - Aerated, Partial Mix Lagoons. Office of water. EPA –832-F02-008.

USEPA. 2004. Primer for Municipal Wastewater Treatment Systems. Office of Water and Wastewater Management. www.epa.gov.owm.

USEPA. 2012. Appendix 1C1: Indicator Organisms.

USEPA and Syrian Lebanese Higher Council. 2012. Wastewater Treatment Guidance Manuel – Integrated Coastal Management Between Jbeil/Amsheet (Lebanon) and Latakia (Syria). Integrated Coastal Management Project.

USEPA, Tetra Tech, Inc. and Herrera Environmental Consultants. .2011. Using Microbial Source Tracking to Support TMDL Development and Implementation. Prepared for U.S. Environmental Protection Agency, Region 10.

Valentukeviciene, M., I. Gytautas and A. Amosenkiene. 2011. The sustainable development assessment of drinking water supply system/Geriamojo vandens tiekimo sistemos darnaus vystymo vertinimas. Technological and Economic Development of Economy 17.4. 688. Academic One File. 30 Apr. 2013.

Van Heerden J., M.M. Ehlers, A. Heim and W.O.K. Grabow. 2005. Prevalence, quantification and typing of adenoviruses detected in river and treated drinking water in South Africa. Journal of Applied Microbiology. **99:**234–242.

Van Heerden J.; M. M. Ehlers, W. B. Van Zyl and W. O. K. Grabow. 2003. Incidence of adenoviruses in raw and treated water. Water Research. **37:**3704-3708.

Van Heerden, J.; M. M. Ehlers, A. Heim and W. O. K. Grabow. 2005. Prevalence, quantification and typing of adenoviruses detected in river and treated drinking water in south Africa. Journal of Applied Microbiology. **99:**234-242.

Van Heerden, J; M. M. Ehlers, W. B. Van Zyl and W. O. K. Grabow. 2004. Prevalence of human adenoviruses I raw and treated water. Water Science and Technology. **50:**39-43.

Van Zyl, W. B., N. A. Page, W. O. K. Gabo, A. D. Steele, and M. B. Taylor. 2006. Molecular Epidemiology of Group A Rotaviruses in Water Sources and Selected Raw Vegetables in Southern Africa. Applied and Environmental Microbiology. **72:**4554–4560.

Varunprasath, K. and A. N. Daniel. 2010. Comparison Studies of Three Freshwater Rivers (Cauvery, Bhavani and Noyyal) in Tamilnadu, India. Iranica Journal of Energy & Environment. **4:**315-320.

Venkatesharaju K., P. Ravikumar, R. K. Somashekar and K. L. Prakash. 2010. Physicochemical and bacteriological investigation on the river Cauvery of Kollegal Stretch in Karnataka. Kathmandu University Journal of Science, Engineering and Technology. **6:**50-59.

Vorosmarty, C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. ReidyLiermann and P. M. Davies. 2010. Global threats to human water security and river biodiversity. Nature. **467:**555-561. DOI: 10.1038/nature09440.

Vreeburg J. 2010. Discolouration in Drinking Water Systems: The Role of Particles Clarified. London:IWA Publishing.

Ward, B. K., Chenoweth, C. M., and Irving, L.G. 1982, Recovery of viruses from vegetable surfaces. *Appl. Environ. Microbiol.* 44:1389–1394.

Wakelin, S. A., M. J. Colloff and R. S. Kookanal. 2008. Effect of wastewater treatment plant effluent on microbial function and community structure in the sediment of a freshwater stream with variable seasonal flow. Applied and Environmental Microbiology. **74:**2659-2668.

Water Industry Market - Asia & Pacific Region. 2010. Australian Government: Australian Trade Commission.

Wilk, J., Andersson, L. and Plermkamon, V. 2001. Hydrological impacts of forest conversion to agriculture in a large river basin in northeast Thailand. Hydrological Processes. **15:**2729-2748.

WHO. 1979. Human viruses in water, wastewater and soil. Report of a WHO Scientific Group. World health organization technical report series 639. Geneva.

WHO. 1989. Health guidelines for the use of wastewater in agriculture and aquaculture. Report of a WHO Scientific Group. Geneva, World Health Organization.

WHO. 2002. *Vibrio cholerae*. In: Guidelines for drinking-water quality, 2nd ed. Addendum:

WHO. 2003a. Guidelines for safe recreational water environments. Volume 1, Coastal and fresh waters.

WHO. 2003b. Guidelines for environmental surveillance of poliovirus circulation. WHO, Geneva, Switzerland. http:// www.who.int/vaccines-documents/DocsPDF03/www737.pdf.

WHO. 2008. Guidelines for drinking-water quality [electronic resource]: incorporating 1st and 2nd addenda, Vol.1, Recommendations. – 3rd ed. ISBN 978 92 4 154761 1

WHO. 2011a. Valuing Water, Valuing Livelihoods. Guidance on Social Cost-benefit Analysis of Drinking-water Interventions, with special reference to Small Community Water Supplies.

Edited by John Cameron, Paul Hunter, Paul Jagals and Katherine Pond. IWA Publishing. Alliance House. ISBN: 9781843393108.

WHO. 2011b. Guidelines for drinking-water quality. Fourth edition. ISBN 978 92 4 154815 1.

Wilson, D., A. Padovan and S. Townsend. 2004. The Water Quality of Spring and Neap Tidal Cycles in the Middle Arm of Darwin Harbour during the Dry Season. Report 41. Water Monitoring Branch. Natural Resource Management Division. Department of Infrastructure, Planning and Environment. Northern Territory Government.

Withey, S., E. Cartmell, L.M. Avery and T. Stephenson. 2005. Bacteriophages – Potential For Application In Wastewater Treatment Processes. Science of The Total Environment. **339:** 1-18.

Wong, K., T. T. Fong, K. Bibby, and M. Molina. 2012.Application of enteric viruses for fecal pollution source tracking in environmental waters, Environmental International. **15:**151–164.

World Water Assessment Programme (WWAP). 2012. The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk. Paris, UNESCO.

Wyn-Jones, A. P. and J. Sellwood, 2001. Enteric viruses in the aquatic environment. Journal of Applied Microbiology. **91:**945–962.

Wyn-Jones, P. A., A. Carducci, N. Cook, M. D'Agostino, M. Divizia, J. Fleischer, C. Gantzer, A. Gawler, R. Girones, C. Holler, A. M. de Roda Husman, D. Kay, I. Kozyra, J. Lopez-Pila, M. Muscillo, M. S. J. Nascimento, G. Papageorgiou, S. Rutjes, J. Sellwood, R. Szewzyk and M. Wyer. 2011. Surveillance of adenoviruses and noroviruses in European recreational waters. Water Research. **45:**1025-1038.

Yeh, H., M. V. Yates, W. Chen and A. Mulchandani. 2009. Real-time molecular methods to detect infectious viruses. Seminars in cell and developmental biology. **20:**49-54. DOI:10.1016/j.semcdb.2009.01.012.

Zhao, Q., D. H. Zeng, Z P Fan, Z Y Yu, Y L Hu and J Zhang. 2009. Seasonal variations in phosphorus fractions in semiarid sandy soils under different vegetation types. Forest Ecology and Management. 258:1376–1382.

APPENDIX I: PHYSICOCHEMICAL ANALYSES

Table I (1): Physicochemical analysis for the Northern WWTP during March 2012 (Month 1)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	26.00	8.08	411.00	7.15	89.00	839.00	0.41	1192.00
BEFORE CHLORINATION	2	26.00	8.12	411.00	7.05	114.00	840.00	0.41	1191.00
	3	26.00	7.53	412.00	7.12	111.33	840.00	0.41	1190.00
	AVG	**26.00**	**7.91**	**411.33**	**7.11**	**104.78**	**839.67**	**0.41**	**1191.00**
	SD	**0.00**	**0.33**	**0.58**	**0.05**	**13.73**	**0.58**	**0.00**	**1.00**
	1	25.00	37.40	436.00	7.31	less 10	889.00	0.44	1125.00
DISCHARGE POINT	2	25.00	16.60	436.00	7.44	less 10	888.00	0.44	1126.00
	3	25.00	16.20	436.00	7.34	less 10	887.00	0.44	1127.00
	AVG	**25.00**	**23.40**	**436.00**	**7.36**	**less 10**	**888.00**	**0.44**	**1126.00**
	SD	**0.00**	**12.13**	**0.00**	**0.07**	**0.00**	**1.00**	**0.00**	**1.00**
	1	26.00	17.10	370.00	7.29	165.33	758.00	0.37	1320.00
UPSTREAM	2	26.00	16.40	371.00	7.15	156.67	760.00	0.37	1316.00
	3	26.00	16.50	369.00	7.31	162.00	755.00	0.37	1325.00
	AVG	**26.00**	**16.67**	**370.00**	**7.25**	**161.33**	**757.67**	**0.37**	**1320.33**
	SD	**0.00**	**0.38**	**1.00**	**0.09**	**4.37**	**2.52**	**0.00**	**4.51**
	1	25.50	15.20	348.00	7.23	116.00	714.00	0.35	1402.00
DOWNSTREAM	2	25.50	15.40	348.00	7.30	309.33	713.00	0.35	1403.00
	3	25.50	15.20	350.00	7.19	152.00	717.00	3.50	1395.00
	AVG	**25.50**	**15.27**	**348.67**	**7.24**	**192.44**	**714.67**	**1.40**	**1400.00**
	SD	**0.00**	**0.12**	**1.15**	**0.06**	**102.82**	**2.08**	**1.82**	**4.36**

Table I (2): Physicochemical analysis for the Northern WWTP during April 2012 (Month 2)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	22.00	56.60	384.00	7.70	221.00	785.00	0.38	1275.00
BEFORE CHLORINATION	2	22.00	56.60	382.00	7.60	227.00	781.00	0.38	1280.00
	3	22.00	56.40	383.00	7.70	240.00	784.00	0.38	1274.00
	AVG	**22.00**	**56.53**	**383.00**	**7.67**	**229.33**	**783.33**	**0.38**	**1276.33**
	SD	**0.00**	**0.12**	**1.00**	**0.06**	**9.71**	**2.08**	**0.00**	**3.21**
	1	22.00	76.60	443.00	7.50	309.00	902.00	0.44	1108.00
DISCHARGE POINT	2	22.00	76.60	444.00	7.30	313.00	903.00	0.44	1108.00
	3	22.00	76.10	445.00	7.40	311.33	906.00	0.45	1104.00
	AVG	**22.00**	**76.43**	**444.00**	**7.40**	**311.11**	**903.67**	**0.44**	**1106.67**
	SD	**0.00**	**0.29**	**1.00**	**0.10**	**2.01**	**2.08**	**0.01**	**2.31**
	1	21.00	19.70	493.00	7.50	306.00	1001.00	0.49	1004.00
UPSTREAM	2	21.00	19.70	490.00	7.30	305.00	996.00	0.49	1004.00
	3	21.00	19.70	490.00	7.50	302.00	996.00	0.49	1004.00
	AVG	**21.00**	**19.70**	**491.00**	**7.43**	**304.33**	**997.67**	**0.49**	**1004.00**
	SD	**0.00**	**0.00**	**1.73**	**0.12**	**2.08**	**2.89**	**0.00**	**0.00**
	1	21.00	14.80	329.00	7.70	151.00	676.00	0.33	1480.00
DOWNSTREAM	2	21.00	14.80	330.00	7.60	151.00	677.00	0.33	1476.00
	3	21.00	14.80	333.00	7.60	151.00	684.00	0.33	1480.00
	AVG	**21.00**	**14.80**	**330.67**	**7.63**	**151.00**	**679.00**	**0.33**	**1478.67**
	SD	**0.00**	**0.00**	**2.08**	**0.06**	**0.00**	**4.36**	**0.00**	**2.31**

Table I (3): Physicochemical analysis for the Northern WWTP during May 2012 (Month 3)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	22.00	19.60	418.00	7.05	50.33	853.00	0.42	1173.00
BEFORE CHLORINATION	2	22.00	19.60	418.00	7.07	37.00	853.00	0.42	1173.00
	3	21.80	19.60	418.00	7.11	27.33	853.00	0.42	1173.00
	AVG	**21.93**	**19.60**	**418.00**	**7.08**	**38.22**	**853.00**	**0.42**	**1173.00**
	SD	**0.12**	**0.00**	**0.00**	**0.03**	**11.55**	**0.00**	**0.00**	**0.00**
	1	21.00	13.60	475.00	7.26	less 10	966.00	0.48	1037.00
DISCHARGE POINT	2	21.00	13.90	475.00	7.29	less 10	966.00	0.48	1035.00
	3	21.00	13.90	475.00	7.28	less 10	966.00	0.48	1036.00
	AVG	**21.00**	**13.80**	**475.00**	**7.28**	**less 10**	**966.00**	**0.48**	**1036.00**
	SD	**0.00**	**0.17**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**1.00**
	1	21.00	12.80	1063.00	6.88	18.33	2116.00	1.07	473.00
UPSTREAM	2	21.00	12.80	1069.00	6.95	20.67	2115.00	1.08	475.00
	3	21.00	12.80	1069.00	6.91	21.67	2116.00	1.08	473.00
	AVG	**21.00**	**12.80**	**1067.00**	**6.91**	**20.22**	**2115.67**	**1.08**	**473.67**
	SD	**0.00**	**0.00**	**3.46**	**0.04**	**1.71**	**0.58**	**0.01**	**1.15**
	1	22.00	12.90	301.00	7.15	308.67	619.00	0.30	1616.00
DOWNSTREAM	2	22.00	12.90	303.00	7.10	307.67	624.00	0.30	1612.00
	3	22.00	12.90	302.00	7.13	311.00	620.00	0.30	1609.00
	AVG	**22.00**	**12.90**	**302.00**	**7.13**	**309.11**	**621.00**	**0.30**	**1612.33**
	SD	**0.00**	**0.00**	**1.00**	**0.03**	**1.71**	**2.65**	**0.00**	**3.51**

Table I (4): Physicochemical analysis for the Northern WWTP during June 2012 (Month 4)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	13.00	11.60	342.00	7.37	290.33	702.00	0.34	1426.00
BEFORE CHLORINATION	2	13.00	11.20	343.00	7.37	302.67	703.00	0.34	1423.00
	3	13.00	11.00	343.00	7.37	307.00	704.00	0.34	1421.00
	AVG	**13.00**	**11.27**	**342.67**	**7.37**	**300.00**	**703.00**	**0.34**	**1423.33**
	SD	**0.00**	**0.31**	**0.58**	**0.00**	**8.65**	**1.00**	**0.00**	**2.52**
	1	12.00	8.87	342.00	7.34	106.67	759.00	0.37	1318.00
DISCHARGE POINT	2	12.00	8.99	343.00	7.35	112.67	755.00	0.37	1324.00
	3	12.00	8.91	343.00	7.35	110.67	758.00	0.37	1319.00
	AVG	**12.00**	**8.92**	**342.67**	**7.35**	**110.00**	**757.33**	**0.37**	**1320.33**
	SD	**0.00**	**0.06**	**0.58**	**0.01**	**3.06**	**2.08**	**0.00**	**3.21**
	1	13.00	9.56	535.00	7.64	109.67	1080.00	0.53	926.00
UPSTREAM	2	12.50	9.57	533.00	7.65	115.67	1083.00	0.54	923.00
	3	12.50	9.57	535.00	7.65	113.33	1084.00	0.54	923.00
	AVG	**12.67**	**9.57**	**534.33**	**7.65**	**112.89**	**1082.33**	**0.54**	**924.00**
	SD	**0.29**	**0.01**	**1.15**	**0.01**	**3.02**	**2.08**	**0.01**	**1.73**
	1	13.50	14.20	308.00	7.84	86.00	634.00	0.31	1578.00
DOWNSTREAM	2	13.50	14.60	308.00	7.85	90.00	633.00	0.31	1581.00
	3	13.50	14.30	308.00	7.84	90.33	633.00	0.31	1581.00
	AVG	**13.50**	**14.37**	**308.00**	**7.84**	**88.78**	**633.33**	**0.31**	**1580.00**
	SD	**0.00**	**0.21**	**0.00**	**0.01**	**2.41**	**0.58**	**0.00**	**1.73**

Table I (5): Physicochemical analysis for the Northern WWTP during July 2012 (Month 5)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	16.00	19.40	340.00	7.47	122.00	718.00	0.34	1368.00
BEFORE CHLORINATION	2	16.00	19.30	351.00	7.49	101.33	725.00	0.34	1365.00
	3	15.50	19.30	354.00	7.48	121.00	731.00	0.35	1379.00
	AVG	**15.83**	**19.33**	**348.33**	**7.48**	**114.78**	**724.67**	**0.34**	**1370.67**
	SD	**0.29**	**0.06**	**7.37**	**0.01**	**11.65**	**6.51**	**0.01**	**7.37**
	1	15.50	23.50	417.00	7.70	291.33	851.00	0.42	1176.00
DISCHARGE POINT	2	15.20	22.80	416.00	7.70	291.00	849.00	0.42	1178.00
	3	15.20	22.90	416.00	7.70	289.67	849.00	0.42	1177.00
	AVG	**15.30**	**23.07**	**416.33**	**7.70**	**290.67**	**849.67**	**0.42**	**1177.00**
	SD	**0.17**	**0.38**	**0.58**	**0.00**	**0.88**	**1.15**	**0.00**	**1.00**
	1	14.80	13.30	705.00	7.54	312.00	1424.00	0.71	702.00
UPSTREAM	2	14.80	13.10	712.00	7.55	311.00	1430.00	0.72	699.00
	3	14.80	13.40	713.00	7.54	310.00	1432.00	0.72	699.00
	AVG	**14.80**	**13.27**	**710.00**	**7.54**	**311.00**	**1428.67**	**0.72**	**700.00**
	SD	**9.00**	**0.15**	**4.36**	**0.01**	**1.00**	**4.16**	**0.01**	**1.73**
	1	15.00	22.80	294.00	7.85	313.00	604.00	0.29	1655.00
DOWNSTREAM	2	15.00	22.80	295.00	7.88	310.67	607.00	0.29	1648.00
	3	14.80	23.00	295.00	7.87	309.33	607.00	0.29	1648.00
	AVG	**14.93**	**22.87**	**294.67**	**7.87**	**311.00**	**606.00**	**0.29**	**1650.33**
	SD	**0.12**	**0.12**	**0.58**	**0.02**	**1.86**	**1.73**	**0.00**	**4.04**

Table I (6): Physicochemical analysis for the Northern WWTP during August 2012 (Month 6)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	21.00	56.70	368.00	6.73	310.33	753.00	0.37	1327.00
BEFORE CHLORINATION	2	21.00	56.00	372.00	6.86	309.33	752.00	0.37	1314.00
	3	21.00	56.40	371.00	6.95	310.67	759.00	0.37	1317.00
	AVG	**21.00**	**56.37**	**370.33**	**6.85**	**310.11**	**754.67**	**0.37**	**1319.33**
	SD	**0.00**	**0.35**	**2.08**	**0.11**	**0.69**	**3.79**	**0.00**	**6.81**
	1	19.00	68.70	412.00	7.05	185.33	841.00	0.41	1189.00
DISCHARGE POINT	2	19.00	67.90	412.00	7.09	181.00	840.00	0.41	1190.00
	3	19.00	69.00	411.00	7.13	182.00	839.00	0.41	1192.00
	AVG	**19.00**	**68.53**	**411.67**	**7.09**	**182.78**	**840.00**	**0.41**	**1190.33**
	SD	**0.00**	**0.57**	**0.58**	**0.04**	**2.27**	**1.00**	**0.00**	**1.53**
	1	20.00	28.70	443.00	7.10	110.00	903.00	0.44	1107.00
UPSTREAM	2	20.00	28.70	441.00	7.11	105.33	898.00	0.44	1114.00
	3	20.00	28.80	440.00	7.15	102.33	896.00	0.44	1116.00
	AVG	**20.00**	**28.73**	**441.33**	**7.12**	**105.89**	**899.00**	**0.44**	**1112.33**
	SD	**0.00**	**0.06**	**1.53**	**0.03**	**3.86**	**3.61**	**0.00**	**4.73**
	1	19.00	20.70	328.00	7.24	308.00	673.00	0.33	1487.00
DOWNSTREAM	2	19.00	20.80	330.00	7.26	312.00	676.00	0.33	1478.00
	3	19.00	20.80	331.00	7.28	308.67	679.00	0.33	1472.00
	AVG	**19.00**	**20.77**	**329.67**	**7.26**	**309.56**	**676.00**	**0.33**	**1479.00**
	SD	**0.00**	**0.06**	**1.53**	**0.02**	**2.14**	**3.00**	**0.00**	**7.55**

Table I (7): Physicochemical analysis for the Northern WWTP during September 2012 (Month 7)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	22.00	20.80	421.00	6.74	309.33	859.00	0.42	1164.00
BEFORE CHLORINATION	**2**	22.00	20.70	425.00	6.75	307.67	866.00	0.42	1153.00
	3	22.00	20.70	425.00	6.78	309.00	867.00	0.42	1153.00
	AVG	**22.00**	**20.73**	**423.67**	**6.76**	**308.67**	**864.00**	**0.42**	**1156.67**
	SD	**0.00**	**0.06**	**2.31**	**0.02**	**0.88**	**4.36**	**0.00**	**6.35**
	1	20.00	19.50	387.00	6.82	309.00	791.00	0.39	1264.00
DISCHARGE POINT	**2**	20.00	19.10	386.00	6.85	309.33	789.00	0.38	1268.00
	3	20.00	19.20	386.00	6.78	307.00	789.00	0.39	1267.00
	AVG	**20.00**	**19.27**	**386.33**	**6.82**	**308.44**	**789.67**	**0.39**	**1266.33**
	SD	**0.00**	**0.21**	**0.58**	**0.04**	**1.26**	**1.15**	**0.01**	**2.08**
	1	20.00	10.70	246.00	6.46	56.00	508.00	0.24	1967.00
UPSTREAM	**2**	20.00	10.60	247.00	6.37	55.00	510.00	0.25	1961.00
	3	20.00	10.70	247.00	6.39	55.67	510.00	0.25	1961.00
	AVG	**20.00**	**10.67**	**246.67**	**6.41**	**55.56**	**509.33**	**0.25**	**1963.00**
	SD	**0.00**	**0.06**	**0.58**	**0.05**	**0.51**	**1.15**	**0.01**	**3.46**
	1	20.00	11.40	387.00	6.50	138.67	792.00	0.39	1263.00
DOWNSTREAM	**2**	20.00	11.60	386.00	6.51	141.67	789.00	0.39	1267.00
	3	20.00	11.50	386.00	6.54	138.67	790.00	0.39	1266.00
	AVG	**20.00**	**11.50**	**386.33**	**6.52**	**139.67**	**790.33**	**0.39**	**1265.33**
	SD	**0.00**	**0.10**	**0.58**	**0.02**	**1.73**	**1.53**	**0.00**	**2.08**

Table I (8): Physicochemical analysis for the Northern WWTP during October 2012 (Month 8)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	22.00	30.80	407.00	6.63	309.00	831.00	0.41	1204.00
BEFORE CHLORINATION	**2**	22.00	30.40	407.00	6.54	306.00	831.00	0.41	1203.00
	3	22.00	30.40	408.00	6.64	305.67	833.00	0.41	1200.00
	AVG	**22.00**	**30.53**	**407.33**	**6.60**	**306.89**	**831.67**	**0.41**	**1202.33**
	SD	**0.00**	**0.23**	**0.58**	**0.06**	**1.84**	**1.15**	**0.00**	**2.08**
	1	23.00	28.50	408.00	6.70	106.67	833.00	0.41	1200.00
DISCHARGE POINT	**2**	23.00	28.50	408.00	6.74	111.67	832.00	0.41	1201.00
	3	23.00	28.50	408.00	6.80	111.33	832.00	0.41	1201.00
	AVG	**23.00**	**28.50**	**408.00**	**6.75**	**109.89**	**832.33**	**0.41**	**1200.67**
	SD	**0.00**	**0.00**	**0.00**	**0.05**	**2.80**	**0.58**	**0.00**	**0.58**
	1	24.00	17.00	241.00	7.02	197.00	499.00	0.24	2004.00
UPSTREAM	**2**	24.00	17.20	241.00	7.01	198.00	499.00	0.24	2004.00
	3	24.00	17.00	242.00	7.02	190.67	500.00	0.24	2001.00
	AVG	**24.00**	**17.07**	**241.33**	**7.02**	**195.22**	**499.33**	**0.24**	**2003.00**
	SD	**0.00**	**0.12**	**0.58**	**0.01**	**3.98**	**0.58**	**0.00**	**1.73**
	1	24.00	29.00	336.00	6.90	148.33	690.00	0.34	1449.00
DOWNSTREAM	**2**	24.00	29.10	336.00	6.92	148.00	690.00	0.34	1449.00
	3	24.00	29.00	336.00	6.92	147.67	689.00	0.33	1450.00
	AVG	**24.00**	**29.03**	**336.00**	**6.91**	**148.00**	**689.67**	**0.34**	**1449.33**
	SD	**0.00**	**0.06**	**0.00**	**0.01**	**0.33**	**0.58**	**0.01**	**0.58**

Table I (9): Physicochemical analysis for the Northern WWTP during November 2012 (Month 9)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	22.00	40.10	446.00	6.80	116.33	0.44	909.00	1100.00
BEFORE CHLORINATION	**2**	22.00	39.90	445.00	6.78	130.00	0.44	907.00	1103.00
	3	22.00	39.90	445.00	6.78	125.00	0.44	907.00	1103.00
	AVG	**22.00**	**39.97**	**445.33**	**6.79**	**123.78**	**0.44**	**907.67**	**1102.00**
	SD	**0.00**	**0.12**	**0.58**	**0.01**	**6.91**	**0.00**	**1.15**	**1.73**
	1	22.50	48.90	475.00	6.65	278.67	0.47	965.00	1036.00
DISCHARGE POINT	**2**	22.50	47.90	478.00	6.68	303.67	0.48	972.00	1029.00
	3	22.50	48.80	479.00	6.70	279.33	0.48	973.00	1028.00
	AVG	**22.50**	**48.53**	**477.33**	**6.68**	**287.22**	**0.48**	**970.00**	**1031.00**
	SD	**0.00**	**0.55**	**2.08**	**0.03**	**14.25**	**0.01**	**4.36**	**4.36**
	1	21.00	20.50	207.00	6.87	230.00	0.20	429.00	2330.00
UPSTREAM	**2**	21.00	22.00	206.60	6.85	266.67	0.20	429.00	2330.00
	3	21.00	21.50	207.00	6.85	228.67	0.21	429.00	2330.00
	AVG	**21.00**	**21.33**	**206.87**	**6.86**	**241.78**	**0.20**	**429.00**	**2330.00**
	SD	**0.00**	**0.76**	**0.23**	**0.01**	**21.56**	**0.01**	**0.00**	**0.00**
	1	23.00	14.20	350.00	6.67	262.67	0.35	718.00	1392.00
DOWNSTREAM	**2**	23.00	14.50	350.00	6.72	241.67	0.35	718.00	1393.00
	3	23.00	13.60	350.00	6.76	234.00	0.35	718.00	1392.00
	AVG	**23.00**	**14.10**	**350.00**	**6.72**	**246.11**	**0.35**	**718.00**	**1392.33**
	SD	**0.00**	**0.46**	**0.00**	**0.05**	**14.84**	**0.00**	**0.00**	**0.58**

Table I (10): Physicochemical analysis for the Northern WWTP during December 2012 (Month 10)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	25.00	36.50	428.00	6.77	175.00	872.00	0.43	1756.00
BEFORE CHLORINATION	**2**	25.00	36.20	428.00	6.82	167.67	872.00	0.43	1762.00
	3	25.00	35.70	428.00	6.76	169.67	873.00	0.43	1763.00
	AVG	**25.00**	**36.13**	**428.00**	**6.78**	**170.78**	**872.33**	**0.43**	**1760.33**
	SD	**0.00**	**0.40**	**0.00**	**0.03**	**3.79**	**0.58**	**0.00**	**3.79**
	1	21.00	31.50	474.00	6.68	154.00	964.00	0.47	1803.00
DISCHARGE POINT	**2**	21.00	31.90	472.00	6.69	154.00	960.00	0.47	1808.00
	3	21.00	31.90	473.00	6.70	153.67	961.00	0.47	1807.00
	AVG	**21.00**	**31.77**	**473.00**	**6.69**	**153.89**	**961.67**	**0.47**	**1806.00**
	SD	**0.00**	**0.23**	**1.00**	**0.01**	**0.19**	**2.08**	**0.00**	**2.65**
	1	22.00	12.00	200.00	6.86	279.33	416.00	0.20	2084.00
UPSTREAM	**2**	22.00	12.50	200.10	6.85	271.00	415.00	0.20	2080.00
	3	22.00	12.10	200.00	6.84	272.67	415.00	0.20	2082.00
	AVG	**22.00**	**12.20**	**200.03**	**6.85**	**274.33**	**415.33**	**0.20**	**2082.00**
	SD	**0.00**	**0.26**	**0.06**	**0.01**	**4.41**	**0.58**	**0.00**	**2.00**
	1	22.00	10.70	360.00	6.64	211.00	737.00	0.36	2011.00
DOWNSTREAM	**2**	22.00	9.88	359.00	6.63	203.33	735.00	0.36	2010.00
	3	22.00	10.40	359.00	6.66	201.67	735.00	0.36	2010.00
	AVG	**22.00**	**10.33**	**359.33**	**6.64**	**205.33**	**735.67**	**0.36**	**2010.33**
	SD	**0.00**	**0.41**	**0.58**	**0.02**	**4.98**	**1.15**	**0.00**	**0.58**

Table I (11): Physicochemical analysis for the Northern WWTP during January 2013 (Month 11)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	24.00	12.80	393.00	6.83	less 10	803.00	0.39	1249.00
BEFORE CHLORINATION	**2**	24.00	12.50	394.00	6.85	less 10	804.00	0.39	1242.00
	3	24.00	12.70	394.00	6.84	less 10	805.00	0.39	1241.00
	AVG	**24.00**	**12.67**	**393.67**	**6.84**	**less 10**	**804.00**	**0.39**	**1244.00**
	SD	**0.00**	**0.15**	**0.58**	**0.01**	**0.00**	**1.00**	**0.00**	**4.36**
	1	23.00	32.20	413.00	6.89	303.33	843.00	0.41	1186.00
DISCHARGE POINT	**2**	23.00	32.20	412.00	6.84	304.00	841.00	0.41	1189.00
	3	23.00	33.60	412.00	6.88	303.67	840.00	0.41	1190.00
	AVG	**23.00**	**32.67**	**412.33**	**6.87**	**303.67**	**841.33**	**0.41**	**1188.33**
	SD	**0.00**	**0.81**	**0.58**	**0.03**	**0.33**	**1.53**	**0.00**	**2.08**
	1	24.00	11.70	154.70	7.05	299.67	323.00	0.15	3100.00
UPSTREAM	**2**	24.00	11.30	155.30	7.04	298.00	324.00	0.15	3090.00
	3	24.00	11.20	155.30	7.04	300.00	324.00	0.15	3090.00
	AVG	**24.00**	**11.40**	**155.10**	**7.04**	**299.22**	**323.67**	**0.15**	**3093.33**
	SD	**0.00**	**0.22**	**0.28**	**0.00**	**0.87**	**0.47**	**0.00**	**4.71**
	1	24.00	8.77	328.00	6.90	152.33	673.00	0.33	1485.00
DOWNSTREAM	**2**	24.00	8.70	327.00	6.93	146.00	671.00	0.33	1490.00
	3	24.00	8.70	327.00	6.93	152.00	672.00	0.33	1490.00
	AVG	**24.00**	**8.72**	**327.33**	**6.92**	**150.11**	**672.00**	**0.33**	**1488.33**
	SD	**0.00**	**0.04**	**0.58**	**0.02**	**3.56**	**1.00**	**0.00**	**2.89**

Table I (12): Physicochemical analysis for the Northern WWTP during February 2013 (Month 12)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	25.00	40.30	455.00	7.81	292.00	927.00	0.46	1079.00
BEFORE CHLORINATION	**2**	25.00	40.60	454.00	7.79	301.00	925.00	0.45	1081.00
	3	25.00	40.20	454.00	7.79	294.00	924.00	0.45	1082.00
	AVG	**25.00**	**40.37**	**454.33**	**7.80**	**295.67**	**925.33**	**0.45**	**1080.67**
	SD	**0.00**	**0.17**	**0.47**	**0.01**	**3.86**	**1.25**	**0.00**	**1.25**
	1	25.00	44.30	459.00	7.88	261.00	933.00	0.46	1186.00
DISCHARGE POINT	**2**	25.00	44.10	457.00	7.89	251.67	930.00	0.46	1189.00
	3	25.00	43.80	457.00	7.88	251.67	930.00	0.46	1190.00
	AVG	**25.00**	**44.07**	**457.67**	**7.88**	**254.78**	**931.00**	**0.46**	**1188.33**
	SD	**0.00**	**0.25**	**1.15**	**0.01**	**5.39**	**1.73**	**0.00**	**2.08**
	1	25.00	6.37	153.00	7.42	308.67	319.00	0.15	3100.00
UPSTREAM	**2**	25.00	6.36	153.40	7.41	310.00	320.00	0.15	3090.00
	3	25.00	6.39	152.80	7.41	308.00	319.00	0.15	3090.00
	AVG	**25.00**	**6.37**	**153.07**	**7.41**	**308.89**	**319.33**	**0.15**	**3093.33**
	SD	**0.00**	**0.02**	**0.31**	**0.01**	**1.02**	**0.58**	**0.00**	**5.77**
	1	27.00	5.94	312.00	7.78	309.00	640.00	0.31	1485.00
DOWNSTREAM	**2**	27.00	5.85	312.00	7.77	310.00	642.00	0.31	1490.00
	3	27.00	6.04	313.00	7.77	309.00	642.00	0.31	1490.00
	AVG	**27.00**	**5.94**	**312.33**	**7.77**	**309.33**	**641.33**	**0.31**	**1488.33**
	SD	**0.00**	**0.10**	**0.58**	**0.01**	**0.58**	**1.15**	**0.00**	**2.89**

Table I (13): Physicochemical analysis for the New Germany TW during March 2012 (Month 1)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	26.00	6.41	438.00	7.08	149.33	893.00	0.44	1120.00
BEFORE CHLORINATION	**2**	26.00	6.86	434.00	6.93	166.67	884.00	0.43	1131.00
	3	26.00	6.67	436.00	7.35	145.00	888.00	0.44	1126.00
	AVG	**26.00**	**6.65**	**436.00**	**7.12**	**153.67**	**888.33**	**0.44**	**1125.67**
	SD	**0.00**	**0.23**	**2.00**	**0.21**	**11.46**	**4.51**	**0.01**	**5.51**
	1	26.00	5.45	471.00	7.29	249.00	957.00	0.47	1025.00
DISCHARGE POINT	**2**	26.00	5.29	480.00	7.05	239.00	976.00	0.48	1022.00
	3	26.00	6.38	481.00	7.21	229.00	978.00	0.48	1024.00
	AVG	**26.00**	**5.71**	**477.33**	**7.18**	**239.00**	**970.33**	**0.48**	**1023.67**
	SD	**0.00**	**0.59**	**5.51**	**0.12**	**10.00**	**11.59**	**0.01**	**1.53**
	1	25.50	5.22	206.00	7.61	314.00	428.00	0.21	2340.00
UPSTREAM	**2**	25.50	5.15	209.00	7.51	314.00	433.00	0.21	2310.00
	3	25.50	5.12	208.90	7.44	313.67	433.00	0.21	2310.00
	AVG	**25.50**	**5.16**	**207.97**	**7.52**	**313.89**	**431.33**	**0.21**	**2320.00**
	SD	**0.00**	**0.05**	**1.70**	**0.09**	**0.19**	**2.89**	**0.00**	**17.32**
	1	26.00	7.70	300.00	7.43	153.00	616.00	0.30	1623.00
DOWNSTREAM	**2**	25.50	7.13	298.00	7.60	140.00	613.00	0.30	1630.00
	3	25.50	7.14	299.00	7.49	131.00	616.00	0.30	1625.00
	AVG	**25.67**	**7.32**	**299.00**	**7.51**	**141.33**	**615.00**	**0.30**	**1626.00**
	SD	**0.29**	**0.33**	**1.00**	**0.09**	**11.06**	**1.73**	**0.00**	**3.61**

Table I (14): Physicochemical analysis for the New Germany TW during April 2012 (Month 2)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	20.00	1.52	387.00	7.08	211.00	791.00	0.39	1265.00
BEFORE CHLORINATION	**2**	20.00	1.52	388.00	7.01	193.00	793.00	0.39	1261.00
	3	20.00	1.52	385.00	7.02	204.33	787.00	0.38	1270.00
	AVG	**20.00**	**1.52**	**386.67**	**7.04**	**202.78**	**790.33**	**0.39**	**1265.33**
	SD	**0.00**	**0.00**	**1.53**	**0.04**	**9.10**	**3.06**	**0.01**	**4.51**
	1	20.50	1.43	433.00	6.83	180.67	883.00	0.43	1132.00
DISCHARGE POINT	**2**	20.00	1.43	432.00	6.82	180.00	880.00	0.43	1137.00
	3	20.00	1.40	436.00	6.82	178.33	889.00	0.44	1125.00
	AVG	**20.17**	**1.42**	**433.67**	**6.82**	**179.67**	**884.00**	**0.43**	**1131.33**
	SD	**0.29**	**0.02**	**2.08**	**0.01**	**1.20**	**4.58**	**0.01**	**6.03**
	1	18.00	8.23	158.30	7.06	101.00	330.00	0.16	3003.00
UPSTREAM	**2**	18.00	8.23	157.80	7.09	105.33	329.00	0.16	3004.00
	3	17.00	8.23	156.90	7.10	106.33	327.00	0.16	3006.00
	AVG	**17.67**	**8.23**	**157.67**	**7.08**	**104.22**	**328.67**	**0.16**	**3004.33**
	SD	**0.58**	**0.00**	**0.71**	**0.02**	**2.83**	**1.53**	**0.00**	**1.53**
	1	19.00	17.00	305.00	7.07	113.00	627.00	0.30	1596.00
DOWNSTREAM	**2**	19.00	17.00	306.00	7.08	116.00	628.00	0.30	1592.00
	3	19.00	17.00	305.00	7.00	113.00	627.00	0.31	1595.00
	AVG	**19.00**	**17.00**	**305.33**	**7.05**	**114.00**	**627.33**	**0.30**	**1594.33**
	SD	**0.00**	**0.00**	**0.58**	**0.04**	**1.73**	**0.58**	**0.01**	**2.08**

Table I (15): Physicochemical analysis for the New Germany TW during May 2012 (Month 3)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	19.00	28.70	565.00	6.97	312.00	1143.00	0.57	875.00
BEFORE CHLORINATION	2	19.00	28.70	567.00	6.94	311.67	1148.00	0.57	871.00
	3	19.00	28.70	570.00	6.81	313.00	1154.00	0.57	867.00
	AVG	**19.00**	**28.70**	**567.33**	**6.91**	**312.22**	**1148.33**	**0.57**	**871.00**
	SD	**0.00**	**0.00**	**2.52**	**0.09**	**0.69**	**5.51**	**0.00**	**4.00**
	1	18.50	30.30	623.00	7.02	247.00	1257.00	0.63	795.00
DISCHARGE POINT	2	18.50	30.30	620.00	7.02	249.00	1251.00	0.62	800.00
	3	18.50	30.30	621.00	7.03	243.00	1253.00	0.62	798.00
	AVG	**18.50**	**30.30**	**621.33**	**7.02**	**246.33**	**1253.67**	**0.62**	**797.67**
	SD	**0.00**	**0.00**	**1.53**	**0.01**	**3.06**	**3.06**	**0.01**	**2.52**
	1	16.00	3.18	175.40	6.39	298.33	365.00	0.17	2740.00
UPSTREAM	2	16.20	3.18	174.40	6.40	298.67	363.00	0.17	2760.00
	3	16.00	3.18	174.20	6.48	299.00	363.00	0.17	2760.00
	AVG	**16.07**	**3.18**	**174.67**	**6.42**	**298.67**	**363.67**	**0.17**	**2753.33**
	SD	**0.12**	**0.00**	**0.64**	**0.05**	**0.33**	**1.15**	**0.00**	**11.55**
	1	13.00	17.80	461.00	7.10	313.33	939.00	0.46	1065.00
DOWNSTREAM	2	14.00	17.80	463.00	7.10	313.00	941.00	0.46	1063.00
	3	14.00	17.80	462.00	7.10	309.33	939.00	0.46	1065.00
	AVG	**13.67**	**17.80**	**462.00**	**7.10**	**311.89**	**939.67**	**0.46**	**1064.33**
	SD	**0.58**	**0.00**	**1.00**	**0.00**	**2.22**	**1.15**	**0.00**	**1.15**

Table I (16): Physicochemical analysis for the New Germany TW during June 2012 (Month 4)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	18.00	9.65	536.00	7.61	312.00	1086.00	0.53	926.00
BEFORE CHLORINATION	2	18.00	9.65	534.00	7.63	309.00	1082.00	0.53	924.00
	3	18.00	9.60	533.00	7.63	309.00	1085.00	0.54	926.00
	AVG	**18.00**	**9.63**	**534.33**	**7.62**	**310.00**	**1084.33**	**0.53**	**925.33**
	SD	**0.00**	**0.03**	**1.53**	**0.01**	**1.73**	**2.08**	**0.01**	**1.15**
	1	17.50	10.50	576.00	7.54	149.00	1164.00	0.58	859.00
DISCHARGE POINT	2	17.50	10.20	578.00	7.55	133.00	1167.00	0.58	857.00
	3	17.50	11.20	578.00	7.55	131.00	1168.00	0.58	856.00
	AVG	**17.50**	**10.63**	**577.33**	**7.55**	**137.67**	**1166.33**	**0.58**	**857.33**
	SD	**0.00**	**0.51**	**1.15**	**0.01**	**9.87**	**2.08**	**0.00**	**1.53**
	1	16.00	8.91	184.20	7.94	25.00	384.00	0.18	2610.00
UPSTREAM	2	16.00	9.15	184.60	7.92	18.00	383.00	0.18	2610.00
	3	16.00	8.99	184.80	7.93	24.00	384.00	0.18	2610.00
	AVG	**16.00**	**9.02**	**184.53**	**7.93**	**22.33**	**383.67**	**0.18**	**2610.00**
	SD	**0.00**	**0.12**	**0.31**	**0.01**	**3.79**	**0.58**	**0.00**	**0.00**
	1	14.00	14.00	405.00	7.83	78.00	828.00	0.40	1208.00
DOWNSTREAM	2	13.80	14.20	404.00	7.83	72.00	827.00	0.40	1210.00
	3	13.80	14.00	405.00	7.83	70.00	825.00	0.40	1210.00
	AVG	**13.87**	**14.07**	**404.67**	**7.83**	**73.33**	**826.67**	**0.40**	**1209.33**
	SD	**0.12**	**0.12**	**0.58**	**0.00**	**4.16**	**1.53**	**0.00**	**1.15**

Table I (17): Physicochemical analysis for the New Germany TW during July 2012 (Month 5)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	16.50	20.00	464.00	6.63	193.67	974.00	0.46	1026.00
BEFORE CHLORINATION	2	16.50	20.00	467.00	6.43	190.00	975.00	0.47	1027.00
	3	16.50	20.20	470.00	6.53	197.33	975.00	0.47	1027.00
	AVG	**16.50**	**20.07**	**467.00**	**6.53**	**193.67**	**974.67**	**0.47**	**1026.67**
	SD	**0.00**	**0.12**	**3.00**	**0.10**	**3.67**	**0.58**	**0.01**	**0.58**
	1	17.00	20.70	523.00	6.88	309.00	1069.00	0.52	936.00
DISCHARGE POINT	2	17.00	20.60	527.00	6.89	308.33	1068.00	0.52	935.00
	3	17.00	20.90	527.00	6.90	308.67	1070.00	0.53	935.00
	AVG	**17.00**	**20.73**	**525.67**	**6.89**	**308.67**	**1069.00**	**0.52**	**935.33**
	SD	**0.00**	**0.15**	**2.31**	**0.01**	**0.33**	**1.00**	**0.01**	**0.58**
	1	13.50	2.43	154.30	6.29	311.67	322.00	0.15	3110.00
UPSTREAM	2	13.50	2.45	154.30	6.30	310.00	322.00	0.15	3110.00
	3	13.50	2.43	153.90	6.31	307.33	321.00	0.15	3110.00
	AVG	**13.50**	**2.44**	**154.17**	**6.30**	**309.67**	**321.67**	**0.15**	**3110.00**
	SD	**0.00**	**0.01**	**0.23**	**0.01**	**2.19**	**0.58**	**0.00**	**0.00**
	1	14.50	16.10	345.00	7.00	298.33	708.00	0.34	1413.00
DOWNSTREAM	2	14.50	16.10	345.00	6.96	295.67	707.00	0.34	1414.00
	3	14.50	16.10	344.00	6.99	304.67	705.00	0.34	1418.00
	AVG	**14.50**	**16.10**	**344.67**	**6.98**	**299.56**	**706.67**	**0.34**	**1415.00**
	SD	**0.00**	**0.00**	**0.58**	**0.02**	**4.62**	**1.53**	**0.00**	**2.65**

Table I (18): Physicochemical analysis for the New Germany TW during August 2012 (Month 6)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	16.80	19.60	416.00	6.73	138.67	849.00	0.41	1175.00
BEFORE CHLORINATION	2	16.80	19.70	417.00	6.86	140.67	851.00	0.42	1206.00
	3	16.80	19.90	417.00	6.95	139.33	848.00	0.42	1180.00
	AVG	**16.80**	**19.73**	**416.67**	**6.85**	**139.56**	**849.33**	**0.42**	**1187.00**
	SD	**0.00**	**0.15**	**0.58**	**0.11**	**1.02**	**1.53**	**0.01**	**16.64**
	1	16.50	16.90	472.00	7.05	307.67	960.00	0.47	1042.00
DISCHARGE POINT	2	16.50	16.60	471.00	7.09	309.00	958.00	0.47	1044.00
	3	16.50	16.90	470.00	7.13	310.33	956.00	0.47	1046.00
	AVG	**16.50**	**16.80**	**471.00**	**7.09**	**309.00**	**958.00**	**0.47**	**1044.00**
	SD	**0.00**	**0.17**	**1.00**	**0.04**	**1.33**	**2.00**	**0.00**	**2.00**
	1	14.50	40.10	341.00	7.10	206.33	699.00	0.35	1432.00
UPSTREAM	2	14.50	40.30	345.00	7.11	208.00	707.00	0.34	1414.00
	3	14.50	40.80	348.00	7.15	208.33	714.00	0.34	1411.00
	AVG	**14.50**	**40.40**	**344.67**	**7.12**	**207.56**	**706.67**	**0.34**	**1419.00**
	SD	**0.00**	**0.36**	**3.51**	**0.03**	**1.07**	**7.51**	**0.01**	**11.36**
	1	12.00	14.00	369.00	7.24	312.67	756.00	0.37	1323.00
DOWNSTREAM	2	12.00	14.10	369.00	7.26	311.67	756.00	0.37	1323.00
	3	12.00	14.20	371.00	7.28	311.00	760.00	0.37	1316.00
	AVG	**12.00**	**14.10**	**369.67**	**7.26**	**311.78**	**757.33**	**0.37**	**1320.67**
	SD	**0.00**	**0.10**	**1.15**	**0.02**	**0.84**	**2.31**	**0.00**	**4.04**

Table I (19): Physicochemical analysis for the New Germany TW during September 2012 (Month 7)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
BEFORE CHLORINATION	1	22.00	5.83	328.00	6.83	96.67	673.00	0.33	1486.00
	2	22.00	5.83	327.00	6.74	101.00	672.00	0.33	1489.00
	3	22.00	5.85	327.00	6.67	97.00	671.00	0.33	1490.00
	AVG	**22.00**	**5.84**	**327.33**	**6.75**	**98.22**	**672.00**	**0.33**	**1488.33**
	SD	**0.00**	**0.01**	**0.58**	**0.08**	**2.41**	**1.00**	**0.00**	**2.08**
DISCHARGE POINT	1	20.00	16.50	380.00	6.34	309.33	778.00	0.38	1285.00
	2	20.00	16.60	381.00	6.38	311.67	779.00	0.38	1284.00
	3	20.00	16.80	381.00	6.39	310.33	779.00	0.38	1283.00
	AVG	**20.00**	**16.63**	**380.67**	**6.37**	**310.44**	**778.67**	**0.38**	**1284.00**
	SD	**0.00**	**0.15**	**0.58**	**0.03**	**1.17**	**0.58**	**0.00**	**1.00**
UPSTREAM	1	20.00	16.00	256.00	6.46	310.00	528.00	0.25	1893.00
	2	20.00	15.70	256.00	6.49	310.00	528.00	0.25	1893.00
	3	20.00	15.80	256.00	6.48	311.00	530.00	0.26	1886.00
	AVG	**20.00**	**15.83**	**256.00**	**6.48**	**310.33**	**528.67**	**0.25**	**1890.67**
	SD	**0.00**	**0.15**	**0.00**	**0.02**	**0.58**	**1.15**	**0.01**	**4.04**
DOWNSTREAM	1	20.00	6.96	260.00	6.59	192.00	536.00	0.26	1834.00
	2	20.00	6.98	263.00	6.59	187.00	541.00	0.26	1844.00
	3	20.00	6.99	262.00	6.59	190.67	549.00	0.26	1847.00
	AVG	**20.00**	**6.98**	**261.67**	**6.59**	**189.89**	**542.00**	**0.26**	**1841.67**
	SD	**0.00**	**0.02**	**1.53**	**0.00**	**2.59**	**6.56**	**0.00**	**6.81**

Table I (20): Physicochemical analysis for the New Germany TW during October 2012 (Month 8)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
BEFORE CHLORINATION	1	20.00	20.10	358.00	6.92	32.67	733.00	0.36	1365.00
	2	20.00	19.90	359.00	6.81	39.67	734.00	0.36	1362.00
	3	20.00	20.00	359.00	6.99	34.67	734.00	0.36	1362.00
	AVG	**20.00**	**20.00**	**358.67**	**6.91**	**35.67**	**733.67**	**0.36**	**1363.00**
	SD	**0.00**	**0.10**	**0.58**	**0.09**	**3.61**	**0.58**	**0.00**	**1.73**
DISCHARGE POINT	1	20.00	16.30	340.00	6.92	53.00	697.00	0.34	1434.00
	2	20.00	16.40	341.00	6.95	57.67	698.00	0.34	1432.00
	3	20.00	16.30	340.00	6.69	51.67	698.00	0.34	1434.00
	AVG	**20.00**	**16.33**	**340.33**	**6.85**	**54.11**	**697.67**	**0.34**	**1433.33**
	SD	**0.00**	**0.06**	**0.58**	**0.14**	**3.15**	**0.58**	**0.00**	**1.15**
UPSTREAM	1	17.00	3.68	222.00	6.98	311.00	460.00	0.22	2172.00
	2	17.00	3.68	221.00	6.98	312.00	457.00	0.22	2186.00
	3	17.00	3.69	221.00	6.95	312.67	458.00	0.22	2184.00
	AVG	**17.00**	**3.68**	**221.33**	**6.97**	**311.89**	**458.33**	**0.22**	**2180.67**
	SD	**0.00**	**0.01**	**0.58**	**0.02**	**0.84**	**1.53**	**0.00**	**7.57**
DOWNSTREAM	1	19.00	5.10	264.00	7.01	242.00	545.00	0.26	1834.00
	2	19.00	5.10	265.00	6.98	242.00	546.00	0.26	1831.00
	3	19.00	5.11	265.00	6.96	233.67	546.00	0.26	1830.00
	AVG	**19.00**	**5.10**	**264.67**	**6.98**	**239.22**	**545.67**	**0.26**	**1831.67**
	SD	**0.00**	**0.01**	**0.58**	**0.03**	**4.81**	**0.58**	**0.00**	**2.08**

Table I (21): Physicochemical analysis for the New Germany TW during November 2012 (Month 9)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	20.00	5.48	427.00	6.84	68.00	888.00	0.43	1115.00
BEFORE CHLORINATION	**2**	20.00	5.60	432.00	6.83	70.67	889.00	0.43	1116.00
	3	20.00	5.46	436.00	6.79	68.67	900.00	0.44	1118.00
	AVG	**20.00**	**5.51**	**431.67**	**6.82**	**69.11**	**892.33**	**0.43**	**1116.33**
	SD	**0.00**	**0.08**	**4.51**	**0.03**	**1.39**	**6.66**	**0.01**	**1.53**
	1	20.00	6.52	536.00	7.10	105.00	1087.00	0.54	916.00
DISCHARGE POINT	**2**	20.00	6.48	539.00	7.15	111.33	1085.00	0.54	916.00
	3	20.00	6.44	529.00	7.18	109.33	1091.00	0.54	912.00
	AVG	**20.00**	**6.48**	**534.67**	**7.14**	**108.56**	**1087.67**	**0.54**	**914.67**
	SD	**0.00**	**0.04**	**5.13**	**0.04**	**3.24**	**3.06**	**0.00**	**2.31**
	1	17.00	8.06	228.00	7.12	304.00	472.00	0.23	2120.00
UPSTREAM	**2**	17.00	8.17	228.00	7.12	308.67	472.00	0.23	2120.00
	3	17.00	8.09	228.00	7.11	307.67	472.00	0.23	2121.00
	AVG	**17.00**	**8.11**	**228.00**	**7.12**	**306.78**	**472.00**	**0.23**	**2120.33**
	SD	**0.00**	**0.06**	**0.00**	**0.01**	**2.46**	**0.00**	**0.00**	**0.58**
	1	18.00	16.40	348.00	7.15	248.33	714.00	0.35	1398.00
DOWNSTREAM	**2**	18.00	16.80	349.00	7.17	250.00	715.00	0.35	1396.00
	3	18.00	16.40	350.00	7.16	274.33	716.00	0.35	1398.00
	AVG	**18.00**	**16.53**	**349.00**	**7.16**	**257.56**	**715.00**	**0.35**	**1397.33**
	SD	**0.00**	**0.23**	**1.00**	**0.01**	**14.55**	**1.00**	**0.00**	**1.15**

Table I (22): Physicochemical analysis for the New Germany TW during December 2012 (Month 10)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	22.00	4.45	267.00	6.40	88.67	551.00	0.27	1756.00
BEFORE CHLORINATION	**2**	22.00	4.68	268.00	6.38	91.33	553.00	0.27	1762.00
	3	22.00	4.09	268.00	6.88	100.00	554.00	0.27	1763.00
	AVG	**22.00**	**4.41**	**267.67**	**6.55**	**93.33**	**552.67**	**0.27**	**1760.33**
	SD	**0.00**	**0.30**	**0.58**	**0.28**	**5.93**	**1.53**	**0.00**	**3.79**
	1	22.00	29.40	276.00	6.45	302.00	569.00	0.27	1803.00
DISCHARGE POINT	**2**	22.00	29.50	275.00	6.46	303.67	568.00	0.27	1808.00
	3	22.00	29.40	275.00	6.45	295.67	567.00	0.27	1807.00
	AVG	**22.00**	**29.43**	**275.33**	**6.45**	**300.44**	**568.00**	**0.27**	**1806.00**
	SD	**0.00**	**0.06**	**0.58**	**0.01**	**4.22**	**1.00**	**0.00**	**2.65**
	1	20.00	32.00	232.00	6.46	22.00	480.00	0.23	2084.00
UPSTREAM	**2**	20.00	32.20	232.00	6.47	26.00	481.00	0.23	2080.00
	3	20.00	32.10	232.00	6.48	25.00	480.00	0.23	2082.00
	AVG	**20.00**	**32.10**	**232.00**	**6.47**	**24.33**	**480.33**	**0.23**	**2082.00**
	SD	**0.00**	**0.10**	**0.00**	**0.01**	**2.08**	**0.58**	**0.00**	**2.00**
	1	20.00	28.20	241.00	6.47	39.67	497.00	0.24	2011.00
DOWNSTREAM	**2**	20.00	28.10	241.00	6.51	34.00	497.00	0.24	2010.00
	3	20.00	28.00	241.00	6.55	32.33	497.00	0.24	2010.00
	AVG	**20.00**	**28.10**	**241.00**	**6.51**	**35.33**	**497.00**	**0.24**	**2010.33**
	SD	**0.00**	**0.10**	**0.00**	**0.04**	**3.84**	**0.00**	**0.00**	**0.58**

Table I (23): Physicochemical analysis for the New Germany TW during January 2012 (Month 11)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	23.00	9.38	419.00	6.60	110.33	847.00	0.42	1178.00
BEFORE CHLORINATION	**2**	23.00	9.45	416.00	6.57	112.00	849.00	0.42	1176.00
	3	23.00	9.45	418.00	6.59	111.00	848.00	0.42	1176.00
	AVG	**23.00**	**9.43**	**417.67**	**6.59**	**111.11**	**848.00**	**0.42**	**1176.67**
	SD	**0.00**	**0.04**	**1.53**	**0.02**	**0.84**	**1.00**	**0.00**	**1.15**
	1	23.00	9.26	417.00	6.60	236.67	850.00	0.42	1177.00
DISCHARGE POINT	**2**	23.00	9.34	416.00	6.59	244.00	849.00	0.42	1178.00
	3	23.00	9.28	416.00	6.63	241.67	849.00	0.42	1177.00
	AVG	**23.00**	**9.29**	**416.33**	**6.61**	**240.78**	**849.33**	**0.42**	**1177.33**
	SD	**0.00**	**0.04**	**0.58**	**0.02**	**3.75**	**0.58**	**0.00**	**0.58**
	1	22.00	10.80	197.90	6.71	84.67	411.00	0.20	2440.00
UPSTREAM	**2**	22.00	10.80	197.50	6.72	81.67	410.00	0.20	2440.00
	3	22.00	10.80	197.50	6.71	74.67	410.00	0.20	2440.00
	AVG	**22.00**	**10.80**	**197.63**	**6.71**	**80.33**	**410.33**	**0.20**	**2440.00**
	SD	**0.00**	**0.00**	**0.23**	**0.01**	**5.13**	**0.58**	**0.00**	**0.00**
	1	22.00	10.60	253.00	6.73	48.33	522.00	0.25	1914.00
DOWNSTREAM	**2**	22.00	10.60	253.00	6.73	43.67	522.00	0.25	1914.00
	3	22.00	10.60	253.00	6.73	41.67	522.00	0.25	1917.00
	AVG	**22.00**	**10.60**	**253.00**	**6.73**	**44.56**	**522.00**	**0.25**	**1915.00**
	SD	**0.00**	**0.00**	**0.00**	**0.00**	**3.42**	**0.00**	**0.00**	**1.73**

Table I (24): Physicochemical analysis for the New Germany TW during February 2012 (Month 12)

		TEMP	TURB	TDS	pH	COD	EC	SAL	RES
	1	24.00	3.92	455.00	7.76	156.33	927.00	0.46	1079.00
BEFORE CHLORINATION	**2**	24.00	3.93	454.00	7.70	164.33	925.00	0.45	1081.00
	3	24.00	3.94	454.00	7.70	156.00	924.00	0.45	1082.00
	AVG	**24.00**	**3.93**	**454.33**	**7.72**	**158.89**	**925.33**	**0.45**	**1080.67**
	SD	**0.00**	**0.01**	**0.58**	**0.03**	**4.72**	**1.53**	**0.01**	**1.53**
	1	24.00	4.00	459.00	7.87	282.33	933.00	0.46	1186.00
DISCHARGE POINT	**2**	24.00	4.05	457.00	7.88	287.67	930.00	0.46	1189.00
	3	24.00	4.01	457.00	7.85	280.33	930.00	0.46	1190.00
	AVG	**24.00**	**4.02**	**457.67**	**7.87**	**283.44**	**931.00**	**0.46**	**1188.33**
	SD	**0.00**	**0.03**	**1.15**	**0.02**	**3.79**	**1.73**	**0.00**	**2.08**
	1	21.00	8.87	153.00	7.56	305.00	319.00	0.15	3100.00
UPSTREAM	**2**	21.00	8.82	153.40	7.48	305.00	320.00	0.15	3090.00
	3	21.00	8.80	152.80	7.47	306.00	319.00	0.15	3090.00
	AVG	**21.00**	**8.83**	**153.07**	**7.50**	**305.33**	**319.33**	**0.15**	**3093.33**
	SD	**0.00**	**0.04**	**0.31**	**0.05**	**0.58**	**0.58**	**0.00**	**5.77**
	1	23.00	5.82	312.00	8.08	264.00	640.00	0.31	1485.00
DOWNSTREAM	**2**	23.00	5.79	312.00	8.08	264.67	642.00	0.31	1490.00
	3	23.00	5.80	313.00	8.08	290.00	642.00	0.31	1490.00
	AVG	**23.00**	**5.80**	**312.33**	**8.08**	**272.89**	**641.33**	**0.31**	**1488.33**
	SD	**0.00**	**0.02**	**0.58**	**0.00**	**14.82**	**1.15**	**0.00**	**2.89**

APPENDIX II: Total suspended solids (TSS)

NOTE: A: Weight of the Petri-dish (g); B: Weight of the Petri-dish and Filter (g); C: Weight of Filter only (g); D: Weight of the Petri-dish and filter after filtration of water sample (g); E: Weight of the Filter only after filtration (g)

Calculation: Total Suspended Solids (g/l) = $\frac{\text{Residue + Filter (g) – Filter (g)}}{\text{sample filtered (ml)}} \times 1000$

Volume of sample filtered: 250 ml

Table II (1): Total Suspended Solids Data for the Northern WWTP during March 2012 (Month 1)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	12.5988	12.6899	0.0911	12.6943	0.0955	0.0176		
BC 2	12.7003	12.7931	0.0928	12.796	0.0957	0.0116	**0.0137**	**0.0034**
BC 3	13.0776	13.1697	0.0921	13.1727	0.0951	0.012		
DP 1	12.7741	12.8652	0.091	12.865	0.091	0		
DP 2	12.4964	12.5895	0.0931	12.598	0.1016	0.034	**0.0263**	**0.0234**
DP 3	13.469	13.5594	0.0904	13.5706	0.1016	0.0448		
US 1	12.7538	12.8458	0.092	12.849	0.0952	0.0128		
US 2	12.7145	12.8056	0.0911	12.8102	0.0957	0.0184	**0.0153**	**0.0028**
US 3	12.8333	12.9256	0.0923	12.9293	0.096	0.0148		
DS 1	14.2821	14.3749	0.0928	14.3782	0.0961	0.0132		
DS 2	12.3402	12.431	0.0908	12.4344	0.0942	0.0136	**0.0140**	**0.0011**
DS 3	12.602	12.6938	0.0918	12.6976	0.0956	0.0152		
C0NTROL	12.4698	12.5611	0.0913	12.5612	0.0914	**0.0004**		

Table II (2): Total Suspended Solids Data for the Northern WWTP during April 2012 (Month 2)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	13.0773	13.1687	0.0914	13.1877	0.1104	**0.095**		
BC 2	12.7	12.7927	0.0927	12.8156	0.1156	**0.1145**	**0.0960**	**0.0180**
BC 3	12.5994	12.6925	0.0931	12.7082	0.1088	**0.0785**		
DP 1	12.7741	12.8661	0.092	12.8815	0.1074	**0.0616**		
DP 2	14.2819	14.3749	0.093	14.3862	0.1043	**0.0452**	**0.0656**	**0.0227**
DP 3	13.4686	13.5615	0.0929	13.584	0.1154	**0.09**		
US 1	12.7533	12.8447	0.0914	12.8488	0.0955	**0.0164**		
US 2	12.4966	12.5895	0.0929	12.5934	0.0968	**0.0156**	**0.0153**	**0.0012**
US 3	12.8333	12.9268	0.0935	12.9303	0.097	**0.014**		
DS 1	12.6015	12.6936	0.0921	12.6969	0.0954	**0.0132**		
DS 2	12.3404	12.4311	0.0907	12.4355	0.0951	**0.0176**	**0.0119**	**0.0065**
DS 3	12.7148	12.808	0.0932	12.8092	0.0944	**0.0048**		
C0NTROL	12.4698	12.5611	0.0913	12.5612	0.0914	**0.0004**		

Table II (3): Total Suspended Solids Data for the Northern WWTP during May 2012 (Month 3)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	24.9914	25.3208	0.3294	25.3274	0.336	**0.033**		
NW BC 2	24.424	24.756	0.332	24.7639	0.3399	**0.0395**		
NW BC 3	37.4848	37.8149	0.3301	37.8211	0.3363	**0.031**	**0.0345**	**0.0044**
NW AC 1	21.9558	22.2827	0.3269	22.2858	0.33	**0.0124**		
NW AC 2	22.2848	22.6155	0.3307	22.6188	0.334	**0.0132**		
NW AC 3	24.431	24.7605	0.3295	24.7662	0.3352	**0.0228**	**0.0161**	**0.0058**
NW US 1	24.3661	24.6937	0.3276	24.6982	0.3321	**0.018**		
NW US 2	22.4333	22.7659	0.3326	22.7683	0.335	**0.0096**		
NW US 3	24.37	24.7013	0.3313	24.7044	0.3344	**0.0124**	**0.0133**	**0.0043**
NW DS 1	59.4128	59.739	0.3262	59.746	0.3332	**0.028**		
NW DS 2	24.3979	24.9689	0.571	25.2957	0.8978	**1.3072**		
NW DS 3	19.9517	20.2856	0.3339	20.3958	0.4441	**0.4408**	**0.5920**	**0.6529**
C0NTROL	21.9423	22.2762	0.3339	22.2768	0.3345	**0.0024**		

Table II (4): Total Suspended Solids Data for the Northern WWTP during June 2012 (Month 4)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.1784	13.273	0.0946	13.276	0.0976	**0.015**		
NW BC 2	12.5997	12.6929	0.0932	12.697	0.0973	**0.0205**		
NW BC 3	12.7012	12.7954	0.0942	12.7989	0.0977	**0.0175**	**0.0177**	**0.0028**
NW AC 1	14.5535	14.6457	0.0922	14.651	0.0975	**0.0212**		
NW AC 2	14.2797	14.372	0.0923	14.3776	0.0979	**0.0224**		
NW AC 3	13.4671	13.5608	0.0937	13.5652	0.0981	**0.0176**	**0.0204**	**0.0025**
NW US 1	12.7521	12.8455	0.0934	12.8471	0.095	**0.0064**		
NW US 2	12.4958	12.5899	0.0941	12.5918	0.096	**0.0076**		
NW US 3	12.8323	12.9258	0.0935	12.9274	0.0951	**0.0064**	**0.0068**	**0.0007**
NW DS 1	12.5412	12.6336	0.0924	12.6358	0.0946	**0.0088**		
NW DS 2	12.34	12.4326	0.0926	12.4359	0.0959	**0.0132**		
NW DS 3	12.7144	12.8064	0.092	12.8093	0.0949	**0.0116**	**0.0112**	**0.0022**
C0NTROL	12.4691	12.5602	0.0911	12.5611	0.092	**0.0036**		

Table II (5): Total Suspended Solids Data for the Northern WWTP during July 2012 (Month 5)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.0768	13.1695	0.0927	13.1765	0.0997	**0.035**		
NW BC 2	12.5997	12.6924	0.0927	12.6972	0.0975	**0.024**		
NW BC 3	12.6995	12.7923	0.0928	12.7985	0.099	**0.031**	**0.0300**	**0.0056**
NW AC 1	14.5553	14.6482	0.0929	14.6554	0.1001	**0.0288**		
NW AC 2	14.2811	14.375	0.0939	14.3807	0.0996	**0.0228**		
NW AC 3	13.4686	13.5619	0.0933	13.57	0.1014	**0.0324**	**0.0280**	**0.0048**
NW US 1	12.7533	12.8455	0.0922	12.8473	0.094	**0.0072**		
NW US 2	12.4961	12.5889	0.0928	12.5909	0.0948	**0.008**		
NW US 3	12.774	12.866	0.092	12.8675	0.0935	**0.006**	**0.0071**	**0.0010**
NW DS 1	12.5399	12.6328	0.0929	12.6377	0.0978	**0.0196**		
NW DS 2	12.6013	12.6946	0.0933	12.6985	0.0972	**0.0156**		
NW DS 3	13.1786	13.2718	0.0932	13.2753	0.0967	**0.014**	**0.0164**	**0.0029**
C0NTROL	12.4683	12.5601	0.0918	12.5602	0.0919	**0.0004**		

Table II (6): Total Suspended Solids Data for the Northern WWTP during August 2012 (Month 6)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.0776	13.1695	0.0919	13.1789	0.1013	**0.047**		
NW BC 2	12.5983	12.6913	0.093	12.6995	0.1012	**0.041**		
NW BC 3	12.6991	12.793	0.0939	12.7978	0.0987	**0.024**	**0.0373**	**0.0119**
NW AC 1	14.5545	14.6474	0.0929	14.6587	0.1042	**0.0452**		
NW AC 2	12.7131	12.8069	0.0938	12.8188	0.1057	**0.0476**		
NW AC 3	13.4671	13.56	0.0929	13.5732	0.1061	**0.0528**	**0.0485**	**0.0039**
NW US 1	12.7516	12.8449	0.0933	12.8519	0.1003	**0.028**		
NW US 2	12.4952	12.5876	0.0924	12.5931	0.0979	**0.022**		
NW US 3	12.7725	12.8649	0.0924	12.8703	0.0978	**0.0216**	**0.0239**	**0.0036**
NW DS 1	12.541	12.6328	0.0918	12.6368	0.0958	**0.016**		
NW DS 2	12.6	12.6929	0.0929	12.6962	0.0962	**0.0132**		
NW DS 3	13.1756	13.2688	0.0932	13.2731	0.0975	**0.0172**	**0.0155**	**0.0021**
C0NTROL	12.4684	12.5609	0.0925	12.561	0.0926	**0.0004**		

Table II (7): Total Suspended Solids Data for the Northern WWTP during September 2012 (Month 7)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.101	13.1953	0.0943	13.1954	0.0944	**0.0005**		
NW BC 2	12.125	12.8102	0.6852	12.8235	0.6985	**0.0665**	**0.0260**	**0.0355**
NW BC 3	12.6216	12.718	0.0964	12.7202	0.0986	**0.011**		
NW AC 1	12.6246	12.718	0.0934	12.7204	0.0958	**0.0096**		
NW AC 2	13.2013	13.2954	0.0941	13.298	0.0967	**0.0104**	**0.0112**	**0.0021**
NW AC 3	12.5655	12.6583	0.0928	12.6617	0.0962	**0.0136**		
NW US 1	12.4918	12.5869	0.0951	12.59	0.0982	**0.0124**		
NW US 2	13.493	13.5888	0.0958	13.589	0.096	**0.0008**	**0.0059**	**0.0059**
NW US 3	14.5798	14.6735	0.0937	14.6746	0.0948	**0.0044**		
NW DS 1	12.52	12.613	0.093	12.6143	0.0943	**0.0052**		
NW DS 2	12.6246	12.891	0.2664	12.8911	0.2665	**0.0004**	**0.0051**	**0.0046**
NW DS 3	12.776	12.8704	0.0944	12.8728	0.0968	**0.0096**		
C0NTROL	12.738	12.8305	0.0925	12.8293	0.0913	**-0.0048**		

Table II (8): Total Suspended Solids Data for the Northern WWTP during October 2012 (Month 8)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.1013	13.1942	0.0929	13.2015	0.1002	**0.0292**		
NW BC 2	12.7254	12.819	0.0936	12.8259	0.1005	**0.0276**	**0.0220**	**0.0111**
NW BC 3	12.6244	12.7171	0.0927	12.7194	0.095	**0.0092**		
NW AC 1	12.625	12.7184	0.0934	12.7247	0.0997	**0.0252**		
NW AC 2	13.2023	13.2951	0.0928	13.2998	0.0975	**0.0188**	**0.0239**	**0.0045**
NW AC 3	12.565	12.6575	0.0925	12.6644	0.0994	**0.0276**		
NW US 1	12.4931	12.5869	0.0938	12.5871	0.094	**0.0008**		
NW US 2	13.4931	13.5864	0.0933	13.5865	0.0934	**0.0004**	**0.0023**	**0.0029**
NW US 3	14.5801	14.6739	0.0938	14.6753	0.0952	**0.0056**		
NW DS 1	12.5207	12.614	0.0933	12.6144	0.0937	**0.0016**		
NW DS 2	12.7976	12.8913	0.0937	12.8965	0.0989	**0.0208**	**0.0140**	**0.0108**
NW DS 3	12.7771	12.8707	0.0936	12.8756	0.0985	**0.0196**		
C0NTROL	12.7385	12.8301	0.0916	12.8307	0.0922	**0.0024**		

Table II (9): Total Suspended Solids Data for the Northern WWTP during November 2012 (Month 9)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.1019	13.1946	0.0927	13.2047	0.1028	**0.0404**		
NW BC 2	12.7253	12.8187	0.0934	12.8282	0.1029	**0.038**	**0.0384**	**0.0018**
NW BC 3	12.6242	12.7173	0.0931	12.7265	0.1023	**0.0368**		
NW AC 1	12.625	12.7186	0.0936	12.7282	0.1032	**0.0384**		
NW AC 2	13.2024	13.2951	0.0927	13.3028	0.1004	**0.0308**	**0.0296**	**0.0095**
NW AC 3	12.565	12.6588	0.0938	12.6637	0.0987	**0.0196**		
NW US 1	12.4934	12.5867	0.0933	12.59	0.0966	**0.0132**		
NW US 2	13.4932	13.5858	0.0926	13.5887	0.0955	**0.0116**	**0.0143**	**0.0033**
NW US 3	14.5802	14.672	0.0918	14.6765	0.0963	**0.018**		
NW DS 1	12.5206	12.6132	0.0926	12.617	0.0964	**0.0152**		
NW DS 2	12.7977	12.8903	0.0926	12.8924	0.0947	**0.0084**	**0.0125**	**0.0036**
NW DS 3	12.7771	12.8693	0.0922	12.8728	0.0957	**0.014**		
C0NTROL	12.7388	12.832	0.0932	12.8321	0.0933	**0.0004**		

Table II (10): Total Suspended Solids Data for the Northern WWTP during December 2012 (Month 10)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	12.6233	12.7177	0.0944	12.7274	0.1041	**0.0388**		
NW BC 2	12.7238	12.8185	0.0947	12.8302	0.1064	**0.0468**	**0.0433**	**0.0041**
NW BC 3	13.2506	13.3441	0.0935	13.3552	0.1046	**0.0444**		
NW AC 1	12.6243	12.7201	0.0958	12.7271	0.1028	**0.028**		
NW AC 2	13.2019	13.2963	0.0944	13.3036	0.1017	**0.0292**	**0.0247**	**0.0068**
NW AC 3	12.5643	12.6587	0.0944	12.6629	0.0986	**0.0168**		
NW US 1	12.4924	12.5858	0.0934	12.5889	0.0965	**0.0124**		
NW US 2	13.4927	13.5863	0.0936	13.5876	0.0949	**0.0052**	**0.0103**	**0.0044**
NW US 3	14.5798	14.6727	0.0929	14.676	0.0962	**0.0132**		
NW DS 1	12.5203	12.6134	0.0931	12.616	0.0957	**0.0104**		
NW DS 2	12.7975	12.8904	0.0929	12.8927	0.0952	**0.0092**	**0.0083**	**0.0027**
NW DS 3	12.7767	12.8692	0.0925	12.8705	0.0938	**0.0052**		
C0NTROL	12.7385	12.8337	0.0952	12.8337	0.0952	**0**		

Table II (11): Total Suspended Solids Data for the Northern WWTP during January 2013 (Month 11)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.2504	13.3388	0.0884	13.3468	0.0964	**0.032**		
NW BC 2	12.724	12.8131	0.0891	12.8176	0.0936	**0.018**	**0.0212**	**0.0096**
NW BC 3	12.6219	12.711	0.0891	12.7144	0.0925	**0.0136**		
NW AC 1	12.625	12.7122	0.0872	12.7239	0.0989	**0.0468**		
NW AC 2	13.2021	13.2889	0.0868	13.305	0.1029	**0.0644**	**0.0585**	**0.0102**
NW AC 3	12.565	12.6522	0.0872	12.6683	0.1033	**0.0644**		
NW US 1	12.4931	12.5799	0.0868	12.5839	0.0908	**0.016**		
NW US 2	13.4931	13.5774	0.0843	13.5785	0.0854	**0.0044**	**0.0092**	**0.0061**
NW US 3	14.5804	14.6665	0.0861	14.6683	0.0879	**0.0072**		
NW DS 1	12.5209	12.6097	0.0888	12.6112	0.0903	**0.006**		
NW DS 2	12.7976	12.8841	0.0865	12.8873	0.0897	**0.0128**	**0.0092**	**0.0034**
NW DS 3	12.7772	12.8636	0.0864	12.8658	0.0886	**0.0088**		
C0NTROL	12.7364	12.8238	0.0874	12.8242	0.0878	**0.0016**		

Table II (12): Total Suspended Solids Data for the Northern WWTP during February 2013 (Month 12)

A	B	C	D	E	F	TSS	FINAL AVG	SD
NW BC 1	13.2508	13.3382	0.0874	13.3525	0.1017	**0.0572**		
NW BC 2	12.7254	12.8126	0.0872	12.8283	0.1029	**0.0628**	**0.0561**	**0.0073**
NW BC 3	12.6242	12.7116	0.0874	12.7237	0.0995	**0.0484**		
NW AC 1	12.6246	12.7180	0.0934	12.7226	0.0980	**0.0184**		
NW AC 2	13.2033	13.2954	0.0921	13.3012	0.0979	**0.0232**	**0.0344**	**0.0237**
NW AC 3	12.5645	12.6516	0.0871	12.6670	0.1025	**0.0616**		
NW US 1	12.4924	12.5869	0.0945	12.5905	0.0981	**0.0144**		
NW US 2	13.4928	13.5850	0.0922	13.5904	0.0976	**0.0216**	**0.0167**	**0.0043**
NW US 3	14.5806	14.6738	0.0932	14.6773	0.0967	**0.0140**		
NW DS 1	12.5204	12.6143	0.0939	12.6167	0.0963	**0.0096**		
NW DS 2	12.7982	12.8907	0.0925	12.8933	0.0951	**0.0104**	**0.0103**	**0.0006**
NW DS 3	12.7775	12.8699	0.0924	12.8726	0.0951	**0.0108**		
C0NTROL	12.7395	12.8261	0.0866	12.8262	0.0867	**0.0004**		

Table II (13): Physico-chemical analysis for the New Germany TW during March 2012 (Month 1)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	13.0782	13.1705	0.0923	13.1727	0.0945	**0.0088**		
BC 2	12.7017	12.7932	0.0915	12.7958	0.0941	**0.0104**	**0.0103**	**0.0014**
BC 3	12.5996	12.6920	0.0924	12.6949	0.0953	**0.0116**		
DP 1	12.7748	12.8674	0.0926	12.8700	0.0952	**0.0104**		
DP 2	14.2826	14.3755	0.0929	14.3811	0.0985	**0.0224**	**0.0164**	**0.0060**
DP 3	13.4693	13.5615	0.0922	13.5656	0.0963	**0.0164**		
US 1	12.7538	12.8464	0.0926	12.8475	0.0937	**0.0044**		
US 2	12.4970	12.5886	0.0916	12.5898	0.0928	**0.0048**	**0.0043**	**0.0006**
US 3	12.8334	12.9275	0.0941	12.9284	0.0950	**0.0036**		
DS 1	12.6001	12.6932	0.0931	12.6966	0.0965	**0.0136**		
DS 2	12.7140	12.8055	0.0915	12.4348	-0.2792	**-1.4828**	**0.0116**	**1.4934**
DS 3	12.3403	12.4327	0.0924	12.8087	0.4684	**1.5040**		
C0NTROL	12.4763	12.5673	0.0910	12.5647	0.0884	**-0.0104**		

Table II (14): Physico-chemical analysis for the New Germany TW during April 2012 (Month 2)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	24.3989	24.7295	0.3306	24.7563	0.3574	**0.1340**		
BC 2	12.7016	12.7953	0.0937	12.7954	0.0938	**0.0005**	**0.0463**	**0.0759**
BC 3	12.5997	12.6928	0.0931	12.6937	0.0940	**0.0045**		
DP 1	24.9109	25.2493	0.3384	25.2712	0.3603	**0.0876**		
DP 2	14.2820	14.3742	0.0922	14.3751	0.0931	**0.0036**	**0.0311**	**0.0490**
DP 3	13.4684	13.5619	0.0935	13.5624	0.0940	**0.0020**		
US 1	12.7534	12.8454	0.0920	12.8479	0.0945	**0.0100**		
US 2	12.4959	12.5862	0.0903	12.5894	0.0935	**0.0128**	**0.0109**	**0.0016**
US 3	12.8327	12.9247	0.0920	12.9272	0.0945	**0.0100**		
DS 1	24.1408	24.4720	0.3312	24.5059	0.3651	**0.1356**		
DS 2	12.3394	12.4304	0.0910	12.4331	0.0937	**0.0108**	**0.0571**	**0.0684**
DS 3	12.7131	12.8057	0.0926	12.8119	0.0988	**0.0248**		
C0NTROL	12.4675	12.5624	0.0949	12.5635	0.0960	**0.0044**		

Table II (15): Physico-chemical analysis for the New Germany TW during May 2012 (Month 3)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	14.5590	14.6491	0.0901	14.6570	0.0980	**0.0395**		
BC 2	14.2817	14.3742	0.0925	14.3822	0.1005	**0.0400**	**0.0375**	**0.0039**
BC 3	13.4486	13.5613	0.1127	13.5679	0.1193	**0.0330**		
DP 1	13.1787	13.2719	0.0932	13.2782	0.0995	**0.0252**		
DP 2	12.7012	12.7936	0.0924	12.6991	-0.0021	**-0.3780**	**0.0267**	**0.4054**
DP 3	12.5997	12.6921	0.0924	12.8003	0.2006	**0.4328**		
US 1	12.7533	12.8461	0.0928	12.8461	0.0928	**0.0000**		
US 2	12.4966	12.5893	0.0927	12.5893	0.0927	**0.0000**	**0.0003**	**0.0005**
US 3	12.8332	12.9264	0.0932	12.9266	0.0934	**0.0008**		
DS 1	12.5415	12.6353	0.0938	12.6392	0.0977	**0.0156**		
DS 2	12.3402	12.4340	0.0938	12.4380	0.0978	**0.0160**	**0.0157**	**0.0002**
DS 3	12.7148	12.8076	0.0928	12.8115	0.0967	**0.0156**		
C0NTROL	12.4695	12.5635	0.0940	12.5638	0.0943	**0.0012**		

Table II (16): Physico-chemical analysis for the New Germany TW during June 2012 (Month 4)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	13.1780	13.2715	0.0935	13.2745	0.0965	**0.0150**		
BC 2	12.5990	12.6914	0.0924	12.6940	0.0950	**0.0130**	**0.0138**	**0.0010**
BC 3	12.7005	12.7936	0.0931	12.7963	0.0958	**0.0135**		
DP 1	14.5552	14.6475	0.0923	14.6500	0.0948	**0.0100**		
DP 2	14.2810	14.3736	0.0926	14.3755	0.0945	**0.0076**	**0.0092**	**0.0014**
DP 3	13.4683	13.5611	0.0928	13.5636	0.0953	**0.0100**		
US 1	12.7527	12.8451	0.0924	12.8455	0.0928	**0.0016**		
US 2	12.4960	12.5886	0.0926	12.5892	0.0932	**0.0024**	**0.0023**	**0.0006**
US 3	12.8321	12.9249	0.0928	12.9256	0.0935	**0.0028**		
DS 1	12.3397	12.4325	0.0928	12.4342	0.0945	**0.0068**		
DS 2	12.5411	12.6338	0.0927	12.6354	0.0943	**0.0064**	**0.0068**	**0.0004**
DS 3	12.7143	12.8074	0.0931	12.8092	0.0949	**0.0072**		
C0NTROL	12.4683	12.5600	0.0917	12.5602	0.0919	**0.0008**		

Table II (17): Physico-chemical analysis for the New Germany TW during July 2012 (Month 5)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	13.0776	13.1706	0.0930	13.1747	0.0971	**0.0205**		
BC 2	12.5998	12.6937	0.0939	12.6978	0.0980	**0.0205**	**0.0212**	**0.0012**
BC 3	12.7007	12.7935	0.0928	12.7980	0.0973	**0.0225**		
DP 1	14.5559	14.6504	0.0945	14.6533	0.0974	**0.0116**		
DP 2	12.7139	12.8074	0.0935	12.8146	0.1007	**0.0288**	**0.0209**	**0.0087**
DP 3	13.4684	13.5618	0.0934	13.5674	0.0990	**0.0224**		
US 1	12.7532	12.8470	0.0938	12.8470	0.0938	**0.0000**		
US 2	12.4959	12.5908	0.0949	12.5908	0.0949	**0.0000**	**0.0000**	**0.0000**
US 3	12.7739	12.8679	0.0940	12.8679	0.0940	**0.0000**		
DS 1	12.5408	12.6349	0.0941	12.6398	0.0990	**0.0196**		
DS 2	12.6008	12.6936	0.0928	12.6978	0.0970	**0.0168**	**0.0155**	**0.0049**
DS 3	13.1783	13.2707	0.0924	13.2732	0.0949	**0.0100**		
C0NTROL	12.4685	12.5631	0.0946	12.5631	0.0946	**0.0000**		

Table II (18): Physico-chemical analysis for the New Germany TW during August 2012 (Month 6)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	13.0777	13.1702	0.0925	13.1733	0.0956	**0.0155**		
BC 2	12.5992	12.6925	0.0933	12.6956	0.0964	**0.0155**	**0.0152**	**0.0006**
BC 3	12.7010	12.7940	0.0930	12.7969	0.0959	**0.0145**		
DP 1	14.5561	14.6489	0.0928	14.6529	0.0968	**0.0160**		
DP 2	12.7142	12.8070	0.0928	12.8100	0.0958	**0.0120**	**0.0137**	**0.0021**
DP 3	13.4688	13.5614	0.0926	13.5647	0.0959	**0.0132**		
US 1	12.7527	12.8471	0.0944	12.8528	0.1001	**0.0228**		
US 2	12.4962	12.5879	0.0917	12.5949	0.0987	**0.0280**	**0.0320**	**0.0117**
US 3	12.7740	12.8661	0.0921	12.8774	0.1034	**0.0452**		
DS 1	12.5414	12.6340	0.0926	12.6373	0.0959	**0.0132**		
DS 2	12.6012	12.6945	0.0933	12.6978	0.0966	**0.0132**	**0.0165**	**0.0058**
DS 3	13.1788	13.2718	0.0930	13.2776	0.0988	**0.0232**		
CONTROL	12.4688	12.5621	0.0933	12.5610	0.0922	**-0.0044**		

Table II (19): Physico-chemical analysis for the New Germany TW during September 2012 (Month 7)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	13.1021	13.1959	0.0938	13.1975	0.0954	**0.0080**		
BC 2	12.7218	12.8162	0.0944	12.8185	0.0967	**0.0115**	**0.0087**	**0.0026**
BC 3	12.6228	12.7154	0.0926	12.7167	0.0939	**0.0065**		
DP 1	12.6230	12.7167	0.0937	12.7188	0.0958	**0.0084**		
DP 2	13.2006	13.2952	0.0946	13.2958	0.0952	**0.0024**	**0.0041**	**0.0037**
DP 3	12.5636	12.6582	0.0946	12.6586	0.0950	**0.0016**		
US 1	12.4915	12.5856	0.0941	12.5892	0.0977	**0.0144**		
US 2	13.4932	13.5875	0.0943	13.5879	0.0947	**0.0016**	**0.0083**	**0.0064**
US 3	14.5788	14.6722	0.0934	14.6744	0.0956	**0.0088**		
DS 1	12.5194	12.6118	0.0924	12.6161	0.0967	**0.0172**		
DS 2	12.7966	12.8912	0.0946	12.8948	0.0982	**0.0144**	**0.0124**	**0.0061**
DS 3	12.7763	12.8694	0.0931	12.8708	0.0945	**0.0056**		
C0NTROL	12.7367	12.8297	0.0930	12.8307	0.0940	**0.0040**		

Table II (20): Physico-chemical analysis for the New Germany TW during October 2012 (Month 8)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	13.1020	13.1949	0.0929	13.1953	0.0933	**0.0020**		
BC 2	12.7246	12.8166	0.0920	12.8177	0.0931	**0.0055**	**0.0043**	**0.0020**
BC 3	12.6240	12.7160	0.0920	12.7171	0.0931	**0.0055**		
DP 1	12.6243	12.7176	0.0933	12.7185	0.0942	**0.0036**		
DP 2	13.2015	13.2956	0.0941	13.2960	0.0945	**0.0016**	**0.0024**	**0.0011**
DP 3	12.5647	12.6572	0.0925	12.6577	0.0930	**0.0020**		
US 1	12.4924	12.5850	0.0926	12.5863	0.0939	**0.0052**		
US 2	13.4931	13.5856	0.0925	13.5871	0.0940	**0.0060**	**0.0048**	**0.0014**
US 3	14.5795	14.6724	0.0929	14.6732	0.0937	**0.0032**		
DS 1	12.5202	12.6128	0.0926	12.6147	0.0945	**0.0076**		
DS 2	12.7972	12.8895	0.0923	12.8919	0.0947	**0.0096**	**0.0084**	**0.0011**
DS 3	12.7765	12.8695	0.0930	12.8715	0.0950	**0.0080**		
C0NTROL	12.7384	12.8319	0.0935	12.8320	0.0936	**0.0004**		

Table II (21): Physico-chemical analysis for the New Germany TW during November 2012 (Month 9)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	12.7386	12.8318	0.0932	12.8320	0.0934	**0.0010**		
BC 2	12.7230	12.8182	0.0952	12.7239	0.0009	**-0.4715**	**0.0053**	**0.2753**
BC 3	12.6216	12.7156	0.0940	12.7175	0.0959	**0.0095**		
DP 1	12.6235	12.7171	0.0936	12.7187	0.0952	**0.0064**		
DP 2	13.2003	13.2932	0.0929	13.2951	0.0948	**0.0076**	**0.0083**	**0.0023**
DP 3	12.5624	12.6566	0.0942	12.6593	0.0969	**0.0108**		
US 1	12.4918	12.5855	0.0937	12.5863	0.0945	**0.0032**		
US 2	13.4919	13.5850	0.0931	13.5865	0.0946	**0.0060**	**0.0068**	**0.0041**
US 3	14.5792	14.6717	0.0925	14.6745	0.0953	**0.0112**		
DS 1	12.5201	12.6141	0.0940	12.6224	0.1023	**0.0332**		
DS 2	12.7972	12.8902	0.0930	12.8989	0.1017	**0.0348**	**0.0311**	**0.0051**
DS 3	12.7770	12.8704	0.0934	12.8767	0.0997	**0.0252**		
C0NTROL	12.7384	13.1940	0.4556	13.1942	0.4558	**0.0008**		

Table II (22): Physico-chemical analysis for the New Germany TW during December 2012 (Month 10)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	13.2504	13.3435	0.0931	13.3530	0.1026	**0.0475**		
BC 2	12.7252	12.8195	0.0943	12.8308	0.1056	**0.0565**	**0.0473**	**0.0093**
BC 3	12.6240	12.7187	0.0947	12.7263	0.1023	**0.0380**		
DP 1	12.6247	12.7189	0.0942	12.7286	0.1039	**0.0388**		
DP 2	13.2010	13.2951	0.0941	13.3052	0.1042	**0.0404**	**0.0392**	**0.0011**
DP 3	12.5637	12.6564	0.0927	12.6660	0.1023	**0.0384**		
US 1	12.4924	12.5850	0.0926	12.5986	0.1062	**0.0544**		
US 2	13.4924	13.5856	0.0932	13.5957	0.1033	**0.0404**	**0.0467**	**0.0071**
US 3	14.5809	14.6731	0.0922	14.6844	0.1035	**0.0452**		
DS 1	12.5212	12.6147	0.0935	12.6274	0.1062	**0.0508**		
DS 2	12.7979	12.8906	0.0927	12.9019	0.1040	**0.0452**	**0.0489**	**0.0032**
DS 3	12.7775	12.8692	0.0917	12.8819	0.1044	**0.0508**		
C0NTROL	12.7390	12.8313	0.0923	12.8313	0.0923	**0.0000**		

Table II (23): Physico-chemical analysis for the New Germany TW during January 2012 (Month 11)

SAMPLE	A	B	C	D	E	TSS	FINAL AVG	SD
BC 1	13.2511	13.3361	0.0850	13.3383	0.0872	**0.0110**		
BC 2	12.7248	12.8125	0.0877	12.8139	0.0891	**0.0070**	**0.0097**	**0.0023**
BC 3	12.6240	12.7101	0.0861	12.7123	0.0883	**0.0110**		
DP 1	12.6246	12.7110	0.0864	12.7132	0.0886	**0.0088**		
DP 2	13.2022	13.2897	0.0875	13.2900	0.0878	**0.0012**	**0.0127**	**0.0138**
DP 3	12.5643	12.6513	0.0870	12.6583	0.0940	**0.0280**		
US 1	12.4928	12.5796	0.0868	12.5804	0.0876	**0.0032**		
US 2	13.4928	13.5801	0.0873	13.5000	0.0072	**-0.3204**	**0.0026**	**0.1865**
US 3	14.5802	14.6671	0.0869	14.6676	0.0874	**0.0020**		
DS 1	12.5204	12.6071	0.0867	12.6084	0.0880	**0.0052**		
DS 2	12.7914	12.8848	0.0934	12.8861	0.0947	**0.0052**	**0.0061**	**0.0016**
DS 3	12.7766	12.8640	0.0874	12.8660	0.0894	**0.0080**		
C0NTROL	12.7386	12.8262	0.0876	12.8262	0.0876	**0.0000**		

Table II (24): Physico-chemical analysis for the New Germany TW during February 2012 (Month 12)

A	B	C	D	E	F	TSS	FINAL AVG	SD
BC 1	13.251	13.338	0.087	13.353	0.102	**0.057**		
BC 2	12.725	12.813	0.087	12.828	0.103	**0.063**	**0.056**	**0.007**
BC 3	12.624	12.712	0.087	12.724	0.099	**0.048**		
DP 1	12.625	12.718	0.093	12.723	0.098	**0.018**		
DP 2	13.203	13.295	0.092	13.301	0.098	**0.023**	**0.034**	**0.024**
DP 3	12.565	12.652	0.087	12.667	0.102	**0.062**		
US 1	12.492	12.587	0.095	12.591	0.098	**0.014**		
US 2	13.493	13.585	0.092	13.590	0.098	**0.022**	**0.017**	**0.004**
US 3	14.581	14.674	0.093	14.677	0.097	**0.014**		
DS 1	12.520	12.614	0.094	12.617	0.096	**0.010**		
DS 2	12.798	12.891	0.093	12.893	0.095	**0.010**	**0.010**	**0.001**
DS 3	12.778	12.870	0.092	12.873	0.095	**0.011**		
C0NTROL	12.740	12.826	0.087	12.826	0.087	**0.000**		

APPENDIX III: BIOLOGICAL OXYGEN DEMAND (BOD_5)

BOD_5 was determined according to a protocol by HACH: Method 8043

PREPARATION OF DILUTION WATER:

- Six litres of sterile distilled water was prepared and stored for 24 hr at 20 °C to allow for dissolution of any oxygen present.

- One sachet of nutrient buffer pillow (Cat. No.: 14862-66) was added to 6 ℓ of sterile distilled water and inverted prior to conducting BOD analyses, followed by vigorous shaking for one minute to dissolve the nutrients and saturate the water with air.

SAMPLE SIZE SELECTION FOR BOD ANALYSES:

- A minimum and maximum sample volume was pre-determined according to Table 1 below. This was followed by estimating an additional two sample volumes in between the minimum and maximum volumes to allow for four replicates in total.

Table 1: Determination of the minimum sample volume for BOD analyses according to sample type

Sample Type	Estimated BOD mg/L	*ml of sample
Strong Trade Waste	600	1
Raw and Settled Sewage	300	2
	200	3
	150	4
	120	5
	100	6
	75	8
	60	10
Oxidized Effluents	50	12
	40	15
	30	20
	20	30
	10	60
Polluted River Waters	6	100
	4	200
	2	300

*ml of sample taken and diluted to 300 ml in standard BOD Bottle

Table 2: Determination of the maximum sample volume for BOD analyses according to altitude

Estimated BOD at			*ml of sample
Sea level	**1000 ft**	**5000 ft**	
2460	2380	2032	1
1230	1189	1016	2
820	793	677	3
615	595	508	4
492	476	406	5
410	397	339	6
304	294	251	8
246	238	203	10
205	198	169	12
164	158	135	15
123	119	101	20
82	79	68	30
41	40	34	60
25	24	21	100
12	12	10	200
8	8	7	300

*ml of sample taken and diluted to 300 ml

For this study, sample volumes were chosen as follows:

Table 3: Sample volumes chosen for BOD analyses between March 2012 – February 2013

SAMPLE	MINIMUM (ml)	INTERMEDIATE 1 (ml)	INTERMEDIATE 2 (ml)	MAXIMUM (ml)
Before Chlorination	200	225	275	300
Discharge Point	200	225	275	300
Upstream	60	150	200	300
Downstream	60	150	200	300

CALCULATION OF BOD:

BOD5 (mg/l) = (D1 – D2) / P

Where: D1: Dissolved Oxygen of sample immediately after preparation (mg/l)

D2: Dissolved Oxygen of sample after 5 day incubation at 20 °C (mg/l)

P: Decimal Volumetric fraction of sample used, i.e.: $^{\text{volume of sample used (ml)}} / _{\text{total volume (300 ml)}}$

Table III (1): Physico-chemical analysis for the Northern WWTP during March 2012 (Month 1)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.63	7.63	7.63	0.00	6.89	6.41	6.65	0.34	0.67	1.10	1.82	1.46	0.51				
BC (225 ml)	7.43	7.43	7.43	0.00	6.50	6.45	6.48	0.04	0.72	1.29	1.36	1.33	0.05	**2.21**	**0.18**	**7.55**	**0.02**
BC (275 ml)	7.46	7.50	7.48	0.03	5.63	5.68	5.66	0.04	0.92	1.99	1.98	1.98	0.01				
BC (300 ml)	7.69	7.63	7.66	0.04	3.51	3.66	3.59	0.11	1.00	4.18	3.97	4.08	0.15				
DP (200 ml)	7.99	7.98	7.99	0.01	4.04	4.00	4.02	0.03	0.67	5.90	5.94	5.92	0.03				
DP (225 ml)	8.26	8.20	8.23	0.04	3.14	3.37	3.26	0.16	0.72	7.11	6.71	6.91	0.28	**5.23**	**0.09**	**8.16**	**0.02**
DP (275 ml)	8.36	8.37	8.37	0.01	4.94	4.96	4.95	0.01	0.92	3.72	3.71	3.71	0.01				
DP (300 ml)	8.09	8.04	8.07	0.04	3.71	3.62	3.67	0.06	1.00	4.38	4.42	4.40	0.03				
US (60 ml)	8.15	8.16	8.16	0.01	6.20	6.00	6.10	0.14	0.20	9.75	10.80	10.28	0.74				
US (150 ml)	8.38	8.36	8.37	0.01	6.61	6.67	6.64	0.04	0.50	3.54	3.38	3.46	0.11	**5.11**	**0.30**	**8.15**	**0.01**
US (200 ml)	7.97	7.94	7.96	0.02	5.98	5.80	5.89	0.13	0.67	2.97	3.19	3.08	0.16				
US (300 ml)	8.14	8.13	8.14	0.01	4.66	4.40	4.53	0.18	1.00	3.48	3.73	3.61	0.18				
DS (60 ml)	8.16	8.15	8.16	0.01	5.58	5.57	5.58	0.01	0.20	12.90	12.90	12.90	0.00				
DS (150 ml)	7.91	7.92	7.92	0.01	5.42	5.52	5.47	0.07	0.50	4.98	4.80	4.89	0.13	**5.54**	**0.05**	**7.96**	**0.02**
DS (200 ml)	8.02	8.03	8.03	0.01	5.80	5.81	5.81	0.01	0.67	3.31	3.31	3.31	0.00				
DS (300 ml)	7.81	7.71	7.76	0.07	6.68	6.69	6.69	0.01	1.00	1.13	1.02	1.08	0.08				
CONTROL	**8.37**	**8.32**	**8.35**	**0.04**	**6.68**	**6.69**	**6.69**	**0.01**	**1.00**	**1.69**	**1.63**	**1.66**	**0.04**				

Table III (2): Physico-chemical analysis for the Northern WWTP during April 2012 (Month 2)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.71	7.82	7.77	0.08	4.84	4.54	4.69	0.21	0.67	4.28	4.90	4.59	0.43				
BC (225 ml)	7.70	7.31	7.51	0.28	4.30	4.99	4.65	0.49	0.72	4.72	3.22	3.97	1.06	**3.23**	**0.50**	**7.54**	**0.10**
BC (275 ml)	7.34	7.29	7.32	0.04	5.50	4.79	5.15	0.50	0.92	2.00	2.72	2.36	0.51				
BC (300 ml)	7.59	7.58	7.59	0.01	5.60	5.58	5.59	0.01	1.00	1.99	2.00	2.00	0.01				
DP (200 ml)	7.69	7.62	7.66	0.05	5.19	5.01	5.10	0.13	0.67	3.73	3.90	3.81	0.12				
DP (225 ml)	7.90	7.78	7.84	0.08	4.77	4.92	4.85	0.11	0.72	4.35	3.97	4.16	0.27	**3.75**	**0.19**	**7.77**	**0.04**
DP (275 ml)	7.63	7.61	7.62	0.01	4.28	4.13	4.21	0.11	0.92	3.64	3.78	3.71	0.10				
DP (300 ml)	7.95	7.95	7.95	0.00	4.45	4.83	4.64	0.27	1.00	3.50	3.12	3.31	0.27				
US (60 ml)	8.52	8.52	8.52	0.00	4.17	4.37	4.27	0.14	0.20	21.75	20.75	21.25	0.71				
US (150 ml)	8.50	8.50	8.50	0.00	5.63	5.55	5.59	0.06	0.50	5.74	5.90	5.82	0.11	**8.59**	**0.40**	**8.50**	**0.00**
US (200 ml)	8.51	8.51	8.51	0.00	5.45	5.96	5.71	0.36	0.67	4.57	3.81	4.19	0.54				
US (300 ml)	8.49	8.48	8.49	0.01	5.54	5.19	5.37	0.25	1.00	2.95	3.29	3.12	0.24				
DS (60 ml)	8.31	8.31	8.31	0.00	5.15	5.14	5.15	0.01	0.20	15.80	15.85	15.83	0.04				
DS (150 ml)	8.05	8.05	8.05	0.00	5.89	5.92	5.91	0.02	0.50	4.32	4.26	4.29	0.04	**6.28**	**0.06**	**7.84**	**0.01**
DS (200 ml)	7.76	7.74	7.75	0.01	5.78	5.80	5.79	0.01	0.67	2.96	2.90	2.93	0.04				
DS (300 ml)	7.23	7.27	7.25	0.03	5.24	5.13	5.19	0.08	1.00	1.99	2.14	2.07	0.11				
CONTROL	**8.37**	**8.36**	**8.37**	**0.01**	**6.68**	**6.69**	**6.69**	**0.01**	**1.00**	**1.69**	**1.67**	**1.68**	**0.01**				

Table III (3): Physico-chemical analysis for the Northern WWTP during May 2012 (Month 3)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	6.72	6.75	6.74	0.02	6.22	6.21	6.22	0.01	0.67	0.75	0.81	0.78	0.04				
BC (225 ml)	6.78	6.81	6.80	0.02	5.25	5.27	5.26	0.01	0.72	2.13	2.14	2.13	0.01	**1.05**	**0.06**	**6.69**	**0.03**
BC (275 ml)	6.23	6.28	6.26	0.04	6.36	6.49	6.43	0.09	0.92	-0.14	-0.23	-0.18	0.06				
BC (300 ml)	6.98	6.93	6.96	0.04	5.42	5.53	5.48	0.08	1.00	1.56	1.40	1.48	0.11				
DP (200 ml)	8.00	8.02	8.01	0.01	5.10	5.09	5.10	0.01	0.67	4.33	4.37	4.35	0.03				
DP (225 ml)	7.95	7.94	7.95	0.01	5.02	5.05	5.04	0.02	0.72	4.07	4.01	4.04	0.04	**3.33**	**0.05**	**7.99**	**0.01**
DP (275 ml)	8.09	8.05	8.07	0.03	5.42	5.49	5.46	0.05	0.92	2.90	2.78	2.84	0.08				
DP (300 ml)	7.94	7.95	7.95	0.01	5.80	5.90	5.85	0.07	1.00	2.14	2.05	2.10	0.06				
US (60 ml)	8.12	8.11	8.12	0.01	6.25	6.45	6.35	0.14	0.20	9.35	8.30	8.83	0.74				
US (150 ml)	8.13	8.11	8.12	0.01	6.14	6.30	6.22	0.11	0.50	3.98	3.62	3.80	0.25	**4.73**	**0.36**	**8.08**	**0.01**
US (200 ml)	-	-	-	-	-	-	-	-	-	-	-	-	-				
US (300 ml)	8.01	8.02	8.02	0.01	6.49	6.40	6.45	0.06	1.00	1.52	1.62	1.57	0.07				
DS (60 ml)	8.17	8.16	8.17	0.01	5.61	5.53	5.57	0.06	0.20	12.80	13.15	12.98	0.25				
DS (150 ml)	8.09	8.10	8.10	0.01	5.99	6.10	6.05	0.08	0.50	4.20	4.00	4.10	0.14	**5.64**	**0.20**	**8.14**	**0.01**
DS (200 ml)	8.19	8.17	8.18	0.01	5.76	5.40	5.58	0.25	0.67	3.63	4.13	3.88	0.36				
DS (300 ml)	8.11	8.14	8.13	0.02	6.54	6.49	6.52	0.04	1.00	1.57	1.65	1.61	0.06				
CONTROL	**8.13**	**8.14**	**8.14**	**0.01**	**8.07**	**8.03**	**8.05**	**0.03**	**1.00**	**0.06**	**0.11**	**0.09**	**0.04**				

Table III (4): Physico-chemical analysis for the Northern WWTP during June 2012 (Month 4)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	8.26	8.24	8.25	0.01	4.40	4.23	4.32	0.12	0.67	5.76	5.99	5.87	0.16				
BC (225 ml)	8.04	8.09	8.07	0.04	5.22	5.36	5.29	0.10	0.72	3.92	3.79	3.85	0.09	**3.79**	**0.13**	**7.97**	**0.03**
BC (275 ml)	7.74	7.73	7.74	0.01	5.05	5.15	5.10	0.07	0.92	2.92	2.80	2.86	0.08				
BC (300 ml)	7.79	7.89	7.84	0.07	5.36	5.22	5.29	0.10	1.00	2.43	2.67	2.55	0.17				
DP (200 ml)	8.67	8.68	8.68	0.01	5.43	5.43	5.43	0.00	0.67	4.84	4.85	4.84	0.01				
DP (225 ml)	8.56	8.59	8.58	0.02	5.09	5.17	5.13	0.06	0.72	4.82	4.75	4.78	0.05	**4.07**	**0.09**	**8.65**	**0.02**
DP (275 ml)	8.63	8.69	8.66	0.04	5.20	5.36	5.28	0.11	0.92	3.73	3.62	3.67	0.08				
DP (300 ml)	8.68	8.66	8.67	0.01	5.55	5.82	5.69	0.19	1.00	3.13	2.84	2.99	0.21				
US (60 ml)	8.54	8.56	8.55	0.01	4.62	4.62	4.62	0.00	0.20	19.60	19.70	19.65	0.07				
US (150 ml)	8.43	8.42	8.43	0.01	5.48	5.38	5.43	0.07	0.50	5.90	6.08	5.99	0.13	**9.73**	**0.11**	**8.44**	**0.02**
US (200 ml)	-	-	-	-	-	-	-	-	-	-	-	-	-				
US (300 ml)	8.37	8.33	8.35	0.03	4.93	4.69	4.81	0.17	1.00	3.44	3.64	3.54	0.14				
DS (60 ml)	8.47	8.48	8.48	0.01	5.68	5.66	5.67	0.01	0.20	13.95	14.10	14.03	0.11				
DS (150 ml)	8.50	8.51	8.51	0.01	5.78	5.80	5.79	0.01	0.50	5.44	5.42	5.43	0.01	**6.83**	**0.15**	**8.43**	**0.01**
DS (200 ml)	8.36	8.37	8.37	0.01	5.33	5.68	5.51	0.25	0.67	4.52	4.01	4.27	0.36				
DS (300 ml)	8.37	8.36	8.37	0.01	4.87	4.69	4.78	0.13	1.00	3.50	3.67	3.59	0.12				
CONTROL	**8.51**	**8.58**	**8.55**	**0.05**	**7.66**	**7.67**	**7.67**	**0.01**	**1.00**	**0.85**	**0.91**	**0.88**	**0.04**				

Table III (5): Physico-chemical analysis for the Northern WWTP during July 2012 (Month 5)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	6.80	6.92	6.86	0.08	4.07	4.27	4.17	0.14	0.67	4.07	3.96	4.01	0.08				
BC (225 ml)	6.67	6.68	6.68	0.01	5.20	5.10	5.15	0.07	0.72	2.04	2.19	2.12	0.11	**2.66**	**0.21**	**6.62**	**0.10**
BC (275 ml)	-	-	-	-	-	-	-	-	-	-	-	-	-				
BC (300 ml)	6.48	6.18	6.33	0.21	4.31	4.64	4.48	0.23	1.00	2.17	1.54	1.86	0.45				
DP (200 ml)	7.73	7.71	7.72	0.01	4.76	4.72	4.74	0.03	0.67	4.43	4.46	4.45	0.02				
DP (225 ml)	7.40	7.13	7.27	0.19	5.10	5.23	5.17	0.09	0.72	3.19	2.64	2.92	0.39	**3.06**	**0.17**	**7.40**	**0.09**
DP (275 ml)	7.35	7.21	7.28	0.10	5.00	5.05	5.03	0.04	0.92	2.55	2.35	2.45	0.15				
DP (300 ml)	7.27	7.36	7.32	0.06	4.92	4.85	4.89	0.05	1.00	2.35	2.51	2.43	0.11				
US (60 ml)	8.35	8.32	8.34	0.02	4.85	4.96	4.91	0.08	0.20	17.50	16.80	17.15	0.49				
US (150 ml)	8.24	8.25	8.25	0.01	4.51	4.34	4.43	0.12	0.50	7.46	7.82	7.64	0.25	**8.54**	**0.21**	**8.26**	**0.03**
US (200 ml)	8.21	8.35	8.28	0.10	4.16	4.27	4.22	0.08	0.67	6.04	6.09	6.07	0.03				
US (300 ml)	8.16	8.17	8.17	0.01	4.90	4.83	4.87	0.05	1.00	3.26	3.34	3.30	0.06				
DS (60 ml)	8.33	8.37	8.35	0.03	4.64	4.52	4.58	0.08	0.20	18.45	19.25	18.85	0.57				
DS (150 ml)	8.21	8.26	8.24	0.04	4.81	4.81	4.81	0.00	0.50	6.80	6.90	6.85	0.07	**8.77**	**0.20**	**8.29**	**0.04**
DS (200 ml)	8.30	8.21	8.26	0.06	4.80	4.77	4.79	0.02	0.67	5.22	5.13	5.18	0.06				
DS (300 ml)	8.34	8.31	8.33	0.02	4.07	4.20	4.14	0.09	1.00	4.27	4.11	4.19	0.11				
CONTROL	**8.51**	**8.45**	**8.48**	**0.04**	**7.35**	**7.29**	**7.32**	**0.04**	**1.00**	**1.16**	**1.16**	**1.16**	**0.00**				

Table III (6): Physico-chemical analysis for the Northern WWTP during August 2012 (Month 6)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	6.89	6.80	6.85	0.06	5.75	5.50	5.63	0.18	0.67	1.70	1.94	1.82	0.17				
BC (225 ml)	6.63	6.64	6.64	0.01	5.80	5.84	5.82	0.03	0.72	1.15	1.11	1.13	0.03	**1.44**	**0.09**	**6.55**	**0.02**
BC (275 ml)	-	-	-	-	-	-	-	-	-	-	-	-	-				
BC (300 ml)	6.17	6.17	6.17	0.00	4.85	4.76	4.81	0.06	1.00	1.32	1.41	1.37	0.06				
DP (200 ml)	6.47	6.47	6.47	0.00	5.25	5.33	5.29	0.06	0.67	1.82	1.70	1.76	0.08				
DP (225 ml)	6.07	6.02	6.05	0.04	4.63	4.73	4.68	0.07	0.72	2.00	1.79	1.90	0.15	**1.87**	**0.11**	**5.94**	**0.05**
DP (275 ml)	5.47	5.30	5.39	0.12	4.60	4.66	4.63	0.04	0.92	0.95	0.70	0.82	0.18				
DP (300 ml)	5.85	5.90	5.88	0.04	5.70	5.80	5.75	0.07	1.00	0.15	0.10	3.00	0.04				
US (60 ml)	7.91	7.91	7.91	0.00	4.77	4.79	4.78	0.01	0.20	15.70	15.60	15.65	0.07				
US (150 ml)	7.58	7.52	7.55	0.04	4.67	4.65	4.66	0.01	0.50	5.82	5.74	5.78	0.06	**7.84**	**0.08**	**7.69**	**0.02**
US (200 ml)	7.72	7.79	7.76	0.05	5.14	5.37	5.26	0.16	0.67	3.85	3.61		0.17				
US (300 ml)	7.54	7.54	7.54	0.00	5.42	5.48	5.45	0.04	1.00	2.12	2.06	2.09	0.04				
DS (60 ml)	8.00	8.00	8.00	0.00	5.72	5.67	5.70	0.04	0.20	11.40	11.65	11.53	0.18				
DS (150 ml)	8.00	8.00	8.00	0.00	5.05	5.18	5.12	0.09	0.50	5.90	5.64	5.77	0.18	**5.58**	**0.17**	**8.01**	**0.00**
DS (200 ml)	8.01	8.00	8.01	0.01	6.22	6.30	6.26	0.06	0.67	2.67	2.54	2.60	0.09				
DS (300 ml)	8.05	8.04	8.05	0.01	5.80	5.46	5.63	0.24	1.00	2.25	2.58	2.42	0.23				
CONTROL	**8.01**	**8.02**	**8.02**	**0.01**	**7.63**	**7.43**	**7.53**	**0.14**	**1.00**	**0.38**	**0.59**	**0.49**	**0.15**				

Table III (7): Physico-chemical analysis for the Northern WWTP during September 2012 (Month 7)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	6.93	6.72	6.83	0.15	4.49	5.00	4.75	0.36	0.67	3.64	2.57	3.10	0.76				
BC (225 ml)	6.36	6.38	6.37	0.01	5.27	5.21	5.24	0.04	0.72	1.51	1.63	1.57	0.08	**1.87**	**0.36**	**6.37**	**0.11**
BC (275 ml)	6.02	6.12	6.07	0.07	4.73	5.50	5.12	0.54	0.92	1.40	0.67	1.04	0.51				
BC (300 ml)	6.08	6.37	6.23	0.21	4.37	4.52	4.45	0.11	1.00	1.71	1.85	1.78	0.10				
DP (200 ml)	7.30	7.36	7.33	0.04	4.82	4.56	4.69	0.18	0.67	3.70	4.18	3.94	0.34				
DP (225 ml)	6.51	6.53	6.52	0.01	4.69	4.28	4.49	0.29	0.72	2.53	3.13	2.83	0.42	**2.91**	**0.27**	**6.61**	**0.05**
DP (275 ml)	6.41	6.54	6.48	0.09	4.82	4.69	4.76	0.09	0.92	1.73	2.01	1.87	0.20				
DP (300 ml)	6.07	6.17	6.12	0.07	4.53	4.81	4.67	0.20	1.00	1.54	1.36	3.00	0.13				
US (60 ml)	8.14	8.18	8.16	0.03	4.76	4.87	4.82	0.08	0.20	16.90	16.55	16.73	0.25				
US (150 ml)	8.35	8.43	8.39	0.06	5.03	5.07	5.05	0.03	0.50	6.64	6.72	6.68	0.06	**8.76**	**0.13**	**8.12**	**0.03**
US (200 ml)	8.24	8.21	8.23	0.02	4.60	4.74	4.67	0.10	0.67	5.43	5.18		0.18				
US (300 ml)	7.67	7.71	7.69	0.03	4.83	4.80	4.82	0.02	1.00	2.84	2.91	2.88	0.05				
DS (60 ml)	7.92	7.93	7.93	0.01	4.33	4.49	4.41	0.11	0.20	17.95	17.20	17.58	0.53				
DS (150 ml)	7.39	7.58	7.49	0.13	5.15	5.04	5.10	0.08	0.50	4.48	5.08	4.78	0.42	**7.17**	**0.31**	**7.56**	**0.07**
DS (200 ml)	7.50	7.64	7.57	0.10	4.87	4.83	4.85	0.03	0.67	3.93	4.19	4.06	0.19				
DS (300 ml)	7.22	7.26	7.24	0.03	5.02	4.90	4.96	0.08	1.00	2.20	2.36	2.28	0.11				
CONTROL	**8.36**	**8.37**	**8.37**	**0.01**	**6.51**	**6.59**	**6.55**	**0.06**	**1.00**	**1.85**	**1.78**	**1.82**	**0.05**				

Table III (8): Physico-chemical analysis for the Northern WWTP during October 2012 (Month 8)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.59	7.73	7.66	0.10	4.71	5.02	4.87	0.22	0.67	4.30	4.04	4.17	0.18				
BC (225 ml)	7.44	7.49	7.47	0.04	4.50	4.84	4.67	0.24	0.72	4.08	3.68	3.88	0.28	**3.20**	**0.18**	**7.32**	**0.30**
BC (275 ml)	7.21	7.13	7.17	0.06	4.63	4.73	4.68	0.07	0.92	2.80	2.61	2.71	0.14				
BC (300 ml)	7.00	7.00	7.00	0.00	5.04	4.90	4.97	0.10	1.00	1.96	2.10	2.03	0.10				
DP (200 ml)	8.06	8.04	8.05	0.01	4.75	4.90	4.83	0.11	0.67	4.94	4.69	4.81	0.18				
DP (225 ml)	7.96	7.97	7.97	0.01	5.05	5.00	5.03	0.04	0.72	4.04	4.13	4.08	0.06	**3.98**	**0.19**	**7.96**	**0.07**
DP (275 ml)	7.97	7.88	7.93	0.06	4.15	4.57	4.36	0.30	0.92	4.15	3.60	3.88	0.39				
DP (300 ml)	7.86	7.90	7.88	0.03	4.63	4.84	4.74	0.15	1.00	3.23	3.06	3.15	0.12				
US (60 ml)	7.75	7.95	7.85	0.14	3.98	3.89	3.94	0.06	0.20	18.85	20.30	19.58	1.03				
US (150 ml)	7.65	7.65	7.65	0.00	4.93	4.92	4.93	0.01	0.50	5.44	5.46	5.45	0.01	**8.19**	**0.30**	**7.70**	**0.20**
US (200 ml)	7.86	7.84	7.85	0.01	4.35	4.45	4.40	0.07	0.67	5.24	5.06	5.15	0.13				
US (300 ml)	7.42	7.44	7.43	0.01	4.80	4.85	4.83	0.04	1.00	2.62	2.59	2.61	0.02				
DS (60 ml)	7.99	7.80	7.90	0.13	4.79	4.99	4.89	0.14	0.20	16.00	14.05	15.03	1.38				
DS (150 ml)	7.81	7.79	7.80	0.01	4.91	5.07	4.99	0.11	0.50	5.80	5.44	5.62	0.25	**6.97**	**0.83**	**7.67**	**0.23**
DS (200 ml)	7.65	7.56	7.61	0.06	4.15	4.96	4.56	0.57	0.67	5.22	3.88	4.55	0.95				
DS (300 ml)	7.39	7.36	7.38	0.02	4.19	5.20	4.70	0.71	1.00	3.20	2.16	2.68	0.74				
CONTROL	**8.13**	**8.03**	**8.08**	**0.07**	**7.43**	**7.33**	**7.38**	**0.07**	**1.00**	**0.70**	**0.70**	**0.70**	**0.00**				

Table III (9): Physico-chemical analysis for the Northern WWTP during November 2012 (Month 9)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.08	7.19	7.14	0.08	4.50	4.46	4.48	0.03	0.67	3.85	4.07	3.96	0.16				
BC (225 ml)	7.03	6.96	7.00	0.05	3.42	4.03	3.73	0.43	0.72	5.01	4.07	4.54	0.67	**3.49**	**0.28**	**6.87**	**0.04**
BC (275 ml)	6.82	6.81	6.82	0.01	4.32	4.21	4.27	0.08	0.92	2.72	2.83	2.77	0.08				
BC (300 ml)	6.51	6.56	6.54	0.04	3.70	4.04	3.87	0.24	1.00	2.81	2.52	2.67	0.21				
DP (200 ml)	7.04	7.05	7.05	0.01	4.30	4.45	4.38	0.11	0.67	4.09	3.88	3.99	0.15				
DP (225 ml)	7.04	7.01	7.03	0.02	4.23	4.17	4.20	0.04	0.72	3.90	3.94	3.92	0.03	**3.12**	**0.12**	**6.83**	**0.03**
DP (275 ml)	6.80	6.76	6.78	0.03	4.38	4.21	4.30	0.12	0.92	2.63	2.77	2.70	0.10				
DP (300 ml)	6.49	6.41	6.45	0.06	4.46	4.68	4.57	0.16	1.00	2.03	1.73	1.88	0.21				
US (60 ml)	7.73	7.72	7.73	0.01	3.93	4.27	4.10	0.24	0.20	19.00	17.25	18.13	1.24				
US (150 ml)	7.66	7.69	7.68	0.02	3.97	4.15	4.06	0.13	0.50	7.38	7.08	7.23	0.21	**8.40**	**0.39**	**7.63**	**0.02**
US (200 ml)	7.56	7.54	7.55	0.01	4.19	4.22	4.21	0.02	0.67	5.03	4.96	4.99	0.05				
US (300 ml)	7.59	7.52	7.56	0.05	4.32	4.31	4.32	0.01	1.00	3.27	3.21	3.24	0.04				
DS (60 ml)	7.55	7.37	7.46	0.13	4.32	4.33	4.33	0.01	0.20	16.15	15.20	15.68	0.67				
DS (150 ml)	7.46	7.45	7.46	0.01	4.24	4.21	4.23	0.02	0.50	6.44	6.48	6.46	0.03	**7.45**	**0.32**	**7.42**	**0.05**
DS (200 ml)	7.25	7.30	7.28	0.04	4.64	4.84	4.74	0.14	0.67	3.90	3.67	3.78	0.16				
DS (300 ml)	7.47	7.49	7.48	0.01	3.89	3.33	3.61	0.40	1.00	3.58	4.16	3.87	0.41				
CONTROL	**7.82**	**7.83**	**7.83**	**0.01**	**4.86**	**4.94**	**4.90**	**0.06**	**1.00**	**2.96**	**2.89**	**2.93**	**0.05**				

Table III (10): Physico-chemical analysis for the Northern WWTP during December 2012 (Month 10)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.17	7.20	7.19	0.02	4.13	4.24	4.19	0.08	0.67	4.54	4.40	4.47	0.10				
BC (225 ml)	7.09	7.06	7.08	0.02	4.50	4.46	4.48	0.03	0.72	3.60	3.63	3.61	0.02	**3.29**	**0.07**	**6.92**	**0.05**
BC (275 ml)	6.83	6.90	6.87	0.05	4.05	4.15	4.10	0.07	0.92	3.02	2.95	2.99	0.05				
BC (300 ml)	6.50	6.63	6.57	0.09	4.48	4.41	4.45	0.05	1.00	2.02	2.16	2.09	0.10				
DP (200 ml)	7.75	7.78	7.77	0.02	5.89	5.41	5.65	0.34	0.67	2.78	3.51	3.15	0.52				
DP (225 ml)	7.62	7.66	7.64	0.03	4.03	4.23	4.13	0.14	0.72	4.99	4.74	4.86	0.18	**3.54**	**0.27**	**7.60**	**0.02**
DP (275 ml)	7.52	7.51	7.52	0.01	4.32	4.44	4.38	0.08	0.92	3.48	3.34	3.41	0.10				
DP (300 ml)	7.47	7.48	7.48	0.01	4.92	4.55	4.74	0.26	1.00	2.55	2.93	2.74	0.27				
US (60 ml)	7.56	7.66	7.61	0.07	4.76	4.47	4.62	0.21	0.20	14.00	15.70	14.85	1.20				
US (150 ml)	7.36	7.37	7.37	0.01	4.55	4.52	4.54	0.02	0.50	5.62	5.69	5.66	0.05	**6.96**	**0.37**	**7.50**	**0.02**
US (200 ml)	7.64	7.66	7.65	0.01	4.66	4.63	4.65	0.02	0.67	4.45	4.51	4.48	0.04				
US (300 ml)	7.38	7.37	7.38	0.01	4.39	4.66	4.53	0.19	1.00	2.99	2.72	2.85	0.19				
DS (60 ml)	7.56	7.61	7.59	0.04	4.30	4.52	4.41	0.16	0.20	16.30	15.33	15.81	0.69				
DS (150 ml)	7.63	7.60	7.62	0.02	4.72	4.57	4.65	0.11	0.50	5.82	6.09	5.96	0.19	**7.37**	**0.24**	**7.59**	**0.02**
DS (200 ml)	7.63	7.67	7.65	0.03	4.44	4.50	4.47	0.04	0.67	4.76	4.70	4.73	0.04				
DS (300 ml)	7.52	7.52	7.52	0.00	4.48	4.56	4.52	0.06	1.00	3.04	2.96	3.00	0.06				
CONTROL	**7.90**	**7.76**	**7.83**	**0.10**	**7.02**	**7.10**	**7.06**	**0.06**	**1.00**	**0.88**	**0.73**	**0.81**	**0.11**				

Table III (11): Physico-chemical analysis for the Northern WWTP during January 2012 (Month 11)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.73	7.73	7.73	0.00	4.45	4.56	4.51	0.08	0.67	4.90	4.73	4.81	0.12				
BC (225 ml)	7.78	7.76	7.77	0.01	4.65	4.59	4.62	0.04	0.72	4.35	4.40	4.38	0.04				
BC (275 ml)	7.54	7.51	7.53	0.02	4.65	4.72	4.69	0.05	0.92	3.14	3.03	3.09	0.08				
BC (300 ml)	7.31	7.42	7.37	0.08	4.75	4.63	4.69	0.08	1.00	2.56	2.79	2.68	0.16	**3.74**	**0.10**	**7.60**	**0.03**
DP (200 ml)	7.74	7.77	7.76	0.02	4.36	4.49	4.43	0.09	0.67	5.04	4.90	4.97	0.11				
DP (225 ml)	7.76	7.74	7.75	0.01	4.55	4.58	4.57	0.02	0.72	4.46	4.39	4.42	0.05				
DP (275 ml)	7.64	7.56	7.60	0.06	4.42	4.67	4.55	0.18	0.92	3.50	3.14	3.32	0.25				
DP (300 ml)	7.55	7.53	7.54	0.01	4.80	4.81	4.81	0.01	1.00	2.75	2.72	2.74	0.02	**3.86**	**0.11**	**7.66**	**0.03**
US (60 ml)	7.04	7.71	7.38	0.47	4.46	4.44	4.45	0.01	0.20	12.90	16.35	14.63	2.44				
US (150 ml)	7.60	7.67	7.64	0.05	4.40	4.47	4.44	0.05	0.50	6.40	6.40	6.40	0.00				
US (200 ml)	7.56	7.62	7.59	0.04	4.59	4.59	4.59	0.00	0.67	4.43	4.52	4.48	0.06				
US (300 ml)	7.50	7.57	7.54	0.05	4.62	4.61	4.62	0.01	1.00	2.88	2.96	2.92	0.06	**7.11**	**0.64**	**7.53**	**0.15**
DS (60 ml)	7.74	7.76	7.75	0.01	4.92	4.99	4.96	0.05	0.20	14.10	13.85	13.98	0.18				
DS (150 ml)	7.75	7.78	7.77	0.02	4.86	4.81	4.84	0.04	0.50	5.78	5.94	5.86	0.11				
DS (200 ml)	7.47	7.65	7.56	0.13	4.83	4.85	4.84	0.01	0.67	3.94	4.18	4.06	0.17				
DS (300 ml)	7.58	7.94	7.76	0.25	4.80	4.70	4.75	0.07	1.00	2.78	3.24	3.01	0.33	**6.73**	**0.20**	**7.71**	**0.10**
CONTROL	**7.95**	**7.94**	**7.95**	**0.01**	**6.04**	**6.40**	**6.22**	**0.25**	**1.00**	**1.91**	**1.54**	**1.73**	**0.26**				

Table III (12): Physico-chemical analysis for the Northern WWTP during February 2012 (Month 12)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	6.53	6.56	6.55	0.02	4.71	4.50	4.61	0.15	0.67	2.72	3.07	2.90	0.25				
BC (225 ml)	6.12	6.14	6.13	0.01	4.72	4.59	4.66	0.09	0.72	1.94	2.15	2.05	0.15	**1.62**	**0.14**	**5.87**	**0.01**
BC (275 ml)	5.73	5.70	5.72	0.02	4.56	4.50	4.53	0.04	0.92	1.27	1.30	1.29	0.02				
BC (300 ml)	5.10	5.10	5.10	0.00	4.78	4.95	4.87	0.12	1.00	0.32	0.15	0.23	0.12				
DP (200 ml)	7.23	7.22	7.23	0.01	4.86	4.79	4.83	0.05	0.67	3.54	3.63	3.58	0.06				
DP (225 ml)	7.08	7.11	7.10	0.02	4.62	4.71	4.67	0.06	0.72	3.42	3.33	3.38	0.06	**2.79**	**0.04**	**6.88**	**0.02**
DP (275 ml)	6.79	6.77	6.78	0.01	4.69	4.65	4.67	0.03	0.92	2.28	2.30	2.29	0.02				
DP (300 ml)	6.45	6.41	6.43	0.03	4.56	4.50	4.53	0.04	1.00	1.89	1.91	1.90	0.01				
US (60 ml)	7.37	7.37	7.37	0.00	4.77	4.76	4.77	0.01	0.20	13.00	13.05	13.03	0.04				
US (150 ml)	7.44	7.40	7.42	0.03	4.57	4.63	4.60	0.04	0.50	5.74	5.54	5.64	0.14	**6.63**	**0.08**	**7.49**	**0.01**
US (200 ml)	7.57	7.59	7.58	0.01	4.50	4.58	4.54	0.06	0.67	4.58	4.49	4.54	0.06				
US (300 ml)	7.59	7.59	7.59	0.00	4.34	4.24	4.29	0.07	1.00	3.25	3.35	3.30	0.07				
DS (60 ml)	7.65	7.64	7.65	0.01	4.80	4.82	4.81	0.01	0.20	14.25	14.10	14.18	0.11				
DS (150 ml)	7.63	7.61	7.62	0.01	4.18	4.28	4.23	0.07	0.50	6.90	6.66	6.78	0.17	**6.97**	**0.10**	**7.51**	**0.02**
DS (200 ml)	7.43	7.46	7.45	0.02	4.47	4.53	4.50	0.04	0.67	4.42	4.37	4.40	0.03				
DS (300 ml)	7.37	7.30	7.34	0.05	4.77	4.81	4.79	0.03	1.00	2.60	2.49	2.55	0.08				
CONTROL	**7.85**	**7.85**	**7.85**	**0.00**	**7.11**	**7.13**	**7.12**	**0.01**	**1.00**	**0.74**	**0.72**	**0.73**	**0.01**				

Table III (13): Physico-chemical analysis for the New Germany TW during March 2012 (Month 1)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	8.35	8.17	8.26	0.13	7.15	7.05	7.10	0.07	0.67	1.79	1.67	1.73	0.08	**2.23**	**0.09**	**8.18**	**0.08**
BC (225 ml)	8.06	8.08	8.07	0.01	6.18	6.36	6.27	0.13	0.72	2.61	2.39	2.50	0.16				
BC (275 ml)	8.24	8.15	8.20	0.06	5.89	5.73	5.81	0.11	0.92	2.55	2.63	2.59	0.05				
BC (300 ml)	8.27	8.12	8.20	0.11	6.12	6.04	6.08	0.06	1.00	2.15	2.08	2.12	0.05				
DP (200 ml)	8.37	8.27	8.32	0.07	5.64	5.86	5.75	0.16	0.67	4.07	3.60	3.84	0.34	**2.68**	**0.26**	**8.18**	**0.08**
DP (225 ml)	8.23	8.25	8.24	0.01	6.69	6.41	6.55	0.20	0.72	2.14	2.56	2.35	0.29				
DP (275 ml)	8.15	8	8.08	0.11	6.06	5.83	5.95	0.16	0.92	2.27	2.36	2.32	0.06				
DP (300 ml)	7.97	8.18	8.08	0.15	5.99	5.73	5.86	0.18	1.00	1.98	2.45	2.22	0.33				
US (60 ml)	8.47	8.56	8.52	0.06	5.57	5.21	5.39	0.25	0.20	14.50	16.75	15.63	1.59	**7.67**	**0.76**	**8.59**	**0.04**
US (150 ml)	8.64	8.59	8.62	0.04	6.59	6.38	6.49	0.15	0.50	4.10	4.42	4.26	0.23				
US (200 ml)	8.61	8.58			4.24	4.12											
US (300 ml)	8.63	8.62	8.63	0.01	5.83	5.15	5.49	0.48	1.00	2.80	3.47	3.14	0.47				
DS (60 ml)	8.69	8.63	8.66	0.04	6.68	6.62	6.65	0.04	0.20	10.05	10.05	10.05	0.00	**4.91**	**0.28**	**8.63**	**0.02**
DS (150 ml)	8.59	8.58	8.59	0.01	6.76	6.25	6.51	0.36	0.50	3.66	4.66	4.16	0.71				
DS (200 ml)	8.65	8.66	8.66	0.01	6.41	6.1	6.26	0.22	0.67	3.34	3.82	3.58	0.34				
DS (300 ml)	8.66	8.61	8.64	0.04	6.86	6.72	6.79	0.10	1.00	1.80	1.89	1.85	0.06				
CONTROL	8.71	8.7	**8.71**	**0.01**	6.84	6.19	**6.52**	**0.46**	**1.00**	**1.87**	**2.51**	**2.19**	**0.45**				

Table III (14): Physico-chemical analysis for the New Germany TW during April 2012 (Month 2)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	8.45	8.45	8.45	0.00	5.49	5.33	5.41	0.11	0.67	4.42	4.66	4.54	0.17	**3.83**	**0.16**	**8.40**	**0.00**
BC (225 ml)	8.37	8.36	8.37	0.01	5.31	5.52	5.42	0.15	0.72	4.25	3.94	4.10	0.22				
BC (275 ml)																	
BC (300 ml)	8.38	8.38	8.38	0.00	5.46	5.59	5.53	0.09	1.00	2.92	2.79	2.86	0.09				
DP (200 ml)	8.49	8.49	8.49	0.00	6.33	6.3	6.32	0.02	0.67	3.22	3.27	3.25	0.03	**3.71**	**0.03**	**8.51**	**0.01**
DP (225 ml)	8.5	8.49	8.50	0.01	5.31	5.37	5.34	0.04	0.72	4.43	4.33	4.38	0.07				
DP (275 ml)	8.52	8.52	8.52	0.00	5.38	5.39	5.39	0.01	0.92	3.41	3.40	3.41	0.01				
DP (300 ml)	8.56	8.52	8.54	0.03	4.74	4.71	4.73	0.02	1.00	3.82	3.81	3.82	0.01				
US (60 ml)	8.46	8.47	8.47	0.01	4.93	4.98	4.96	0.04	0.20	17.65	17.45	17.55	0.14	**9.24**	**0.10**	**8.68**	**0.02**
US (150 ml)	8.64	8.68	8.66	0.03	4.22	4.22	4.22	0.00	0.50	8.84	8.92	8.88	0.06				
US (200 ml)	8.73	8.78	8.76	0.04	4.34	4.25	4.30	0.06	0.67	6.55	6.76	6.66	0.15				
US (300 ml)	8.83	8.86	8.85	0.02	4.97	4.95	4.96	0.01	1.00	3.86	3.91	3.89	0.04				
DS (60 ml)	8.54	8.52	8.53	0.01	4.25	4.2	4.23	0.04	0.20	21.45	21.60	21.53	0.11	**9.50**	**0.17**	**8.68**	**0.01**
DS (150 ml)	8.64	8.64	8.64	0.00	4.63	4.35	4.49	0.20	0.50	8.02	8.58	8.30	0.40				
DS (200 ml)	8.71	8.72	8.72	0.01	5.69	5.86	5.78	0.12	0.67	4.51	4.27	4.39	0.17				
DS (300 ml)	8.85	8.85	8.85	0.00	5.07	5.05	5.06	0.01	1.00	3.78	3.80	3.79	0.01				
CONTROL	**8.38**	**8.38**	**8.38**	**0.00**	5.13	5.64	**5.39**	**0.36**	**1.00**	**3.25**	**2.74**	**3.00**	**0.36**				

Table III (15): Physico-chemical analysis for the New Germany TW during May 2012 (Month 3)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	8.34	8.36	8.35	0.01	5.1	5	5.05	0.07	0.67	4.84	5.01	4.93	0.13	**3.28**	**0.07**	**8.29**	**0.01**
BC (225 ml)	8.35	8.34	8.35	0.01	4.81	4.88	4.85	0.05	0.72	4.92	4.81	4.86	0.08				
BC (275 ml)									0.92	0.00	0.00	0.00	0.00				
BC (300 ml)	8.17	8.16	8.17	0.01	4.81	4.88	4.85	0.05	1.00	3.36	3.28	3.32	0.06				
DP (200 ml)	8.08	8.16	8.12	0.06	4.44	4.35	4.40	0.06	0.67	5.43	5.69	5.56	0.18	**4.70**	**0.12**	**8.18**	**0.04**
DP (225 ml)	8.41	8.45	8.43	0.03	4.39	4.61	4.50	0.16	0.72	5.58	5.33	5.46	0.18				
DP (275 ml)	8.09	8	8.05	0.06	4.41	4.4	4.41	0.01	0.92	4.00	3.91	3.96	0.06				
DP (300 ml)	8.14	8.13	8.14	0.01	4.36	4.24	4.30	0.08	1.00	3.78	3.89	3.84	0.08				
US (60 ml)	8.79	8.73	8.76	0.04	4.88	4.87	4.88	0.01	0.20	19.55	19.30	19.43	0.18	**10.90**	**0.36**	**8.78**	**0.03**
US (150 ml)	8.61	8.65	8.63	0.03	4.44	4.09	4.27	0.25	0.50	8.34	9.12	8.73	0.55				
US (200 ml)	8.89	8.87	8.88	0.01	4.64	4.38											
US (300 ml)	8.83	8.87	8.85	0.03	4.52	4.07	4.30	0.32	1.00	4.31	4.80	4.56	0.35				
DS (60 ml)	8.59	8.56	8.58	0.02	4.35	4.24	4.30	0.08	0.20	21.20	21.60	21.40	0.28	**9.79**	**0.29**	**8.60**	**0.02**
DS (150 ml)	8.64	8.64	8.64	0.00	4.56	4.21	4.39	0.25	0.50	8.16	8.86	8.51	0.49				
DS (200 ml)	8.65	8.65	8.65	0.00	4.3	4.62	4.46	0.23	0.67	6.49	6.01	6.25	0.34				
DS (300 ml)	8.57	8.51	8.54	0.04	5.55	5.53	5.54	0.01	1.00	3.02	2.98	3.00	0.03				
CONTROL	**8.65**	**8.63**	**8.64**	**0.01**	**7.66**	**7.67**	**7.67**	**0.01**	**1.00**	**0.99**	**0.96**	**0.98**	**0.02**				

Table III (16): Physico-chemical analysis for the New Germany TW during June 2012 (Month 4)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.86	7.84	7.85	0.01	4.31	4.15	4.23	0.11	0.67	5.30	5.51	5.40	0.15				
BC (225 ml)	7.82	7.85	7.84	0.02	4.47	4.13	4.30	0.24	0.72	4.65	5.17	4.91	0.36	**4.18**	**0.22**	**7.89**	**0.01**
BC (275 ml)	7.91	7.91	7.91	0.00	4.7	4.99	4.85	0.21	0.92	3.49	3.17	3.33	0.22				
BC (300 ml)	7.93	7.96	7.95	0.02	4.95	4.79	4.87	0.11	1.00	2.98	3.17	3.08	0.13				
DP (200 ml)	8.11	8.11	8.11	0.00	5.57	5.57	5.57	0.00	0.67	3.79	3.79	3.79	0.00				
DP (225 ml)	8.04	8.03	8.04	0.01	5.23	5.21	5.22	0.01	0.72	3.90	3.92	3.91	0.01	**3.57**	**0.01**	**8.08**	**0.00**
DP (275 ml)																	
DP (300 ml)	8.1	8.1	8.10	0.00	5.02	5.05	5.04	0.02	1.00	3.08	3.05	3.00	0.02				
US (60 ml)	7.97	7.98	7.98	0.01	4.89	4.88	4.89	0.01	0.20	15.40	15.50	15.45	0.07				
US (150 ml)	8.1	8.13	8.12	0.02	4.69	4.54	4.62	0.11	0.50	6.82	7.18	7.00	0.25	**8.72**	**0.16**	**8.22**	**0.01**
US (200 ml)	8.22	8.23			4.38	4.48											
US (300 ml)	8.58	8.56	8.57	0.01	4.98	4.76	4.87	0.16	1.00	3.60	3.80	3.70	0.14				
DS (60 ml)	7.82	7.82	7.82	0.00	5.78	5.82	5.80	0.03	0.20	10.20	10.00	10.10	0.14				
DS (150 ml)	8.04	8.03	8.04	0.01	4.3	4.39	4.35	0.06	0.50	7.48	7.28	7.38	0.14	**6.58**	**0.25**	**8.06**	**0.01**
DS (200 ml)	7.74	7.74	7.74	0.00	4.26	4.7	4.48	0.31	0.67	5.19	4.54	4.87	0.46				
DS (300 ml)	8.64	8.67	8.66	0.02	4.5	4.9	4.70	0.28	1.00	4.14	3.77	3.96	0.26				
CONTROL	**8.15**	**8.13**	**8.14**	**0.01**	**7.40**	**7.56**	**7.48**	**0.11**	**1.00**	**0.75**	**0.57**	**0.66**	**0.13**				

Table III (17): Physico-chemical analysis for the New Germany TW during July 2012 (Month 5)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.75	7.67	7.71	0.06	4.82	4.8	4.81	0.01	0.67	4.37	4.28	4.33	0.06				
BC (225 ml)	7.33	7.34	7.34	0.01	4.15	4.35	4.25	0.14	0.72	4.42	4.15	4.28	0.19	**2.73**	**0.11**	**7.17**	**0.05**
BC (275 ml)									0.92	0.00	0.00	0.00	0.00				
BC (300 ml)	6.52	6.39	6.46	0.09	4.06	4.21	4.14	0.11	1.00	2.46	2.18	2.32	0.20				
DP (200 ml)	8.62	8.65	8.64	0.02	4.59	4.49	4.54	0.07	0.67	6.01	6.21	6.11	0.14				
DP (225 ml)	8.66	8.66	8.66	0.00	4.22	4.38	4.30	0.11	0.72	6.17	5.94	6.06	0.16	**5.06**	**0.15**	**8.71**	**0.02**
DP (275 ml)	8.68	8.69	8.69	0.01	4.26	4.52	4.39	0.18									
DP (300 ml)	8.8	8.88	8.84	0.06	4.35	4.22	4.29	0.09	1.00	4.45	4.66	3.00	0.15				
US (60 ml)	8.31	8.36	8.34	0.04	4.12	4.31	4.22	0.13	0.20	20.95	20.25	20.60	0.49				
US (150 ml)	8.58	8.58	8.58	0.00	4.15	4.19	4.17	0.03	0.50	8.86	8.78	8.82	0.06	**11.22**	**0.21**	**8.54**	**0.02**
US (200 ml)	8.37	8.42			4.98	4.27											
US (300 ml)	8.69	8.74	8.72	0.04	4.39	4.57	4.48	0.13	1.00	4.30	4.17	4.24	0.09				
DS (60 ml)	8.28	8.25	8.27	0.02	4.92	4.85	4.89	0.05	0.20	16.80	17.00	16.90	0.14				
DS (150 ml)	8.32	8.38	8.35	0.04	3.62	3.61	3.62	0.01	0.50	9.40	9.54	9.47	0.10	**9.42**	**0.15**	**8.46**	**0.05**
DS (200 ml)	8.55	8.59	8.57	0.03	4.29	4.08	4.19	0.15	0.67	6.36	6.73	6.54	0.26				
DS (300 ml)	8.57	8.73	8.65	0.11	3.87	3.89	3.88	0.01	1.00	4.70	4.84	4.77	0.10				
CONTROL	**8.17**	**8.17**	**8.17**	**0.00**	**7.21**	**7.26**	**7.24**	**0.04**	**1.00**	**0.96**	**0.91**	**0.94**	**0.04**				

Table III (18): Physico-chemical analysis for the New Germany TW during August 2012 (Month 6)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.92	7.88	7.90	0.03	4.83	4.76	4.80	0.05	0.67	4.61	4.66	4.63	0.03				
BC (225 ml)	7.99	7.94	7.97	0.04	4.27	4.55	4.41	0.20	0.72	5.17	4.71	4.94	0.32	**4.04**	**0.15**	**7.90**	**0.02**
BC (275 ml)																	
BC (300 ml)	7.83	7.83	7.83	0.00	5.2	5.35	5.28	0.11	1.00	2.63	2.48	2.56	0.11				
DP (200 ml)	8.06	8.13	8.10	0.05	4.42	4.43	4.43	0.01	0.67	5.43	5.52	5.48	0.06				
DP (225 ml)	8.19	8.11	8.15	0.06	4.5	4.66	4.58	0.11	0.72	5.13	4.79	4.96	0.24	**4.29**	**0.09**	**8.07**	**0.04**
DP (275 ml)	8.06	8.11	8.09	0.04	4.82	4.8	4.81	0.01	0.92	3.52	3.60	3.56	0.05				
DP (300 ml)	7.96	7.93	7.95	0.02	4.79	4.77	4.78	0.01	1.00	3.17	3.16	3.17	0.01				
US (60 ml)	7.98	7.99	7.99	0.01	3.39	3.64	3.52	0.18	0.20	22.95	21.75	22.35	0.85				
US (150 ml)	7.66	7.65	7.66	0.01	4.59	4.47	4.53	0.08	0.50	6.14	6.36	6.25	0.16	**8.94**	**0.28**	**7.51**	**0.03**
US (200 ml)	7.28	7.22	7.25	0.04	4.91	4.92			0.67	3.54	3.43	3.49	0.07				
US (300 ml)	7.12	7.2	7.16	0.06	3.47	3.47	3.47	0.00	1.00	3.65	3.73	3.69	0.06				
DS (60 ml)	8.14	8.18	8.16	0.03	4.74	4.66	4.70	0.06	0.20	17.00	17.60	17.30	0.42				
DS (150 ml)	8.5	8.53	8.52	0.02	4.47	4.51	4.49	0.03	0.50	8.06	8.04	8.05	0.01	**8.74**	**0.18**	**8.44**	**0.02**
DS (200 ml)	8.57	8.53	8.55	0.03	4.76	4.66	4.71	0.07	0.67	5.69	5.78	5.73	0.06				
DS (300 ml)	8.54	8.55	8.55	0.01	4.83	4.53	4.68	0.21	1.00	3.71	4.02	3.87	0.22				
CONTROL	**8.19**	**8.27**	**8.23**	**0.06**	**7.20**	**7.26**	**7.23**	**0.04**	**1.00**	**0.99**	**1.01**	**1.00**	**0.01**				

Table III (19): Physico-chemical analysis for the New Germany TW during September 2012 (Month 7)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	8.32	8.31	8.32	0.01	4.17	4.71	4.44	0.38	0.67	6.19	5.37	5.78	0.58				
BC (225 ml)	8.32	8.3	8.31	0.01	4.43	4.45	4.44	0.01	0.72	5.40	5.35	5.38	0.04	**4.82**	**0.21**	**8.28**	**0.01**
BC (275 ml)	8.23	8.21	8.22	0.01	4.36	4.32			0.92	4.21	4.23	4.22	0.02				
BC (300 ml)	8.25	8.27	8.26	0.01	4.5	4.22	4.36	0.20	1.00	3.75	4.05	3.90	0.21				
DP (200 ml)	8.22	8.25	8.24	0.02	4.3	4.3	4.30	0.00	0.67	5.85	5.90	5.87	0.03				
DP (225 ml)	8.23	8.25	8.24	0.01	4.22	4.39	4.31	0.12	0.72	5.57	5.36	5.47	0.15	**4.49**	**0.12**	**8.21**	**0.03**
DP (275 ml)	8.23	8.25	8.24	0.01	4.99	4.86	4.93	0.09	0.92	3.52	3.68	3.60	0.12				
DP (300 ml)	8.18	8.08	8.13	0.07	4.11	4.3	4.21	0.13	1.00	4.07	3.78	3.00	0.21				
US (60 ml)	7.82	7.82	7.82	0.00	4.15	4.56	4.36	0.29	0.20	18.35	16.30	17.33	1.45				
US (150 ml)	7.98	7.83	7.91	0.11	4.44	4.3	4.37	0.10	0.50	7.08	7.06	7.07	0.01	**8.13**	**0.44**	**7.76**	**0.04**
US (200 ml)	7.65	7.72	7.69	0.05	4.07	4.23			0.67	5.34	5.21	5.28	0.09				
US (300 ml)	7.65	7.62	7.64	0.02	4.65	4.91	4.78	0.18	1.00	3.00	2.71	2.86	0.21				
DS (60 ml)	7.47	7.42	7.45	0.04	4.8	4.99	4.90	0.13	0.20	13.35	12.15	12.75	0.85				
DS (150 ml)	7.46	7.55	7.51	0.06	4.39	4.46	4.43	0.05	0.50	6.14	6.18	6.16	0.03	**6.68**	**0.27**	**7.39**	**0.03**
DS (200 ml)	7.37	7.39	7.38	0.01	4.1	4.22	4.16	0.08	0.67	4.88	4.73	4.81	0.11				
DS (300 ml)	7.22	7.24	7.23	0.01	4.28	4.19	4.24	0.06	1.00	2.94	3.05	3.00	0.08				
CONTROL	8.41	8.43	8.42	0.01	7.1	7.05	7.08	0.04	**1.00**	**1.31**	**1.38**	**1.35**	**0.05**				

Table III (20): Physico-chemical analysis for the New Germany TW during October 2012 (Month 8)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	8.23	8.24	8.24	0.01	4.48	4.69	4.59	0.15	0.67	5.60	5.30	5.45	0.21				
BC (225 ml)	8.15	8.19	8.17	0.03	5	5.19	5.10	0.13	0.72	4.38	4.17	4.27	0.15	**4.12**	**0.28**	**8.11**	**0.02**
BC (275 ml)	7.93	7.98	7.96	0.04	4.15	4.53	4.34	0.27	0.92	4.11	3.75	3.93	0.25				
BC (300 ml)	8.06	8.09	8.08	0.02	4.84	5.61	5.23	0.54	1.00	3.22	2.48	2.85	0.52				
DP (200 ml)	8.38	8.37	8.38	0.01	4.73	4.96	4.85	0.16	0.67	5.45	5.09	5.27	0.25				
DP (225 ml)	8.36	8.4	8.38	0.03	4.25	4.9	4.58	0.46	0.72	5.71	4.86	5.28	0.60	**4.38**	**0.38**	**8.35**	**0.03**
DP (275 ml)	8.26	8.36	8.31	0.07	4.25	5.07	4.66	0.58	0.92	4.36	3.58	3.97	0.55				
DP (300 ml)	8.3	8.33	8.32	0.02	4.67	4.54	4.61	0.09	1.00	3.63	3.79	3.00	0.11				
US (60 ml)	8.41	8.42	8.42	0.01	5.25	5.28	5.27	0.02	0.20	15.80	15.70	15.75	0.07				
US (150 ml)	8.43	8.46	8.45	0.02	4.63	4.9	4.77	0.19	0.50	7.60	7.12	7.36	0.34	**7.98**	**0.23**	**8.44**	**0.02**
US (200 ml)	8.43	8.43	8.43	0.00	4.46	4.9	4.68	0.31	0.67	5.93	5.27	5.60	0.46				
US (300 ml)	8.46	8.51	8.49	0.04	5.28	5.24	5.26	0.03	1.00	3.18	3.27	3.23	0.06				
DS (60 ml)	8.47	8.46	8.47	0.01	4.7	4.78	4.74	0.06	0.20	18.85	18.40	18.63	0.32				
DS (150 ml)	8.49	8.46	8.48	0.02	4.66	4.62	4.64	0.03	0.50	7.66	7.68	7.67	0.01	**8.92**	**0.32**	**8.50**	**0.02**
DS (200 ml)	8.52	8.53	8.53	0.01	4.48	5.16	4.82	0.48	0.67	6.03	5.03	5.53	0.71				
DS (300 ml)	8.5	8.55	8.53	0.04	4.46	4.87	4.67	0.29	1.00	4.04	3.68	3.86	0.25				
CONTROL	8.31	8.33	8.32	0.01	5.23	5.6	5.42	0.26	**1.00**	**3.08**	**2.73**	**2.91**	**0.25**				

Table III (21): Physico-chemical analysis for the New Germany TW during November 2012 (Month 9)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.52	7.53	7.53	0.01	4.27	4.44	4.36	0.12	0.67	4.85	4.61	4.73	0.17				
BC (225 ml)	7.46	7.71	7.59	0.18	4.42	4.3	4.36	0.08	0.72	4.22	4.74	4.48	0.36	**4.12**	**0.21**	**7.60**	**0.06**
BC (275 ml)	7.63	7.7	7.67	0.05	4.07	4.34			0.92	3.87	3.65	3.76	0.15				
BC (300 ml)	7.61	7.62	7.62	0.01	4.22	4.02	4.12	0.14	1.00	3.39	3.60	3.50	0.15				
DP (200 ml)	7.57	7.48	7.53	0.06	4.28	4.2	4.24	0.06	0.67	4.91	4.90	4.90	0.01				
DP (225 ml)	7.65	7.67	7.66	0.01	4.12	4.27	4.20	0.11	0.72	4.90	4.72	4.81	0.13	**4.14**	**0.05**	**7.64**	**0.03**
DP (275 ml)	7.64	7.61	7.63	0.02	4.09	4.1	4.10	0.01	0.92	3.86	3.82	3.84	0.03				
DP (300 ml)	7.73	7.75	7.74	0.01	4.36	4.4	4.38	0.03	1.00	3.37	3.35	3.00	0.01				
US (60 ml)	7.82	7.84	7.83	0.01	4.27	4.35	4.31	0.06	0.20	17.75	17.45	17.60	0.21				
US (150 ml)	7.79	7.8	7.80	0.01	4.33	4.53	4.43	0.14	0.50	6.92	6.54	6.73	0.27	**8.27**	**0.23**	**7.84**	**0.01**
US (200 ml)	7.85	7.86	7.86	0.01	4.31	4.09	4.20	0.16	0.67	5.28	5.63	5.46	0.24				
US (300 ml)	7.85	7.87	7.86	0.01	4.45	4.72	4.59	0.19	1.00	3.40	3.15	3.28	0.18				
DS (60 ml)	7.59	7.62	7.61	0.02	4.37	4.24	4.31	0.09	0.20	16.10	16.90	16.50	0.57				
DS (150 ml)	7.65	7.64	7.65	0.01	4.06	4.21	4.14	0.11	0.50	7.18	6.86	7.02	0.23	**7.96**	**0.27**	**7.60**	**0.02**
DS (200 ml)	7.64	7.59	7.62	0.04	4.26	4.39	4.33	0.09	0.67	5.04	4.78	4.91	0.19				
DS (300 ml)	7.53	7.54	7.54	0.01	4.06	4.19	4.13	0.09	1.00	3.47	3.35	3.41	0.08				
CONTROL	7.9	7.87	7.89	0.02	7.04	7.07	7.06	0.02	**1.00**	**0.86**	**0.80**	**0.83**	**0.04**				

Table III (22): Physico-chemical analysis for the New Germany TW during December 2012 (Month 10)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.52	7.53	7.53	0.01	4.76	5.09	4.93	0.23	0.67	4.12	3.64	3.88	0.34	**2.88**	**0.24**	**7.07**	**0.07**
BC (225 ml)	7	6.9	6.95	0.07	4.71	4.41	4.56	0.21	0.72	3.18	3.46	3.32	0.20				
BC (275 ml)	6.93	6.94	6.94	0.01	5.17	4.85			0.92	1.91	2.27	2.09	0.25				
BC (300 ml)	6.75	7.01	6.88	0.18	4.64	4.68	4.66	0.03	1.00	2.11	2.33	2.22	0.16				
DP (200 ml)	7.52	7.48	7.50	0.03	4.41	4.33	4.37	0.06	0.67	4.64	4.70	4.67	0.04	**3.37**	**0.14**	**7.42**	**0.04**
DP (225 ml)	7.37	7.46	7.42	0.06	4.82	5.21	5.02	0.28	0.72	3.54	3.13	3.33	0.29				
DP (275 ml)	7.4	7.42	7.41	0.01	4.63	4.52	4.58	0.08	0.92	3.01	3.15	3.08	0.10				
DP (300 ml)	7.31	7.38	7.35	0.05	4.85	5.07	4.96	0.16	1.00	2.46	2.31	2.39	0.11				
US (60 ml)	7.82	7.85	7.84	0.02	4.62	4.94	4.78	0.23	0.20	16.00	14.55	15.28	1.03	**7.20**	**0.45**	**7.88**	**0.01**
US (150 ml)	7.88	7.91	7.90	0.02	5.14	5.16	5.15	0.01	0.50	5.48	5.50	5.49	0.01				
US (200 ml)	7.91	7.91	7.91	0.00	4.5	4.95	4.73	0.32	0.67	5.09	4.42	4.75	0.47				
US (300 ml)	7.87	7.89	7.88	0.01	4.79	4.43	4.61	0.25	1.00	3.08	3.46	3.27	0.27				
DS (60 ml)	7.67	7.69	7.68	0.01	4.78	4.98	4.88	0.14	0.20	14.45	13.55	14.00	0.64	**6.96**	**0.44**	**7.70**	**0.02**
DS (150 ml)	7.85	7.86	7.86	0.01	4.47	4.89	4.68	0.30	0.50	6.76	5.94	6.35	0.58				
DS (200 ml)	7.61	7.63	7.62	0.01	4.64	4.25	4.45	0.28	0.67	4.43	5.04	4.74	0.43				
DS (300 ml)	7.62	7.68	7.65	0.04	4.79	4.98	4.89	0.13	1.00	2.83	2.70	2.77	0.09				
CONTROL	8.04	8.02															

Table III (23): Physico-chemical analysis for the New Germany TW during January 2012 (Month 11)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.49	7.59	7.54	0.07	4.45	4.47	4.46	0.01	0.67	4.54	4.66	4.60	0.08	**3.46**	**0.17**	**7.25**	**0.04**
BC (225 ml)	7.45	7.45	7.45	0.00	4.36	4.66	4.51	0.21	0.72	4.29	3.88	4.08	0.29				
BC (275 ml)	7.05	7	7.03	0.04	4.46	4.8	4.63	0.24	0.92	2.82	2.39	2.60	0.30				
BC (300 ml)	6.95	7	6.98	0.04	4.39	4.43	4.41	0.03	1.00	2.56	2.57	2.57	0.01				
DP (200 ml)	7.79	7.79	7.79	0.00	4.86	4.5	4.68	0.25	0.67	4.37	4.91	4.64	0.38	**3.79**	**0.22**	**7.70**	**0.04**
DP (225 ml)	7.75	7.81	7.78	0.04	4.85	4.78	4.82	0.05	0.72	4.03	4.21	4.12	0.13				
DP (275 ml)	7.69	7.66	7.68	0.02	4.32	4.56	4.44	0.17	0.92	3.66	3.37	3.52	0.21				
DP (300 ml)	7.47	7.62	7.55	0.11	4.72	4.62	4.67	0.07	1.00	2.75	3.00	2.88	0.18				
US (60 ml)	7.72	7.76	7.74	0.03	4.67	4.97	4.82	0.21	0.20	15.25	13.95	14.60	0.92	**7.25**	**0.38**	**7.70**	**0.03**
US (150 ml)	7.73	7.78	7.76	0.04	4.31	4.67	4.49	0.25	0.50	6.84	6.22	6.53	0.44				
US (200 ml)	7.62	7.7	7.66	0.06	4.43	4.67	4.55	0.17	0.67	4.76	4.52	4.64	0.17				
US (300 ml)	7.64	7.66	7.65	0.01	4.42	4.45	4.44	0.02	1.00	3.22	3.21	3.22	0.01				
DS (60 ml)	8.04	8.02	8.03	0.01	4.68	4.63	4.66	0.04	0.20	16.80	16.95	16.88	0.11	**7.91**	**0.25**	**8.03**	**0.02**
DS (150 ml)	8.04	8.04	8.04	0.00	4.91	5.05	4.98	0.10	0.50	6.26	5.98	6.12	0.20				
DS (200 ml)	8.02	8.02	8.02	0.00	4.06	4.66	4.36	0.42	0.67	5.91	5.01	5.46	0.63				
DS (300 ml)	7.98	8.05	8.02	0.05	4.78	4.92	4.85	0.10	1.00	3.20	3.13	3.17	0.05				
CONTROL	7.95	7.99	7.97	0.03	6.24	6.12											

Table III (24): Physico-chemical analysis for the New Germany TW during February 2012 (Month 12)

SAMPLE	DAY 0		AVG	SD	DAY 7		AVG	SD	p VALUE	BOD 1	BOD 2	AVG	SD	FINAL	SD	DO AVG	SD
	1	2			1	2											
BC (200 ml)	7.67	7.64	7.66	0.02	4.25	4.22	4.24	0.02	0.67	5.10	5.10	5.10	0.00	**4.06**	**0.03**	**7.54**	**0.02**
BC (225 ml)	7.68	7.67	7.68	0.01	4.12	4.14	4.13	0.01	0.72	4.94	4.90	4.92	0.03				
BC (275 ml)	7.38	7.38	7.38	0.00	4.51	4.55	4.53	0.03	0.92	3.12	3.08	3.10	0.03				
BC (300 ml)	7.49	7.41	7.45	0.06	4.32	4.32	4.32	0.00	1.00	3.17	3.09	3.13	0.06				
DP (200 ml)	7.86	7.87	7.87	0.01	4.27	4.25	4.26	0.01	0.67	5.36	5.40	5.38	0.03	**4.13**	**0.03**	**7.75**	**0.01**
DP (225 ml)	7.84	7.84	7.84	0.00	4.59	4.64	4.62	0.04	0.72	4.51	4.44	4.48	0.05				
DP (275 ml)	7.65	7.6	7.63	0.04	4.58	4.49	4.54	0.06	0.92	3.34	3.38	3.36	0.03				
DP (300 ml)	7.65	7.65	7.65	0.00	4.33	4.36	4.35	0.02	1.00	3.32	3.29	3.31	0.02				
US (60 ml)	7.51	7.52	7.52	0.01	4.26	4.28	4.27	0.01	0.20	16.25	16.20	16.23	0.04	**7.10**	**0.08**	**7.22**	**0.04**
US (150 ml)	7.37	7.33	7.35	0.03	4.2	4.21	4.21	0.01	0.50	6.34	6.24	6.29	0.07				
US (200 ml)	7.06	7.2	7.13	0.10	4.55	4.5	4.53	0.04	0.67	3.75	4.03	3.89	0.20				
US (300 ml)	6.88	6.86	6.87	0.01	4.9	4.86	4.88	0.03	1.00	1.98	2.00	1.99	0.01				
DS (60 ml)	7.99	7.99	7.99	0.00	4.47	4.49	4.48	0.01	0.20	17.60	17.50	17.55	0.07	**8.63**	**0.14**	**7.94**	**0.01**
DS (150 ml)	7.98	7.97	7.98	0.01	4.11	4.21	4.16	0.07	0.50	7.74	7.52	7.63	0.16				
DS (200 ml)	7.93	7.91	7.92	0.01	3.98	3.71	3.85	0.19	0.67	5.90	6.27	6.08	0.26				
DS (300 ml)	7.84	7.88	7.86	0.03	4.62	4.57	4.60	0.04	1.00	3.22	3.31	3.27	0.06				
CONTROL	8.02	8.02	8.02	0.00	7.26	7.34	7.30	0.06	**1.00**	0.76	0.68	0.72	0.06				

Table 4: Nutrient data for the Northern WWTP and New Germany TW between March 2012 and February 2013

		NORTHERN WWTP				NEW GERMANY TW			
MONTH		**NO_3**	**PO_4**	**SO_4**	**CL_2**	**NO_3**	**PO_4**	**SO_4**	**CL_2**
MARCH	BC	less 0.057	3.509	37.95	less 0.1	1.81	0.904	65.86	less 0.1
	DP	less 0.057	3.473	42.27	less 0.1	1.401	0.797	68.83	less 0.1
	US	1.062	0.051	42.59	less 0.1	1.062	0.051	42.59	less 0.1
	DS	less 0.057	0.157	487	0.1	2.143	0.047	56.35	less 0.1
APRIL	BC	less 0.057	2.105	17.07	less 0.1	2.809	1.091	36.19	less 0.1
	DP	less 0.057	2.097	13.35	less 0.1	2.351	0.859	26.3	less 0.1
	US	0.856	0.232	27.58	less 0.1	1.292	0.168	17.58	less 0.1
	DS	0.318	0.381	26.07	less 0.1	0.818	0.282	7.32	less 0.1
MAY	BC	0.156	2.72	25.24	less 0.1	less 0.057	0.051	46.17	less 0.1
	DP	0.202	2.338	26.25	less 0.1	less 0.057	less 0.025	39.05	less 0.1
	US	1.028	1.08	64.23	less 0.1	0.843	less 0.025	23.88	less 0.1
	DS	1.716	0.816	30.48	less 0.1	0.514	less 0.025	57.26	less 0.1
JUNE	BC	5.98	12.377	26.19	less 0.1	3.76	1.048	37.24	0.1
	DP	3.92	9.021	11.03	less 0.1	1.99	0.876	23.44	0.1
	US	2.4	2.173	29.29	less 0.1	2.38	0.655	25.73	-0.1
	DS	1.78	1.439	17.94	less 0.1	2.15	0.33	13.74	0.1
JULY	BC	1	1.829	25.04	less 0.1	0.472	-0.025	40.93	-0.1
	DP	0.892	0.751	21.69	less 0.1	0.573	0.093	47.09	0
	US	0.785	-0.025	23.87	less 0.1	1.03	-0.025	10.8	-0.1
	DS	1.35	0.092	16.31	less 0.1	0.712	0.071	34.2	-0.1
AUGUST	BC	-	-	-	less 0.1	1.42	0.931	52.21	-0.1
	DP	less 0.057	1.994	10.93	0.1	1.96	1.467	72.02	-0.1
	US	less 0.057	0.115	14.43	0.1	2.29	0.591	20.55	-0.1
	DS	-	-	-	0.1	0.8	1.894	82.45	-0.1
SEPTEMBER	BC	0.148	1.696	40.22	less 0.1	8.22	0.577	38.9	less 0.1
	DP	0.079	1.903	34.55	less 0.1	0.232	0.142	17.77	0.1
	US	0.172	0.097	14.47	less 0.1	2.65	0.541	14.9	less 0.1
	DS	1.47	0.163	35.68	less 0.1	0.724	0.169	18.62	less 0.1
OCTOBER	BC	0.875	1.88	30.6	0.1	1.23	1.12	45	0.1
	DP	0.824	1.57	26.4	0.1	1.64	1.26	43.3	0.1
	US	1.02	0.365	18.1	less 0.1	2.32	0.049	25.5	0.2
	DS	1.3	0.418	21.2	0.1	2.47	0.491	35.9	0.1
NOVEMBER	BC	0.284	3.53	27.7	less 0.1	0.496	3.22	61.2	0.1
	DP	0.307	3.69	27.9	0.1	0.332	3.99	56.4	0.1
	US	0.974	0.639	14	0.1	2.11	0.024	29.1	0.1
	DS	3.38	0.446	26.5	0.2	1.27	1.7	55.9	0.1
DECEMBER	BC	0.243	1.82	37.2	less 0.1	0.11	0.126	17.8	less 0.1
	DP	0.766	1.37	44.2	less 0.1	less 0.017	0.137	21.5	less 0.1
	US	0.391	0.027	11.2	less 0.1	less 0.017	0.037	1.58	less 0.1
	DS	1.95	0.349	34.4	less 0.1	0.508	0.059	8.4	less 0.1
JANUARY	BC	less 0.017	4.7	30	less 0.1	less 0.017	0.014	31.8	less 0.1
	DP	less 0.017	4.69	31.8	less 0.1	less 0.017	0.15	39.7	less 0.1
	US	0.58	0.226	14	less 0.1	1.21	less 0.08	26	less 0.1
	DS	1.22	0.124	26.4	less 0.1	0.837	0.131	29.5	less 0.1
FEBRUARY	BC	less 0.017	3.51	400	less 0.1	less 0.017	0.756	54.9	less 0.1
	DP	less 0.017	2.71	37.6	less 0.1	less 0.017	1.16	55.3	0.1
	US	0.22	0.025	13.2	less 0.1	0.444	0.014	28.1	less 0.1
	DS	0.159	0.525	25.9	0.1	0.391	0.643	41.5	less 0.1

Table 4: Daily rainfall data obtained from the South African Weather Service for the sampling period between March 2012 And February 2013

	MONTHLY RAINFALL (mm)											
DATE	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**
1	0	2	0.4	0	0	0	0	0	5.4	0	11.2	0
2	0	0.2	0.2	0	0	***	0	0	0	2.6	0.2	0
3	23.2	0	0	0	0	0	8.6	0	0.4	0.2	4.2	2.2
4	141	0	0	0	0	0	12.8	10	2.2	23.4	1.8	2.8
5	4.6	0	4.2	0	0	0	76.6	2.2	1.8	2	0	0.2
6	0	0	0	2.6	0	40.4	56.2	0	5.4	***	3.2	0.4
7	0.2	0	0	0	4.4	22.6	1	15.2	12.2	0.2	0	0
8	0	0.4	0	0	0.2	13.4	0	5.8	5.4	0	0	0
9	0	3.8	0	0	0	***	0	28	6.8	0.8	0	5.6
10	0.2	0	0	0	0	0	0.4	5.2	0	65.6	40.6	6.4
11	62.4	2.6	0	0	0	0	0	0.6	0	0.4	40	1.2
12	0.4	***	0	0	0	0	0	1	0	0	18	0.2
13	8.8	0	0	19.8	0	0	11	0	5	***	3	0
14	1	0	7.4	0.4	0	0	40.4	0	0.2	0	0	0.2
15	0.4	0	2.2	0	0	0	34.6	1.6	0	6.4	6.2	18.2
16	0	0	0	0	0	***	0	2.2	0	0.8	0	4
17	0	0.6	0	0	0.8	0	0	17.6	4	0	0	0.2
18	0.2	2.4	0	3.6	0	0	0	0	0	0	2.6	0
19	0	0	0	0	0	0	0.2	7.6	0	0	1	0.8
20	0.4	***	0	0	0	2.8	0	17.4	0.6	***	1.2	0.2
21	0	0	0	0	0	0.6	1.8	1	7.2	0	2.2	0
22	0.6	5	0	***	0.4	1	0.6	0	0.2	0	0.2	0
23	0	0	0	2	0	***	0	20.6	0	0	0	0
24	2.4	0	0	***	0	***	0	7.4	13.2	2.2	0	0
25	0	0	0	***	0	0	0	0.4	0	0	15	0
26	0	***	0.4	0	0	0	0	10	0.2	0.8	5.2	0
27	0	0	3.2	0	0	0	1.2	1.2	3.2	***	0.6	0
28	0	0	0.2	0	0	0	19.6	17.4	0	0	3	14.6
29	0	0	0	0	0	0	0	5.8	4.8	0	2.4	***
30	32.4	0	0	0	0	***	0	25.4	47.4	0	0	***
31	4.2	***	0	***	0		***	6.2	***	18.8	4	***
TOTAL	**282.4**	**17**	**18.2**	**28.4**	**5.8**	**80.8**	**265**	**209.8**	**125.6**	**124.2**	**165.8**	**57.2**

NOTE:

Only rainfall greater than 0.1 mm is reflected in the report obtained

*** indicates that data is missing or not available in the current month

Table 5: Sampling Dates for the Northern WWTP and respective tidal times

SAMPLING MONTH / DATE	TIDES (HIGH / LOW)	TIME (AM/PM)	THB COUNTS DURING SAMPLING (× 10^3 cfu/ml)	
			UPSTREAM	DOWNSTREAM
Mar (19/03/12)	High	02:11 / 14:27	626.67	333.37
	Low	08.21 / 20:34		
Apr (19/04/12)	High	02:43 / 14:59	226.67	606.67
	Low	08:54 / 21:02		
May (09/05/12)	High	05:32 / 18:02	128	93.33
	Low	11:48 / -		
Jun (12/06/12)	High	09:42 / 22:28	2426.67	1906.67
	Low	03:40 / 15:51		
Jul (11/07/12)	High	08:25 / 21:04	746.67	333.33
	Low	02:27 / 14:32		
Aug (18/08/12)	High	04:01 / 16:21	213.33	3173.33
	Low	10:09 / 22:30		
Sept (19/09/12)	High	05:18 / 17:36	35	66.67
	Low	11:24 / 23:48		
Oct (17/10/12)	High	04:25 / 16:42	13.33	47.20
	Low	10:30 / 22:55		
Nov (20/11/12)	High	08:23 / 20:43	36.67	40
	Low	01:51 / 14:41		
Dec (04/12/12)	High	06:40 / 18:44	160	106.67
	Low	00:20 / 12:45		
Jan (16/01/13)	High	06:32 / 18:40	146.67	146.67
	Low	00:17 / 12:39		
Feb (12/02/13)	High	05:00 / 17:10	2720	170.67
	Low	11:07 / 23:19		

Table 7: Sampling Dates for New Germany TW and respective tidal times

SAMPLING MONTH / DATE	TIDES (HIGH / LOW)	TIME (AM/PM)	THB COUNTS DURING SAMPLING (× 10^4 cfu/ml)	
			UPSTREAM	DOWNSTREAM
Mar (26/03/12)	High	05:24 / 17:35	320.00	0.667
	Low	11:31 / 23:40		
Apr (24/04/12)	High	05:00 / 17:17	76.67	1.67
	Low	11:10 / 23:22		
May (22/05/12)	High	04:14 / 16:36	213.33	826.67
	Low	10:27 / 22:40		
Jun (19/06/12)	High	03:29 / 15:54	586.67	493.33
	Low	09:43 / 21:57		
Jul (17/07/12)	High	02:41 / 15:08	3760.00	2480.00
	Low	08:55 / 21:12		
Aug (15/08/12)	High	02:25 / 14:49	3760.00	10.00
	Low	08:36 / 20:56		
Sept (25/09/12)	High	00:03 / 12:53	2186.67	3093.33
	Low	06:25 / 19:10		
Oct (23/10/12)	High	10:49 / 23:31	2133.33	20.00
	Low	03:58 / 17:23		
Nov (27/11/12)	High	02:51 / 15:02	3226.67	5120.00
	Low	08:51 / 21:17		
Dec (11/12/12)	High	01:49 / 14:11	4186.67	5306.67
	Low	07:54 / 20:30		
Jan (28/01/13)	High	04:33 / 16:40	5013.33	61.10
	Low	10:37 / 22:50		
Feb	High		1306.67	2640.00
	Low			

APPENDIX IV: MICROBIAL ANALYSES

Table IV (1): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during March 2012 (Month 1)

		DILUTIONS																				
		1×10^0			1×10^1			1×10^2			1×10^3			1×10^4			1×10^5			1×10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	384	50	7.68	76	50	1.52	24	50	0.48	5	50	0.1	0	50	0	-	-	-
		-	-	-	312	50	6.24	128	50	2.56	28	50	0.56	6	50	0.12	0	50	0	-	-	-
		-	-	-	416	50	8.32	136	50	2.72	32	50	0.64	4	50	0.08	0	50	0	-	-	-
	EC	-	-	-	224	50	4.48	52	50	1.04	16	50	0.32	1	50	0.02	0	50	0	-	-	-
		-	-	-	176	50	3.52	72	50	1.44	12	50	0.24	0	50	0	0	50	0	-	-	-
		-	-	-	272	50	5.44	60	50	1.2	12	50	0.24	0	50	0	0	50	0	-	-	-
	FC	-	-	-	TNTC	50	TNTC	108	50	2.16	7	50	0.14	1	50	0.02	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	88	50	1.76	9	50	0.18	0	50	0	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	96	50	1.92	0	50	0	0	50	0	-	-	-	-	-	-
	FS	-	-	-	40	50	0.8	4	50	0.08	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	44	50	0.88	7	50	0.14	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	56	50	1.12	3	50	0.06	0	50	0	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	48	50	0.96	7	50	0.14	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	36	50	0.72	8	50	0.16	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	52	50	1.04	7	50	0.14	1	50	0.02	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	180	0.1	1800	52	0.1	520	40	0.1	400	0	0.1	0	0	0.1	0	0	0.1	0
		-	-	-	256	0.1	2560	56	0.1	560	28	0.1	280	0	0.1	0	0	0.1	0	0	0.1	0
		-	-	-	168	0.1	1680	85	0.1	850	24	0.1	240	0	0.1	0	0	0.1	0	0	0.1	0
DISCHARGE POINT	TC	TNTC	50	TNTC	1208	50	24.16	360	50	7.2	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	704	50	14.08	208	50	4.16	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	816	50	16.32	168	50	3.36	-	-	-	-	-	-	-	-	-	-	-	-
	EC	TNTC	50	TNTC	344	50	6.88	184	50	3.68	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	328	50	6.56	112	50	2.24	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	416	50	8.32	176	50	3.52	-	-	-	-	-	-	-	-	-	-	-	-
	FC	TNTC	50	TNTC	996	50	19.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	944	50	18.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	956	50	19.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FS	248	50	4.96	72	50	1.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		268	50	5.36	60	50	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		128	50	2.56	84	50	1.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	216	50	4.32	68	50	1.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		252	50	5.04	92	50	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		204	50	4.08	88	50	1.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	384	0.1	3840	108	0.1	1080	68	0.1	680	36	0.1	360	-	-	-	-	-	-	-	-	-
		416	0.1	4160	148	0.1	1480	56	0.1	560	16	0.1	160	-	-	-	-	-	-	-	-	-
		492	0.1	4920	112	0.1	1120	68	0.1	680	20	0.1	200	-	-	-	-	-	-	-	-	-

Table IV (2): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during March 2012 (Month 2)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^1$)**	**COUNT**	**V**	**CFU/ml ($x10^2$)**	**COUNT**	**V**	**CFU/ml ($x10^3$)**	**COUNT**	**V**	**CFU/ml ($x10^4$)**	**COUNT**	**V**	**CFU/ml ($x10^5$)**	**COUNT**	**V**	**CFU/ml ($x10^6$)**
UPSTREAM	**TC**	-	50	-	-	50	-	124	50	2.48	24	50	0.48	3	50	0.06	1	50	0.02	-	50	-
		-	50	-	-	50	-	60	50	1.2	12	50	0.24	6	50	0.12	2	50	0.04	-	50	-
		-	50	-	-	50	-	72	50	1.44	12	50	0.24	5	50	0.1	1	50	0.02	-	50	-
	EC	-	50	-	-	50	-	20	50	0.4	8	50	0.16	1	50	0.02	0	50	0	-	50	-
		-	50	-	-	50	-	16	50	0.32	4	50	0.08	1	50	0.02	0	50	0	-	50	-
		-	50	-	-	50	-	12	50	0.24	4	50	0.08	0	50	0	0	50	0	-	50	-
	FC	-	50	-	6	50	0.12	2	50	0.04	1	50	0.02	-	50	-	-	50	-	-	50	-
		-	50	-	8	50	0.16	5	50	0.1	1	50	0.02	-	50	-	-	50	-	-	50	-
		-	50	-	5	50	0.1	2	50	0.04	0	50	0	-	50	-	-	50	-	-	50	-
	FS	-	50	-	20	50	0.4	4	50	0.08	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	20	50	0.4	4	50	0.08	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	16	50	0.32	4	50	0.08	0	50	0	-	50	-	-	50	-	-	50	-
	ENT	-	50	-	3	50	0.06	1	50	0.02	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	8	50	0.16	0	50	0	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	12	50	0.24	0	50	0	0	50	0	-	50	-	-	50	-	-	50	-
	HPC	-	50	-	272	50	2720	88	50	880	36	50	360	5	50	500	-	50	-	-	50	-
		-	50	-	208	50	2080	40	50	400	32	50	320	4	50	400	-	50	-	-	50	-
		-	50	-	236	50	2360	60	50	600	44	50	440	2	50	200	-	50	-	-	50	-
DOWNSTREAM	**TC**	-	50	-	-	50	-	112	50	2.24	12	50	0.24	4	50	0.08	2	50	0.04	-	50	-
		-	50	-	-	50	-	120	50	2.4	20	50	0.4	5	50	0.1	1	50	0.02	-	50	-
		-	50	-	-	50	-	160	50	3.2	16	50	0.32	3	50	0.06	1	50	0.02	-	50	-
	EC	-	50	-	-	50	-	32	50	0.64	8	50	0.16	0	50	0	1	50	0.02	-	50	-
		-	50	-	-	50	-	24	50	0.48	4	50	0.08	0	50	0	0	50	0	-	50	-
		-	50	-	-	50	-	24	50	0.48	8	50	0.16	0	50	0	0	50	0	-	50	-
	FC	-	50	-	10	50	0.2	7	50	0.14	2	50	0.04	-	50	-	-	50	-	-	50	-
		-	50	-	14	50	0.28	7	50	0.14	2	50	0.04	-	50	-	-	50	-	-	50	-
		-	50	-	18	50	0.36	8	50	0.16	0	50	0	-	50	-	-	50	-	-	50	-
	FS	-	50	-	20	50	0.4	2	50	0.04	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	24	50	0.48	1	50	0.02	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	16	50	0.32	0	50	0	0	50	0	-	50	-	-	50	-	-	50	-
	ENT	-	50	-	20	50	0.4	2	50	0.04	1	50	0.02	-	50	-	-	50	-	-	50	-
		-	50	-	12	50	0.24	2	50	0.04	0	50	0	-	50	-	-	50	-	-	50	-
		-	50	-	28	50	0.56	5	50	0.1	0	50	0	-	50	-	-	50	-	-	50	-
	HPC	-	50	-	144	50	1440	32	50	320	16	50	160	7	50	70	4	50	40	2	50	20
		-	50	-	112	50	1120	26	50	260	22	50	220	8	50	80	5	50	50	1	50	10
		-	50	-	160	50	1600	42	50	420	14	50	140	5	50	50	0	50	0	0	50	0

Table IV (3): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during April 2012 (Month 1)

		DILUTIONS																				
		$1 X 10^{0}$			**$1 X 10^{1}$**			**$1 X 10^{2}$**			**$1 X 10^{3}$**			**$1 X 10^{4}$**			**$1 X 10^{5}$**			**$1 X 10^{6}$**		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^{1}$)**	**COUNT**	**V**	**CFU/ml ($x10^{2}$)**	**COUNT**	**V**	**CFU/ml ($x10^{3}$)**	**COUNT**	**V**	**CFU/ml ($x10^{4}$)**	**COUNT**	**V**	**CFU/ml ($x10^{5}$)**	**COUNT**	**V**	**CFU/ml ($x10^{6}$)**
BEFORE CHLORINATION	**TC**	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	376	50	7.52	100	50	2	32	50	0.64	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	416	50	8.32	88	50	1.76	36	50	0.72	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	448	50	8.96	68	50	1.36	36	50	0.72	-	-	-
	EC	-	-	-	TNTC	50	TNTC	384	50	7.68	232	50	4.64	64	50	1.28	8	50	0.16	-	-	-
		-	-	-	TNTC	50	TNTC	416	50	8.32	208	50	4.16	48	50	0.96	8	50	0.16	-	-	-
		-	-	-	TNTC	50	TNTC	456	50	9.12	216	50	4.32	8	50	0.16	4	50	0.08	-	-	-
	FC	-	-	-	TNTC	50	TNTC	192	50	3.84	84	50	1.68	15	50	0.3	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	208	50	4.16	96	50	1.92	16	50	0.32	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	196	50	3.92	92	50	1.84	17	50	0.34	-	-	-	-	-	-
	FS	-	-	-	256	50	5.12	92	50	1.84	44	50	0.88	-	-	-	-	-	-	-	-	-
		-	-	-	288	50	5.76	100	50	2	40	50	0.8	-	-	-	-	-	-	-	-	-
		-	-	-	312	50	6.24	116	50	2.32	48	50	0.96	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	336	50	6.72	108	50	2.16	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	184	50	3.68	100	50	2	36	50	0.72	-	-	-	-	-	-	-	-	-
		-	-	-	176	50	3.52	88	50	1.76	52	50	1.04	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	576	0.1	5760	296	0.1	2960	160	0.1	1600	32	0.1	320	-	-	-	-	-	-
		-	-	-	712	0.1	7120	272	0.1	2720	152	0.1	1520	16	0.1	160	-	-	-	-	-	-
		-	-	-	624	0.1	6240	312	0.1	3120	128	0.1	1280	48	0.1	480	-	-	-	-	-	-
DISCHARGE POINT	**TC**	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	304	50	6.08	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	416	50	8.32	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	496	50	9.92	-	-	-	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	576	50	11.52	272	50	5.44	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	584	50	11.68	336	50	6.72	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	656	50	13.12	334	50	6.68	-	-	-	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	384	50	7.68	172	50	3.44	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	408	50	8.16	208	50	4.16	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	480	50	9.6	216	50	4.32	-	-	-	-	-	-	-	-	-
	FS	-	-	-	336	50	6.72	136	50	2.72	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	392	50	7.84	152	50	3.04	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	357	50	7.14	148	50	2.96	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	208	50	4.16	128	50	2.56	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	252	50	5.04	144	50	2.88	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	232	50	4.64	152	50	3.04	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	752	0.1	7520	416	0.1	4160	52	0.1	520	-	-	-	-	-	-	-	-	-
		-	-	-	816	0.1	8160	352	0.1	3520	48	0.1	480	-	-	-	-	-	-	-	-	-
		-	-	-	784	0.1	7840	376	0.1	3760	52	0.1	520	-	-	-	-	-	-	-	-	-

Table IV (4): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during April 2012 (Month 2)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	576	50	11.52	432	50	8.64	148	50	2.96	36	50	0.72	-	-	-	-	-	-
		-	-	-	672	50	13.44	480	50	9.6	128	50	2.56	20	50	0.4	-	-	-	-	-	-
		-	-	-	608	50	12.16	464	50	9.28	112	50	2.24	24	50	0.48	-	-	-	-	-	-
	EC	-	-	-	336	50	6.72	216	50	4.32	36	50	0.72	12	50	0.24	-	-	-	-	-	-
		-	-	-	368	50	7.36	192	50	3.84	28	50	0.56	4	50	0.08	-	-	-	-	-	-
		-	-	-	384	50	7.68	208	50	4.16	32	50	0.64	8	50	0.16	-	-	-	-	-	-
	FC	-	-	-	160	50	3.2	56	50	1.12	11	50	0.22	-	-	-	-	-	-	-	-	-
		-	-	-	168	50	3.36	56	50	1.12	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	156	50	3.12	48	50	0.96	14	50	0.28	-	-	-	-	-	-	-	-	-
	FS	-	-	-	48	50	0.96	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	40	50	0.8	5	50	0.1	1	50	0.02	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	48	50	0.96	4	50	0.08	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	3	50	0.06	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	56	50	1.12	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	132	0.1	1320	64	0.1	640	24	0.1	240	2	0.1	20	-	-	-	-	-	-
		-	-	-	168	0.1	1680	48	0.1	480	24	0.1	240	2	0.1	20	-	-	-	-	-	-
		-	-	-	152	0.1	1520	80	0.1	800	20	0.1	200	3	0.1	30	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	TNTC	50	TNTC	200	50	4	104	50	2.08	24	50	0.48	16	50	0.32	-	-	-
		-	-	-	TNTC	50	TNTC	256	50	5.12	112	50	2.24	16	50	0.32	20	50	0.4	-	-	-
		-	-	-	TNTC	50	TNTC	232	50	4.64	128	50	2.56	32	50	0.64	12	50	0.24	-	-	-
	EC	-	-	-	168	50	3.36	48	50	0.96	24	50	0.48	2	50	0.04	1	50	0.02	-	-	-
		-	-	-	192	50	3.84	48	50	0.96	28	50	0.56	4	50	0.08	2	50	0.04	-	-	-
		-	-	-	224	50	4.48	40	50	0.8	36	50	0.72	3	50	0.06	8	50	0.16	-	-	-
	FC	-	-	-	TNTC	50	TNTC	490	50	9.8	224	50	4.48	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	576	50	11.52	176	50	3.52	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	512	50	10.24	232	50	4.64	-	-	-	-	-	-	-	-	-
	FS	-	-	-	128	50	2.56	60	50	1.2	10	50	0.2	-	-	-	-	-	-	-	-	-
		-	-	-	112	50	2.24	40	50	0.8	11	50	0.22	-	-	-	-	-	-	-	-	-
		-	-	-	108	50	2.16	72	50	1.44	4	50	0.08	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	168	50	3.36	116	50	2.32	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	152	50	3.04	92	50	1.84	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	156	50	3.12	112	50	2.24	20	50	0.4	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	1232	0.1	12320	360	0.1	3600	68	0.1	680	16	0.1	160	-	-	-	-	-	-
		-	-	-	1312	0.1	13120	384	0.1	3840	56	0.1	560	44	0.1	440	-	-	-	-	-	-
		-	-	-	1536	0.1	15360	416	0.1	4160	58	0.1	580	32	0.1	320	-	-	-	-	-	-

Table IV (5): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during May 2012 (Month 3)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	TNTC	50	TNTC	TNTC	50	TNTC	352	50	TNTC	192	50	3.84	32	50	0.64	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	448	50	TNTC	224	50	4.48	52	50	1.04	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	472	50	TNTC	256	50	5.12	40	50	0.8	-	-	-	-	-	-
	EC	TNTC	50	TNTC	TNTC	50	TNTC	256	50	5.12	88	50	1.76	8	50	0.16	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	248	50	4.96	80	50	1.6	8	50	0.16	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	280	50	5.6	120	50	2.4	12	50	0.24	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	368	50	7.36	168	50	3.36	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	384	50	7.68	176	50	3.52	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	400	50	8	144	50	2.88	-	-	-	-	-	-
	FS	-	-	-	TNTC	50	TNTC	168	50	3.36	44	50	0.88	20	50	0.4	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	200	50	4	48	50	0.96	16	50	0.32	-	-	-	-	-	-
		-	-	-	416	50	8.32	160	50	3.2	64	50	1.28	12	50	0.24	-	-	-	-	-	-
	ENT	-	-	-	TNTC	50	TNTC	224	50	4.48	64	50	1.28	20	50	0.4	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	252	50	5.04	30	50	0.6	20	50	0.4	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	232	50	4.64	80	50	1.6	16	50	0.32	-	-	-	-	-	-
	HPC	-	-	-	768	0.1	7680	192	0.1	1920	44	0.1	440	24	0.1	240	8	0.1	80	-	-	-
		-	-	-	752	0.1	7520	176	0.1	1760	32	0.1	320	12	0.1	120	4	0.1	40	-	-	-
		-	-	-	760	0.1	7600	160	0.1	1600	48	0.1	480	16	0.1	160	4	0.1	40	-	-	-
DISCHARGE POINT	TC	-	-	-	TNTC	50	TNTC	288	50	5.76	152	50	3.04	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	304	50	6.08	144	50	2.88	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	272	50	5.44	176	50	3.52	-	-	-	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	192	50	3.84	88	50	1.76	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	160	50	3.2	72	50	1.44	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	176	50	3.52	120	50	2.4	-	-	-	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	256	50	5.12	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	384	50	7.68	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	224	50	4.48	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	216	50	4.32	140	50	2.8	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	136	50	2.72	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	132	50	2.64	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	336	50	6.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	416	50	8.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	384	50	7.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	TNTC	0.1	TNTC	656	0.1	6560	64	0.1	640	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	0.1	TNTC	528	0.1	5280	124	0.1	1240	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	0.1	TNTC	624	0.1	6240	68	0.1	680	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (6): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during May 2012 (Month 3)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	**TC**	-	-	-	0	50	0	408	50	8.16	168	50	3.36	60	50	1.2	-	-	-	-	-	-
		-	-	-	0	50	0	400	50	8	224	50	4.48	64	50	1.28	-	-	-	-	-	-
		-	-	-	0	50	0	392	50	7.84	192	50	3.84	72	50	1.44	-	-	-	-	-	-
	EC	-	-	-	0	50	0	104	50	2.08	40	50	0.8	12	50	0.24	-	-	-	-	-	-
		-	-	-	0	50	0	128	50	2.56	56	50	1.12	12	50	0.24	-	-	-	-	-	-
		-	-	-	0	50	0	144	50	2.88	52	50	1.04	16	50	0.32	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	84	50	1.68	56	50	1.12	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	92	50	1.84	40	50	0.8	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	100	50	2	44	50	0.88	-	-	-	-	-	-	-	-	-
	FS	-	-	-	72	50	1.44	36	50	0.72	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	68	50	1.36	32	50	0.64	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	30	50	0.6	36	50	0.72	5	50	0.1	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	32	50	0.64	248	50	4.96	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	28	50	0.56	224	50	4.48	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	36	50	0.72	232	50	4.64	5	50	0.1	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	248	0.1	2480	128	0.1	1280	108	0.1	1080	3	0.1	30	-	-	-	-	-	-
		-	-	-	240	0.1	2400	152	0.1	1520	76	0.1	760	6	0.1	60	-	-	-	-	-	-
		-	-	-	224	0.1	2240	104	0.1	1040	28	0.1	280	4	0.1	40	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	TNTC	50	TNTC	328	50	6.56	68	50	1.36	8	50	0.16	2	50	0.04	-	-	-
		-	-	-	TNTC	50	TNTC	320	50	6.4	52	50	1.04	24	50	0.48	1	50	0.02	-	-	-
		-	-	-	TNTC	50	TNTC	304	50	6.08	40	50	0.8	16	50	0.32	3	50	0.06	-	-	-
	EC	-	-	-	0	50	0	20	50	0.4	16	50	0.32	3	50	0.06	0	50	0	-	-	-
		-	-	-	0	50	0	18	50	0.36	16	50	0.32	5	50	0.1	0	50	0	-	-	-
		-	-	-	0	50	0	21	50	0.42	24	50	0.48	1	50	0.02	0	50	0	-	-	-
	FC	-	-	-	TNTC	50	TNTC	112	50	2.24	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	184	50	3.68	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	312	50	6.24	12	50	0.24	-	-	-	-	-	-	-	-	-
	FS	-	-	-	52	50	1.04	16	50	0.32	5	50	0.1	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	12	50	0.24	5	50	0.1	-	-	-	-	-	-	-	-	-
		-	-	-	56	50	1.12	12	50	0.24	3	50	0.06	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	104	50	2.08	36	50	0.72	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	160	50	3.2	48	50	0.96	7	50	0.14	-	-	-	-	-	-	-	-	-
		-	-	-	176	50	3.52	44	50	0.88	4	50	0.08	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	TNTC	0.1	TNTC	104	0.1	1040	56	0.1	560	0	0.1	0	-	-	-	-	-	-
		-	-	-	TNTC	0.1	TNTC	84	0.1	840	68	0.1	680	0	0.1	0	-	-	-	-	-	-
		-	-	-	TNTC	0.1	TNTC	92	0.1	920	80	0.1	800	0	0.1	0	-	-	-	-	-	-

Table IV (7): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during June 2012 (Month 4)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml (x10^1)	COUNT	V	CFU/ml (x10^2)	COUNT	V	CFU/ml (x10^3)	COUNT	V	CFU/ml (x10^4)	COUNT	V	CFU/ml (x10^5)	COUNT	V	CFU/ml (x10^6)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	768	50	15.36	152	20	7.6	176	50	3.52	36	50	0.72	-	-	-
		-	-	-	-	-	-	640	50	12.8	88	20	4.4	112	50	2.24	160	50	3.2	-	-	-
		-	-	-	-	-	-	688	50	13.76	312	50	6.24	128	50	2.56	184	50	3.68	-	-	-
	EC	-	-	-	-	-	-	376	50	7.52	64	20	3.2	24	50	0.48	2	50	0.04	-	-	-
		-	-	-	-	-	-	256	50	5.12	40	20	2	24	50	0.48	20	50	0.4	-	-	-
		-	-	-	-	-	-	288	50	5.76	120	50	2.4	16	50	0.32	44	50	0.88	-	-	-
	FC	-	-	-	-	-	-	264	50	5.28	52	50	1.04	16	50	0.32	-	-	-	-	-	-
		-	-	-	-	-	-	232	50	4.64	24	50	0.48	16	50	0.32	-	-	-	-	-	-
		-	-	-	-	-	-	256	50	5.12	36	50	0.72	20	50	0.4	-	-	-	-	-	-
	FS	-	-	-	-	-	-	132	50	2.64	46	50	0.92	24	50	0.48	-	-	-	-	-	-
		-	-	-	-	-	-	96	50	1.92	40	50	0.8	20	50	0.4	-	-	-	-	-	-
		-	-	-	-	-	-	128	50	2.56	44	50	0.88	18	50	0.36	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	160	50	3.2	16	20	0.8	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	48	20	2.4	12	20	0.6	5	50	0.1	-	-	-	-	-	-
		-	-	-	-	-	-	128	50	2.56	8	20	0.4	4	50	0.08	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	168	0.1	1680	56	0.1	560	24	0.1	240	-	-	-	-	-	-
		-	-	-	-	-	-	176	0.1	1760	64	0.1	640	36	0.1	360	-	-	-	-	-	-
		-	-	-	-	-	-	216	0.1	2160	44	0.1	440	32	0.1	320	-	-	-	-	-	-
DISCHARGE POINT	TC	TNTC	50	TNTC	TNTC	50	TNTC	352	50	7.04	240	30	8	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	392	50	7.84	248	25	9.92	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	448	50	8.96	224	30	7.47	-	-	-	-	-	-	-	-	-
	EC	TNTC	50	TNTC	TNTC	50	TNTC	144	50	2.88	120	30	4	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	160	50	3.2	104	25	4.16	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	184	50	3.68	72	30	2.4	-	-	-	-	-	-	-	-	-
	FC	TNTC	50	TNTC	392	50	7.84	144	50	2.88	60	50	1.2	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	424	50	8.48	168	50	3.36	28	30	0.93	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	408	50	8.16	136	50	2.72	36	30	1.2	-	-	-	-	-	-	-	-	-
	FS	-	-	-	140	50	2.8	120	50	2.4	80	50	1.6	-	-	-	-	-	-	-	-	-
		-	-	-	136	50	2.72	116	50	2.32	72	50	1.44	-	-	-	-	-	-	-	-	-
		-	-	-	132	50	2.64	128	50	2.56	76	50	1.52	-	-	-	-	-	-	-	-	-
	ENT	448	50	8.96	264	50	5.28	120	50	2.4	-	-	-	-	-	-	-	-	-	-	-	-
		504	50	10.08	256	50	5.12	124	50	2.48	-	-	-	-	-	-	-	-	-	-	-	-
		472	50	9.44	232	50	4.64	118	50	2.36	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	TNTC	0.1	TNTC	328	0.1	3280	184	0.1	1840	28	0.1	280	-	-	-	-	-	-	-	-	-
		TNTC	0.1	TNTC	552	0.1	5520	160	0.1	1600	44	0.1	320	-	-	-	-	-	-	-	-	-
		TNTC	0.1	TNTC	448	0.1	4480	136	0.1	1360	20	0.1	200	-	-	-	-	-	-	-	-	-

Table IV (8): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during June 2012 (Month 4)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml (x10^1)	COUNT	V	CFU/ml (x10^2)	COUNT	V	CFU/ml (x10^3)	COUNT	V	CFU/ml (x10^4)	COUNT	V	CFU/ml (x10^5)	COUNT	V	CFU/ml (x10^6)
UPSTREAM	TC	-	-	-	-	-	-	496	50	9.92	40	50	0.8	28	50	0.56	-	-	-	-	-	-
		-	-	-	-	-	-	448	50	8.96	44	50	0.88	28	50	0.56	-	-	-	-	-	-
		-	-	-	-	-	-	392	50	7.84	40	50	0.8	16	50	0.32	-	-	-	-	-	-
	EC	-	-	-	-	-	-	56	50	1.12	8	50	0.16	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	52	50	1.04	16	50	0.32	4	50	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	56	50	1.12	12	50	0.24	2	50	0.04	-	-	-	-	-	-
	FC	-	-	-	176	50	TNTC	64	50	1.28	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	192	50	TNTC	64	50	1.28	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	224	50	TNTC	80	50	1.6	8	50	0.16	-	-	-	-	-	-	-	-	-
	FS	-	-	-	44	50	0.88	22	50	0.44	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	24	50	0.48	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	40	50	0.8	28	50	0.56	8	50	0.16	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	48	50	0.96	13	50	0.26	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	96	50	1.92	16	50	0.32	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	108	50	2.16	21	50	0.42	1	50	0.02	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	584	0.1	5840	392	0.1	3920	184	0.1	1840	-	-	-	-	-	-	-	-	-
		-	-	-	704	0.1	7040	416	0.1	4160	264	0.1	2640	-	-	-	-	-	-	-	-	-
		-	-	-	632	0.1	6320	464	0.1	4640	280	0.1	2800	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	-	-	-	-	-	-	64	50	1.28	36	50	0.72	16	50	0.32	-	-	-
		-	-	-	-	-	-	-	-	-	72	50	1.44	68	50	1.36	20	50	0.4	-	-	-
		-	-	-	-	-	-	-	-	-	76	50	1.52	48	50	0.96	24	50	0.48	-	-	-
	EC	-	-	-	-	-	-	-	-	-	16	50	0.32	8	50	0.16	3	50	0.06	-	-	-
		-	-	-	-	-	-	-	-	-	20	50	0.4	12	50	0.24	4	50	0.08	-	-	-
		-	-	-	-	-	-	-	-	-	24	50	0.48	12	50	0.24	0	50	0	-	-	-
	FC	-	-	-	184	50	TNTC	48	50	0.96	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	216	50	TNTC	56	50	1.12	9	50	0.18	-	-	-	-	-	-	-	-	-
		-	-	-	256	50	TNTC	52	50	1.04	3	50	0.06	-	-	-	-	-	-	-	-	-
	FS	-	-	-	128	50	2.56	88	50	1.76	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	132	50	2.64	72	50	1.44	22	50	0.44	-	-	-	-	-	-	-	-	-
		-	-	-	124	50	2.48	68	50	1.36	18	50	0.36	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	152	50	3.04	32	50	0.64	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	232	50	4.64	60	50	1.2	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	200	50	4	44	50	0.88	12	50	0.24	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	488	0.1	4880	280	0.1	2800	168	0.1	1680	-	-	-	-	-	-	-	-	-
		-	-	-	512	0.1	5120	344	0.1	3440	156	0.1	1560	-	-	-	-	-	-	-	-	-
		-	-	-	456	0.1	4560	392	0.1	3920	248	0.1	2480	-	-	-	-	-	-	-	-	-

Table IV (9): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during July 2012 (Month 5)

	DILUTIONS																				
	1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
	COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
TC	-	-	-	-	-	-	480	50	9.6	176	50	3.52	52	50	1.04	5	50	0.1	-	-	-
	-	-	-	-	-	-	TNTC	50	TNTC	256	50	5.12	52	50	1.04	6	50	0.12	-	-	-
	-	-	-	-	-	-	TNTC	50	TNTC	224	50	4.48	60	50	1.2	9	50	0.18	-	-	-
EC	-	-	-	-	-	-	256	50	5.12	120	50	2.4	16	50	0.32	0	50	0	-	-	-
	-	-	-	-	-	-	280	50	5.6	128	50	2.56	20	50	0.4	0	50	0	-	-	-
	-	-	-	-	-	-	176	50	3.52	112	50	2.24	12	50	0.24	0	50	0	-	-	-
FC	-	-	-	-	-	-	336	50	6.72	36	50	0.72	7	50	0.14	-	-	-	-	-	-
	-	-	-	-	-	-	384	50	7.68	60	50	1.2	7	50	0.14	-	-	-	-	-	-
	-	-	-	-	-	-	432	50	8.64	60	50	1.2	13	50	0.26	-	-	-	-	-	-
FS	-	-	-	-	-	-	56	50	1.12	12	50	0.24	2	50	0.04	-	-	-	-	-	-
	-	-	-	-	-	-	84	50	1.68	17	50	0.34	6	50	0.12	-	-	-	-	-	-
	-	-	-	-	-	-	72	50	1.44	15	50	0.3	2	50	0.04	-	-	-	-	-	-
ENT	-	-	-	-	-	-	68	50	1.36	6	50	0.12	0	50	0	-	-	-	-	-	-
	-	-	-	-	-	-	64	50	1.28	5	50	0.1	0	50	0	-	-	-	-	-	-
	-	-	-	-	-	-	60	50	1.2	4	50	0.08	0	50	0	-	-	-	-	-	-
HPC	-	-	-	-	-	-	408	0.1	4080	36	0.1	360	5	0.1	50	-	-	-	-	-	-
	-	-	-	-	-	-	368	0.1	3680	32	0.1	320	4	0.1	40	-	-	-	-	-	-
	-	-	-	-	-	-	376	0.1	3760	40	0.1	400	7	0.1	70	-	-	-	-	-	-
TC	TNTC	50	TNTC	TNTC	50	TNTC	720	50	14.4	0	50	0	-	-	-	-	-	-	-	-	-
	TNTC	50	TNTC	TNTC	50	TNTC	832	50	16.64	0	50	0	-	-	-	-	-	-	-	-	-
	TNTC	50	TNTC	TNTC	50	TNTC	624	50	12.48	0	50	0	-	-	-	-	-	-	-	-	-
EC	TNTC	50	TNTC	TNTC	50	TNTC	208	50	4.16	0	50	0	-	-	-	-	-	-	-	-	-
	TNTC	50	TNTC	TNTC	50	TNTC	200	50	4	0	50	0	-	-	-	-	-	-	-	-	-
	TNTC	50	TNTC	TNTC	50	TNTC	216	50	4.32	0	50	0	-	-	-	-	-	-	-	-	-
FC	TNTC	50	TNTC	296	50	19.73	-	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	TNTC	50	TNTC	608	50	15.2	-	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	TNTC	50	TNTC	512	50	12.8	-	50	0	0	50	0	-	-	-	-	-	-	-	-	-
FS	80	50	2	23	50	0.46	-	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	72	50	1.8	32	50	0.64	-	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	64	50	1.6	22	50	0.44	-	50	0	0	50	0	-	-	-	-	-	-	-	-	-
ENT	76	50	1.9	28	50	0.56	-	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	64	50	1.6	24	50	0.48	-	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	60	50	1.5	28	50	0.56	-	50	0	-	-	-	-	-	-	-	-	-	-	-	-
HPC	1760	0.1	17600	976	0.1	9760	976	0.1	9760	-	-	-	-	-	-	-	-	-	-	-	-
	1968	0.1	19680	1168	0.1	11680	608	0.1	6080	-	-	-	-	-	-	-	-	-	-	-	-
	2112	0.1	21120	1024	0.1	10240	704	0.1	7040	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (10): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during July 2012 (Month 5)

	DILUTIONS																				
	1×10^0			1×10^1			1×10^2			1×10^3			1×10^4			1×10^5			1×10^6		
	COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
TC	-	-	-	-	-	-	472	50	9.44	104	50	2.08	28	50	0.56	5	50	0.1	-	-	-
	-	-	-	-	-	-	336	50	6.72	160	50	3.2	24	50	0.48	8	50	0.16	-	-	-
	-	-	-	-	-	-	312	50	6.24	112	50	2.24	32	50	0.64	4	50	0.08	-	-	-
EC	-	-	-	-	-	-	108	50	2.16	28	50	0.56	4	50	0.08	0	50	0	-	-	-
	-	-	-	-	-	-	128	50	2.56	36	50	0.72	4	50	0.08	0	50	0	-	-	-
	-	-	-	-	-	-	110	50	2.2	32	50	0.64	8	50	0.16	0	50	0	-	-	-
FC	-	-	-	384	50	7.68	312	50	6.24	32	50	0.64	-	50	-	-	-	-	-	-	-
	-	-	-	336	50	6.72	224	50	4.48	28	50	0.56	-	50	-	-	-	-	-	-	-
	-	-	-	368	50	7.36	192	50	3.84	28	50	0.56	-	50	-	-	-	-	-	-	-
FS	-	-	-	92	50	1.84	32	50	0.64	5	50	0.1	-	50	-	-	-	-	-	-	-
	-	-	-	80	50	1.6	44	50	0.88	4	50	0.08	-	50	-	-	-	-	-	-	-
	-	-	-	72	50	1.44	28	50	0.56	3	50	0.06	-	50	-	-	-	-	-	-	-
ENT	-	-	-	160	50	3.2	36	50	0.72	3	50	0.06	-	50	-	-	-	-	-	-	-
	-	-	-	168	50	3.36	28	50	0.56	3	50	0.06	-	50	-	-	-	-	-	-	-
	-	-	-	144	50	2.88	32	50	0.64	2	50	0.04	-	50	-	-	-	-	-	-	-
HPC	-	-	-	-	-	-	128	0.1	1280	44	0.1	440	20	0.1	200	-	-	-	-	-	-
	-	-	-	-	-	-	160	0.1	1600	64	0.1	640	24	0.1	240	-	-	-	-	-	-
	-	-	-	-	-	-	144	0.1	1440	116	0.1	1160	28	0.1	280	-	-	-	-	-	-
TC	-	-	-	-	-	-	296	50	5.92	96	50	1.92	52	50	1.04	-	-	-	-	-	-
	-	-	-	-	-	-	336	50	6.72	152	50	3.04	32	50	0.64	-	-	-	-	-	-
	-	-	-	-	-	-	304	50	6.08	128	50	2.56	56	50	1.12	-	-	-	-	-	-
EC	-	-	-	-	-	-	136	50	2.72	28	50	0.56	12	50	0.24	-	-	-	-	-	-
	-	-	-	-	-	-	208	50	4.16	40	50	0.8	8	50	0.16	-	-	-	-	-	-
	-	-	-	-	-	-	176	50	3.52	36	50	0.72	16	50	0.32	-	-	-	-	-	-
FC	-	-	-	624	50	TNTC	144	50	2.88	28	50	0.56	-	-	-	-	-	-	-	-	-
	-	-	-	512	50	TNTC	120	50	2.4	24	50	0.48	-	-	-	-	-	-	-	-	-
	-	-	-	560	50	TNTC	128	50	2.56	28	50	0.56	-	-	-	-	-	-	-	-	-
FS	-	-	-	84	50	1.68	52	50	1.04	7	50	0.14	-	-	-	-	-	-	-	-	-
	-	-	-	72	50	1.44	56	50	1.12	6	50	0.12	-	-	-	-	-	-	-	-	-
	-	-	-	76	50	1.52	44	50	0.88	6	50	0.12	-	-	-	-	-	-	-	-	-
ENT	-	-	-	256	50	5.12	24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-
	-	-	-	176	50	3.52	28	50	0.56	4	50	0.08	-	-	-	-	-	-	-	-	-
	-	-	-	192	50	3.84	36	50	0.72	3	50	0.06	-	-	-	-	-	-	-	-	-
HPC	-	-	-	176	0.1	1760	44	0.1	440	24	0.1	240	-	-	-	-	-	-	-	-	-
	-	-	-	312	0.1	3120	56	0.1	560	32	0.1	320	-	-	-	-	-	-	-	-	-
				272	0.1	2720	68	0.1	680	44	0.1	440	-	-	-	-	-	-	-	-	-

Table IV (11): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during August 2012 (Month 6)

		DILUTIONS																				
		1 X 10^0			**1 X 10^1**			**1 X 10^2**			**1 X 10^3**			**1 X 10^4**			**1 X 10^5**			**1 X 10^6**		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^1$)**	**COUNT**	**V**	**CFU/ml ($x10^2$)**	**COUNT**	**V**	**CFU/ml ($x10^3$)**	**COUNT**	**V**	**CFU/ml ($x10^4$)**	**COUNT**	**V**	**CFU/ml ($x10^5$)**	**COUNT**	**V**	**CFU/ml ($x10^6$)**
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	TNTC	50	TNTC	352	25	14.08	160	50	3.2	36	50	0.72	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	304	25	12.16	128	50	2.56	28	50	0.56	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	232	25	9.28	116	50	2.32	52	50	1.04	-	-	-
	EC	-	-	-	-	-	-	-	-	-	144	50	2.88	56	50	1.12	8	50	0.16	-	-	-
		-	-	-	-	-	-	-	-	-	128	50	2.56	32	50	0.64	4	50	0.08	-	-	-
		-	-	-	-	-	-	-	-	-	152	50	3.04	44	50	0.88	12	50	0.24	-	-	-
	FC	-	-	-	-	-	-	336	25	13.44	72	50	1.44	8	50	0.16	-	-	-	-	-	-
		-	-	-	-	-	-	1144	25	45.76	88	50	1.76	15	50	0.3	-	-	-	-	-	-
		-	-	-	-	-	-	304	25	12.16	100	50	2	16	50	0.32	-	-	-	-	-	-
	FS	-	-	-	-	-	-	208	50	4.16	68	25	2.72	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	152	50	3.04	60	25	2.4	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	176	50	3.52	56	25	2.24	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	104	50	4.16	9	50	0.18	2	25	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	136	50	5.44	16	50	0.32	4	25	0.16	-	-	-	-	-	-
		-	-	-	-	-	-	112	50	4.48	18	50	0.36	3	25	0.12	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	56	0.1	560	8	0.1	80	4	0.1	40	-	-	-
		-	-	-	-	-	-	-	-	-	76	0.1	760	20	0.1	200	2	0.1	20	-	-	-
		-	-	-	-	-	-	-	-	-	52	0.1	520	32	0.1	320	3	0.1	30	-	-	-
DISCHARGE POINT	**TC**	-	-	-	TNTC	50	TNTC	436	25	17.44	312	25	12.48	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	444	25	17.76	340	25	13.6	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	456	25	18.24	368	25	14.72	-	-	-	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	170	25	6.8	120	25	4.8	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	178	25	7.12	112	25	4.48	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	169	25	6.76	98	25	3.92	-	-	-	-	-	-	-	-	-
	FC	-	-	-	352	50	7.04	254	50	10.16	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	336	50	6.72	263	50	10.52	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	320	50	6.4	276	50	11.04	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	298	50	5.96	143	50	2.86	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	286	50	5.72	134	50	2.68	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	282	50	5.64	138	50	2.76	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	384	50	7.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	400	50	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	368	50	7.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	2956	0.1	29560	1436	0.1	14360	256	0.1	2560	-	-	-	-	-	-	-	-	-	-	-	-
		3444	0.1	34440	1112	0.1	11120	296	0.1	2960	-	-	-	-	-	-	-	-	-	-	-	-
		2052	0.1	20520	968	0.1	9680	284	0.1	2840	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (12): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during August 2012 (Month 6)

		DILUTIONS																				
		1×10^0			1×10^1			1×10^2			1×10^3			1×10^4			1×10^5			1×10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($\times 10^1$)	COUNT	V	CFU/ml ($\times 10^2$)	COUNT	V	CFU/ml ($\times 10^3$)	COUNT	V	CFU/ml ($\times 10^4$)	COUNT	V	CFU/ml ($\times 10^5$)	COUNT	V	CFU/ml ($\times 10^6$)
UPSTREAM	TC	-	-	-	-	-	-	256	50	5.12	52	25	2.08	20	50	0.4	24	50	0.48	-	-	-
		-	-	-	-	-	-	208	50	4.16	36	25	1.44	16	50	0.32	0	50	0	-	-	-
		-	-	-	-	-	-	224	50	4.48	40	25	1.6	20	50	0.4	8	50	0.16	-	-	-
	EC	-	-	-	-	-	-	92	50	1.84	28	25	1.12	3	50	0.06	1	50	0.02	-	-	-
		-	-	-	-	-	-	80	50	1.6	16	25	0.64	1	50	0.02	2	50	0.04	-	-	-
		-	-	-	-	-	-	88	50	1.76	16	25	0.64	2	50	0.04	0	50	0	-	-	-
	FC	-	-	-	456	50	9.12	28	50	0.56	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	256	25	10.24	32	50	0.64	3	25	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	248	25	9.92	20	50	0.4	1	25	0.04	-	-	-	-	-	-	-	-	-
	FS	-	-	-	120	50	2.4	22	25	0.88	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	144	50	2.88	15	25	0.6	2	25	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	120	50	2.4	14	25	0.56	3	25	0.12	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	112	25	4.48	4	25	0.16	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	96	25	3.84	3	25	0.12	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	120	25	4.8	2	25	0.08	3	25	0.12	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	216	0.1	2160	40	0.1	400	12	0.1	120	-	-	-	-	-	-	-	-	-
		-	-	-	196	0.1	1960	16	0.1	160	36	0.1	360	-	-	-	-	-	-	-	-	-
		-	-	-	228	0.1	2280	20	0.1	200	16	0.1	160	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	320	50	6.4	168	25	6.72	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	352	50	7.04	152	25	6.08	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	328	50	6.56	272	50	5.44	-	-	-
	EC	-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	44	50	0.88	56	25	2.24	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	72	50	1.44	32	25	1.28	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	60	50	1.2	72	25	1.44	-	-	-
	FC	-	-	-	60	25	2.4	32	50	0.64	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	52	25	2.08	20	50	0.4	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	56	25	2.24	24	50	0.48	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	24	25	1.2	3	50	0.06	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	4	25	0.08	4	50	0.08	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	16	25	0.32	4	50	0.08	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	12	25	0.48	1	25	0.04	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	12	25	0.48	2	25	0.08	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	24	25	0.96	2	25	0.08	0	25	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	1444	0.1	14440	324	0.1	3240	276	0.1	2760	-	-	-	-	-	-	-	-	-
		-	-	-	2176	0.1	21760	412	0.1	4120	292	0.1	2920	-	-	-	-	-	-	-	-	-
		-	-	-	1980	0.1	19800	368	0.1	3680	384	0.1	3840	-	-	-	-	-	-	-	-	-

Table IV (13): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during September 2012 (Month 7)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^1$)**	**COUNT**	**V**	**CFU/ml ($x10^2$)**	**COUNT**	**V**	**CFU/ml ($x10^3$)**	**COUNT**	**V**	**CFU/ml ($x10^4$)**	**COUNT**	**V**	**CFU/ml ($x10^5$)**	**COUNT**	**V**	**CFU/ml ($x10^6$)**
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	TNTC	50	TNTC	380	50	7.6	160	50	3.2	36	50	0.72	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	352	50	7.04	128	50	2.56	28	50	0.56	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	348	50	6.96	116	50	2.32	52	50	1.04	-	-	-
	EC	-	-	-	-	-	-	-	-	-	88	50	1.76	45	50	0.9	12	50	0.24	-	-	-
		-	-	-	-	-	-	-	-	-	108	50	2.16	52	50	1.04	10	50	0.2	-	-	-
		-	-	-	-	-	-	-	-	-	180	50	3.6	48	50	0.96	8	50	0.16	-	-	-
	FC	-	-	-	-	-	-	360	50	7.2	88	50	1.76	16	50	0.32	-	-	-	-	-	-
		-	-	-	-	-	-	376	50	7.52	108	50	2.16	24	50	0.48	-	-	-	-	-	-
		-	-	-	-	-	-	416	50	8.32	96	50	1.92	32	50	0.64	-	-	-	-	-	-
	FS	-	-	-	-	-	-	72	50	1.44	12	50	0.24	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	104	50	2.08	28	50	0.56	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	92	50	1.84	16	50	0.32	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	112	50	4.48	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	108	50	4.32	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	92	50	3.68	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	80	0.1	800	8	0.1	80	4	0.1	40	-	-	-
		-	-	-	-	-	-	-	-	-	72	0.1	720	12	0.1	120	9	0.1	90	-	-	-
		-	-	-	-	-	-	-	-	-	112	0.1	1120	8	0.1	80	5	0.1	50	-	-	-
DISCHARGE POINT	**TC**	TNTC	50	TNTC	992	50	19.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	984	50	19.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	994	50	19.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	EC	360	50	7.2	216	50	4.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		392	50	7.84	200	50	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		410	50	8.2	176	50	3.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FC	664	50	13.28	336	50	6.72	180	25	7.2	-	-	-	-	-	-	-	-	-	-	-	-
		736	50	14.72	312	50	6.24	144	25	5.76	-	-	-	-	-	-	-	-	-	-	-	-
		696	50	13.92	320	50	6.4	156	25	6.24	-	-	-	-	-	-	-	-	-	-	-	-
	FS	88	50	1.76	20	50	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		100	50	2	28	50	0.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		108	50	2.16	32	50	0.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	576	50	11.52	216	50	4.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		624	50	12.48	256	50	5.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		672	50	13.44	208	50	4.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	480	0.1	4800	184	0.1	1840	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	528	0.1	5280	128	0.1	1280	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	592	0.1	5920	160	0.1	1600												

Table IV (14): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during September 2012 (Month 7)

		DILUTIONS																				
		1 X 10^{0}			1 X 10^{1}			1 X 10^{2}			1 X 10^{3}			1 X 10^{4}			1 X 10^{5}			1 X 10^{6}		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^{1}$)	COUNT	V	CFU/ml ($x10^{2}$)	COUNT	V	CFU/ml ($x10^{3}$)	COUNT	V	CFU/ml ($x10^{4}$)	COUNT	V	CFU/ml ($x10^{5}$)	COUNT	V	CFU/ml ($x10^{6}$)
UPSTREAM	**TC**	-	-	-	592	50	11.84	488	50	9.76	72	50	1.44	-	-	-	-	-	-	-	-	-
		-	-	-	656	50	13.12	472	50	9.44	76	50	1.52	-	-	-	-	-	-	-	-	-
		-	-	-	632	50	12.64	504	50	10.08	64	50	1.28	-	-	-	-	-	-	-	-	-
	EC	-	-	-	256	50	5.12	128	50	2.56	26	50	0.52	-	-	-	-	-	-	-	-	-
		-	-	-	336	50	6.72	152	50	3.04	36	50	0.72	-	-	-	-	-	-	-	-	-
		-	-	-	296	50	5.92	168	50	3.36	12	50	0.24	-	-	-	-	-	-	-	-	-
	FC	-	-	-	548	50	10.96	144	50	2.88	48	50	0.96	-	-	-	-	-	-	-	-	-
		-	-	-	608	50	12.16	124	50	2.48	36	50	0.72	-	-	-	-	-	-	-	-	-
		-	-	-	672	50	13.44	136	50	2.72	40	50	0.8	-	-	-	-	-	-	-	-	-
	FS	-	-	-	92	50	1.84	12	50	0.24	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	84	50	1.68	16	50	0.32	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	84	50	1.68	24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	92	50	1.84	12	50	0.24	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	84	50	1.68	16	50	0.32	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	84	50	1.68	24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	52	0.1	520	4	0.1	40	0	0.1	0	-	-	-	-	-	-
		-	-	-	-	-	-	40	0.1	400	3	0.1	30	0	0.1	0	-	-	-	-	-	-
		-	-	-	-	-	-	44	0.1	440	13	0.1	130	0	0.1	0	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	360	50	7.2	224	50	4.48	56	50	1.12	-	-	-	-	-	-	-	-	-
		-	-	-	416	50	8.32	256	50	5.12	40	50	0.8	-	-	-	-	-	-	-	-	-
		-	-	-	312	50	6.24	272	50	5.44	36	50	0.72	-	-	-	-	-	-	-	-	-
	EC	-	-	-	232	50	4.64	32	50	0.64	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	260	50	5.2	52	50	1.04	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	256	50	5.12	44	50	0.88	4	50	0.08	-	-	-	-	-	-	-	-	-
	FC	-	-	-	208	50	4.16	44	50	0.88	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	232	50	4.64	36	50	0.72	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	256	50	5.12	52	50	1.04	8	50	0.16	-	-	-	-	-	-	-	-	-
	FS	-	-	-	36	50	0.72	6	50	0.12	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	7	50	0.14	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	28	50	0.56	8	50	0.16	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	44	50	0.88	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	36	50	0.72	10	50	0.2	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	5	50	0.1	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	136	0.1	1360	37	0.1	370	4	0.1	40	-	-	-	-	-	-	-	-	-
		-	-	-	192	0.1	1920	29	0.1	290	9	0.1	90	-	-	-	-	-	-	-	-	-
		-	-	-	152	0.1	1520	39	0.1	390	7	0.1	70	-	-	-	-	-	-	-	-	-

Table IV (15): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during October 2012 (Month 8)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	-	-	-	104	25	4.16	40	50	0.8	3	50	0.06	-	-	-
		-	-	-	-	-	-	-	-	-	68	25	2.72	16	50	0.32	4	50	0.08	-	-	-
		-	-	-	-	-	-	-	-	-	72	25	2.88	20	50	0.4	0	50	0	-	-	-
	EC	-	-	-	-	-	-	-	-	-	24	25	0.96	12	50	0.24	1	50	0.02	-	-	-
		-	-	-	-	-	-	-	-	-	36	25	1.44	8	50	0.16	3	50	0.06	-	-	-
		-	-	-	-	-	-	-	-	-	5	25	0.2	8	50	0.16	0	50	0	-	-	-
	FC	-	-	-	-	-	-	96	25	3.84	44	25	1.76	4	50	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	108	25	4.32	36	25	1.44	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	124	25	4.96	36	25	1.44	0	50	0	-	-	-	-	-	-
	FS	-	-	-	-	-	-	48	25	1.92	7	25	0.28	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	52	25	2.08	7	25	0.28	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	56	25	2.24	8	25	0.32	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	32	25	1.28	2	25	0.08	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	36	25	1.44	0	25	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	24	25	0.96	0	25	0	0	50	0	-	-	-	-	-	-
	HPC	800	0.1	8000	-	-	-	-	-	-	36	0.1	360	1	0.1	10	1	0.1	10	-	-	-
		912	0.1	9120	-	-	-	-	-	-	5	0.1	50	1	0.1	10	1	0.1	10	-	-	-
		640	0.1	6400	-	-	-	-	-	-	7	0.1	70	0	0.1	0	0	0.1	0	-	-	-
DISCHARGE POINT	**TC**	-	-	-	-	-	-	416	25	16.64	25	25	1	10	25	0.4	-	-	-	-	-	-
		-	-	-	-	-	-	352	25	14.08	32	25	1.28	8	25	0.32	-	-	-	-	-	-
		-	-	-	-	-	-	384	25	15.36	40	25	1.6	10	25	0.4	-	-	-	-	-	-
	EC	-	-	-	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-
	FC	-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	-	-	-	2	25	0.08	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	25	0.04	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	1088	0.1	10880	-	-	-	72	0.1	720	16	0.1	160	-	-	-	-	-	-	-	-	-
		1072	0.1	10720	-	-	-	112	0.1	1120	12	0.1	120	-	-	-	-	-	-	-	-	-
		992	0.1	9920	-	-	-	96	0.1	960	40	0.1	400	-	-	-	-	-	-	-	-	-

Table IV (16): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during October 2012 (Month 8)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	544	25	21.76	160	25	6.4	24	25	0.96	-	-	-	-	-	-	-	-	-
		-	-	-	432	25	17.28	168	25	6.72	28	25	1.12	-	-	-	-	-	-	-	-	-
		-	-	-	512	25	20.48	256	25	10.24	32	25	1.28	-	-	-	-	-	-	-	-	-
	EC	-	-	-	24	25	0.96	8	25	0.32	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	20	25	0.8	8	25	0.32	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	28	25	1.12	8	25	0.32	0	25	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	16	25	0.64	1	25	0.04	3	25	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	20	25	0.8	4	25	0.16	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	40	25	1.6	3	25	0.12	0	25	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	8	25	0.32	1	25	0.04	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	8	25	0.32	1	25	0.04	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	2	25	0.08	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	1	25	0.04	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	25	0.04	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	2	25	0.08	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	HPC	312	0.1	3120	80	0.1	800	16	0.1	160	1	0.1	10	-	-	-	-	-	-	-	-	-
		336	0.1	3360	108	0.1	1080	12	0.1	120	2	0.1	20	-	-	-	-	-	-	-	-	-
		256	0.1	2560	104	0.1	1040	12	0.1	120	1	0.1	10	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	232	25	9.28	120	25	4.8	32	25	1.28	-	-	-	-	-	-	-	-	-
		-	-	-	224	25	8.96	168	25	6.72	20	25	0.8	-	-	-	-	-	-	-	-	-
		-	-	-	248	25	9.92	128	25	5.12	12	25	0.48	-	-	-	-	-	-	-	-	-
	EC	-	-	-	20	25	0.8	4	25	0.16	2	25	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	28	25	1.12	12	25	0.48	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	24	25	0.96	8	25	0.32	0	25	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	28	25	1.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	20	25	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	12	25	0.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	3	25	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	2	25	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	1	25	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	752	0.1	7520	1664	0.1	16640	32	0.1	320	1	0.1	10	-	-	-	-	-	-	-	-	-
		688	0.1	6880	1936	0.1	19360	512	0.1	5120	1	0.1	10	-	-	-	-	-	-	-	-	-
		672	0.1	6720	304	0.1	3040	584	0.1	5840	2	0.1	20	-	-	-	-	-	-	-	-	-

Table IV (17): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during November 2012 (Month 9)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	-	-	-	248	25	9.92	112	25	4.48	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	280	25	11.2	120	25	4.8	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	336	25	13.44	96	25	3.84	-	-	-	-	-	-
	EC	-	-	-	-	-	-	-	-	-	116	25	4.64	24	25	0.96	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	128	25	5.12	28	25	1.12	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	100	25	4	16	25	0.64	-	-	-	-	-	-
	FC	-	-	-	-	-	-	120	25	4.8	124	25	4.96	40	25	1.6	-	-	-	-	-	-
		-	-	-	-	-	-	280	25	11.2	108	25	4.32	32	25	1.28	-	-	-	-	-	-
		-	-	-	-	-	-	296	25	11.84	112	25	4.48	48	25	1.92	-	-	-	-	-	-
	FS	-	-	-	-	-	-	92	25	3.68	28	25	1.12	3	25	0.12	-	-	-	-	-	-
		-	-	-	-	-	-	120	25	4.8	20	25	0.8	3	25	0.12	-	-	-	-	-	-
		-	-	-	-	-	-	104	25	4.16	24	25	0.96	3	25	0.12	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	152	25	6.08	20	25	0.8	1	25	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	232	25	9.28	16	25	0.64	1	25	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	208	25	8.32	12	25	0.48	2	25	0.08	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	360	0.1	3600	136	0.1	1360	112	0.1	1120	-	-	-	-	-	-
		-	-	-	-	-	-	416	0.1	4160	140	0.1	1400	100	0.1	1000	-	-	-	-	-	-
		-	-	-	-	-	-	384	0.1	3840	148	0.1	1480	96	0.1	960	-	-	-	-	-	-
DISCHARGE POINT	TC	-	-	-	-	-	-	tntc	25	tntc	504	25	20.16	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	tntc	25	tntc	552	25	22.08	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	tntc	25	tntc	576	25	23.04	-	-	-	-	-	-	-	-	-
	EC	-	-	-	-	-	-	392	25	15.68	240	25	9.6	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	416	25	16.64	280	25	11.2	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	344	25	13.76	264	25	10.56	-	-	-	-	-	-	-	-	-
	FC	-	-	-	-	-	-	408	25	16.32	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	392	25	15.68	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	432	25	17.28	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	104	25	4.16	56	25	2.24	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	116	25	4.64	52	25	2.08	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	96	25	3.84	60	25	2.4	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	464	25	18.56	200	25	8	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	432	25	17.28	168	25	6.72	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	196	25	7.84	152	25	6.08	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	480	0.1	4800	196	0.1	1960	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	576	0.1	5760	200	0.1	2000	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	592	0.1	5920	192	0.1	1920	-	-	-	-	-	-	-	-	-

Table IV (18): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during November 2012 (Month 9)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml (x10^1)	COUNT	V	CFU/ml (x10^2)	COUNT	V	CFU/ml (x10^3)	COUNT	V	CFU/ml (x10^4)	COUNT	V	CFU/ml (x10^5)	COUNT	V	CFU/ml (x10^6)
UPSTREAM	**TC**	-	-	-	576	50	11.52	188	50	3.76	32	50	0.64	-	-	-	-	-	-	-	-	-
		-	-	-	552	50	11.04	168	50	3.36	40	50	0.8	-	-	-	-	-	-	-	-	-
		-	-	-	584	50	11.68	168	50	3.36	24	50	0.48	-	-	-	-	-	-	-	-	-
	EC	-	-	-	320	50	6.4	104	50	2.08	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	288	50	5.76	72	50	1.44	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	312	50	6.24	60	50	1.2	5	50	0.1	-	-	-	-	-	-	-	-	-
	FC	-	-	-	488	50	9.76	156	50	3.12	64	50	1.28	-	-	-	-	-	-	-	-	-
		-	-	-	456	50	9.12	128	50	2.56	80	50	1.6	-	-	-	-	-	-	-	-	-
		-	-	-	552	50	11.04	176	50	3.52	84	50	1.68	-	-	-	-	-	-	-	-	-
	FS	-	-	-	144	50	2.88	44	50	0.88	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	108	50	2.16	60	50	1.2	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	120	50	2.4	68	50	1.36	9	50	0.18	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	108	25	4.32	60	50	1.2	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	264	50	5.28	32	50	0.64	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	312	50	6.24	36	50	0.72	1	50	0.02	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	44	0.1	440	5	0.1	50	2	0.1	20	-	-	-	-	-	-
		-	-	-	-	-	-	56	0.1	560	4	0.1	40	2	0.1	20	-	-	-	-	-	-
		-	-	-	-	-	-	48	0.1	480	2	0.1	20	1	0.1	10	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	TNTC	25	TNTC	376	25	15.04	84	25	3.36	6	25	0.24	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	416	25	16.64	100	25	4	12	25	0.48	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	424	25	16.96	104	25	4.16	7	25	0.28	-	-	-	-	-	-
	EC	-	-	-	264	25	10.56	68	25	2.72	1	25	0.04	1	25	0.04	-	-	-	-	-	-
		-	-	-	280	25	11.2	64	25	2.56	6	25	0.24	1	25	0.04	-	-	-	-	-	-
		-	-	-	312	25	12.48	52	25	2.08	4	25	0.16	0	25	0	-	-	-	-	-	-
	FC	-	-	-	216	25	8.64	80	25	3.2	9	25	0.36	-	-	-	-	-	-	-	-	-
		-	-	-	192	25	7.68	60	25	2.4	14	25	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	232	25	9.28	88	25	3.52	15	25	0.6	-	-	-	-	-	-	-	-	-
	FS	-	-	-	36	25	1.44	3	25	0.12	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	28	25	1.12	4	25	0.16	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	44	25	1.76	2	25	0.08	0	25	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	28	25	1.12	3	25	0.12	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	24	25	0.96	3	25	0.12	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	28	25	1.12	55	25	2.2	0	25	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	20	0.1	200	5	0.1	50	2	0.1	20	-	-	-	-	-	-
		-	-	-	-	-	-	52	0.1	520	4	0.1	40	0	0.1	0	-	-	-	-	-	-
		-	-	-	-	-	-	40	0.1	400	3	0.1	30	0	0.1	0	-	-	-	-	-	-

Table IV (19): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during December 2012 (Month 10)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	528	50	10.56	108	50	2.16	24	50	0.48	-	-	-	-	-	-
		-	-	-	-	-	-	544	50	10.88	116	50	2.32	32	50	0.64	-	-	-	-	-	-
		-	-	-	-	-	-	592	50	11.84	124	50	2.48	48	50	0.96	-	-	-	-	-	-
	EC	-	-	-	232	50	4.64	80	50	1.6	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	272	50	5.44	52	50	1.04	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	256	50	5.12	60	50	1.2	0	50	0	0	50	0	-	-	-	-	-	-
	FC	-	-	-	-	-	-	64	50	1.28	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	72	50	1.44	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	108	50	2.16	20	50	0.4	-	-	-	-	-	-	-	-	-
	FS	-	-	-	44	50	0.88	2	25	0.08	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	72	50	1.44	3	25	0.12	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	100	50	2	2	25	0.08	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	60	50	1.2	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	64	50	1.28	16	50	0.32	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	76	50	1.52	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	184	0.1	1840	28	0.1	280	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	192	0.1	1920	24	0.1	240	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	176	0.1	1760	36	0.1	360	-	-	-	-	-	-
DISCHARGE POINT	**TC**	-	-	-	TNTC	25	TNTC	TNTC	25	TNTC	992	25	39.68	544	25	21.76	120	25	4.8	-	-	-
		-	-	-	TNTC	25	TNTC	TNTC	25	TNTC	1152	25	46.08	656	25	26.24	224	25	8.96	-	-	-
		-	-	-	TNTC	25	TNTC	TNTC	25	TNTC	1088	25	43.52	624	25	24.96	184	25	7.36	-	-	-
	EC	-	-	-	-	-	-	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	TNTC	25	TNTC	56	15	3.73	28	25	1.12	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	64	15	4.27	32	25	1.28	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	72	15	4.8	36	25	1.44	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	0	0.1	0	528	0.1	5280	0	0.1	0	0	0.1	0	-	-	-	-	-	-
		-	-	-	0	0.1	0	832	0.1	8320	0	0.1	0	0	0.1	0	-	-	-	-	-	-
		-	-	-	0	0.1	0	848	0.1	8480	0	0.1	0	0	0.1	0	-	-	-	-	-	-

Table IV (20): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during December 2012 (Month 10)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	-	-	-	208	50	4.16	88	50	1.76	52	50	1.04	-	-	-	-	-	-
		-	-	-	-	-	-	192	50	3.84	116	50	2.32	26	50	0.52	-	-	-	-	-	-
		-	-	-	-	-	-	176	50	3.52	128	50	2.56	40	50	0.8	-	-	-	-	-	-
	EC	-	-	-	-	-	-	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	-	-	-	60	50	1.2	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	56	50	1.12	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	8	50	0.16	-	-	-	-	-	-	-	-	-
	FS	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	2	50	0.04	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	5	50	0.1	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	6	50	0.12	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	5	50	0.1	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-		-	200	0.1	2000	12	0.1	120	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	264	0.1	2640	16	0.1	160	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	272	0.1	2720	20	0.1	200	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	-	-	-	144	50	2.88	32	25	1.28	12	50	0.24	-	-	-	-	-	-
		-	-	-	-	-	-	168	50	3.36	36	25	1.44	16	50	0.32	-	-	-	-	-	-
		-	-	-	-	-	-	192	50	3.84	28	25	1.12	12	50	0.24	-	-	-	-	-	-
	EC	-	-	-	-	-	-	8	50	0.16	0	25	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	8	50	0.16	0	25	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	8	50	0.16	0	25	0	0	50	0	-	-	-	-	-	-
	FC	-	-	-	-	-	-	36	50	0.72	12	25	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	32	50	0.64	8	25	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	32	50	0.64	8	25	0.32	-	-	-	-	-	-	-	-	-
	FS	-	-	-	12	50	0.24	0	50	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	12	50	0.24	0	50	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	16	50	0.32	0	50	0	0	25	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	20	50	0.4	0	50	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	16	50	0.32	0	50	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	24	50	0.48	0	50	0	0	25	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	184	0.1	1840	12	0.1	120	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	128	0.1	1280	8	0.1	80	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	144	0.1	1440	12	0.1	120	-	-	-	-	-	-	-	-	-

Table IV (21): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during January 2012 (Month 11)

		DILUTIONS																				
		1 X 10^{0}			1 X 10^{1}			1 X 10^{2}			1 X 10^{3}			1 X 10^{4}			1 X 10^{5}			1 X 10^{6}		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml (x10^{1})	COUNT	V	CFU/ml (x10^{2})	COUNT	V	CFU/ml (x10^{3})	COUNT	V	CFU/ml (x10^{4})	COUNT	V	CFU/ml (x10^{5})	COUNT	V	CFU/ml (x10^{6})
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	-	-	-	544	50	10.88	336	50	6.72	148	50	2.96	-	-	-
		-	-	-	-	-	-	-	-	-	512	50	10.24	248	50	4.96	168	50	3.36	-	-	-
		-	-	-	-	-	-	-	-	-	512	50	10.24	304	50	6.08	96	50	1.92	-	-	-
	EC	-	-	-	-	-	-	480	50	9.6	208	50	4.16	64	50	1.28	56	50	1.12	-	-	-
		-	-	-	-	-	-	496	50	9.92	272	50	5.44	96	50	1.92	24	50	0.48	-	-	-
		-	-	-	-	-	-	544	50	10.88	296	50	5.92	88	50	1.76	16	50	0.32	-	-	-
	FC	-	-	-	-	-	-	TNTC	50	TNTC	320	50	6.4	104	50	2.08	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	344	50	6.88	64	50	1.28	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	392	50	7.84	96	50	1.92	-	-	-	-	-	-
	FS	-	-	-	-	-	-	312	50	6.24	56	50	1.12	8	50	0.16	-	-	-	-	-	-
		-	-	-	-	-	-	336	50	6.72	88	50	1.76	6	50	0.12	-	-	-	-	-	-
		-	-	-	-	-	-	352	50	7.04	64	50	1.28	12	50	0.24	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	272	50	5.44	36	50	0.72	4	50	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	336	50	6.72	32	50	0.64	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	152	50	3.04	36	50	0.72	1	50	0.02	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	600	50	6000	160	50	1600	24	50	240	-	-	-	-	-	-
		-	-	-	-	-	-	664	50	6640	192	50	1920	40	50	400	-	-	-	-	-	-
		-	-	-	-	-	-	712	50	7120	256	50	2560	28	50	280	-	-	-	-	-	-
DISCHARGE POINT		-	-	-																		
	TC	-	-	-	TNTC	25	TNTC	1088	25	43.52	576	25	23.04	120	25	4.8	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	1264	25	50.56	464	25	18.56	224	25	8.96	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	1328	25	53.12	624	25	24.96	184	25	7.36	-	-	-	-	-	-
	EC	-	-	-	-	-	-	272	25	10.88	152	25	6.08	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	296	25	11.84	96	25	3.84	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	344	25	13.76	192	25	7.68	-	-	-	-	-	-	-	-	-
	FC	-	-	-	TNTC	25	TNTC	TNTC	25	TNTC	32	25	0.64	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	TNTC	25	TNTC	56	25	1.12	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	25	TNTC	TNTC	25	TNTC	48	25	0.96	-	-	-	-	-	-	-	-	-
	FS	-	-	-	464	25	18.56	72	25	2.88	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	512	25	20.48	56	25	2.24	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	528	25	21.12	64	25	2.56	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	256	25	10.24	14	25	0.56	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	224	25	8.96	13	25	0.52	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	168	25	6.72	12	25	0.48	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	1104	0.1	11040	360	0.1	3600	328	0.1	3280	-	-	-	-	-	-	-	-	-
		-	-	-	1152	0.1	11520	376	0.1	3760	224	0.1	2240	-	-	-	-	-	-	-	-	-
		-	-	-	1200	0.1	12000	392	0.1	3920	224	0.1	2240	-	-	-	-	-	-	-	-	-

Table IV (22): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during January 2012 (Month 11)

		DILUTIONS																				
		1×10^0			1×10^1			1×10^2			1×10^3			1×10^4			1×10^5			1×10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($\times 10^1$)	COUNT	V	CFU/ml ($\times 10^2$)	COUNT	V	CFU/ml ($\times 10^3$)	COUNT	V	CFU/ml ($\times 10^4$)	COUNT	V	CFU/ml ($\times 10^5$)	COUNT	V	CFU/ml ($\times 10^6$)
UPSTREAM	**TC**	-	-	-	132	50	2.64	20	50	0.4	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	128	50	2.56	40	50	0.8	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	112	50	2.24	36	50	0.72	12	50	0.24	-	-	-	-	-	-	-	-	-
	EC	-	-	-	48	50	0.96	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	56	50	1.12	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	48	50	0.96	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
	FC	TNTC	50	TNTC	TNTC	50	TNTC	14	50	0.28	5	50	0.1	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	13	50	0.26	6	50	0.12	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	12	50	0.24	8	50	0.16	-	-	-	-	-	-	-	-	-
	FS	12	50	0.24	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		16	50	0.32	2	50	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	10	50	0.2	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		20	50	0.4	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		16	50	0.32	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	84	0.1	840	16	0.1	160	5	0.1	50	-	-	-	-	-	-
		-	-	-	-	-	-	52	0.1	520	12	0.1	120	7	0.1	70	-	-	-	-	-	-
		-	-	-	-	-	-	68	0.1	680	16	0.1	160	6	0.1	60	-	-	-	-	-	-
DOWNSTREAM		-	-	-	-	-	-										-	-	-	-	-	-
	TC	-	-	-	-	-	-	88	50	1.76	28	50	0.56	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	86	50	1.72	36	50	0.72	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	128	50	2.56	40	50	0.8	4	50	0.08	-	-	-	-	-	-
	EC	-	-	-	-	-	-	16	50	0.32	12	50	0.24	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	20	50	0.4	12	50	0.24	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	16	50	0.32	8	50	0.16	0	50	0	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	20	50	0.4	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	24	50	0.48	4	50	0.08	-	-	-	-	-	-	-	-	-
	FS	-	-	-	36	50	0.72	4	50	0.08	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	4	50	0.08	1	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	40	50	0.8	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	4	50	0.08	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	4	50	0.08	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	5	50	0.1	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	80	0.1	800	-	-	-	8	0.1	80	6	0.1	60	-	-	-	-	-	-
		-	-	-	576	0.1	5760	-	-	-	20	0.1	200	2	0.1	20	-	-	-	-	-	-
		-	-	-	522	0.1	5220	-	-	-	16	0.1	160	1	0.1	10	-	-	-	-	-	-

Table IV (23): Microbial indicators enumerated before chlorination and at the discharge point for the Northern WWTP during February 2012 (Month 13)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	-	-	-	488	50	9.76	160	50	3.2	40	50	0.8	-	-	-
		-	-	-	-	-	-	-	-	-	528	50	10.56	144	50	2.88	36	50	0.72	-	-	-
		-	-	-	-	-	-	-	-	-	496	50	9.92	152	50	3.04	32	50	0.64	-	-	-
	EC	-	-	-	-	-	-	-	-	-	208	50	4.16	40	50	0.8	3	50	0.06	-	-	-
		-	-	-	-	-	-	-	-	-	216	50	4.32	48	50	0.96	5	50	0.1	-	-	-
		-	-	-	-	-	-	-	-	-	152	50	3.04	40	50	0.8	4	50	0.08	-	-	-
	FC	-	-	-	-	-	-	-	-	-	128	50	2.56	32	50	0.64	4	50	0.08	-	-	-
		-	-	-	-	-	-	-	-	-	136	50	2.72	36	50	0.72	7	50	0.14	-	-	-
		-	-	-	-	-	-	-	-	-	160	50	3.2	24	50	0.48	5	50	0.1	-	-	-
	FS	-	-	-	-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	288	50	5.76	28	50	0.56	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	224	50	4.48	20	50	0.4	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	208	50	4.16	36	50	0.72	3	50	0.06	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	496	0.1	4960	128	0.1	1280	4	0.1	40	-	-	-	-	-	-
		-	-	-	-	-	-	528	0.1	5280	136	0.1	1360	3	0.1	30	-	-	-	-	-	-
		-	-					624	0.1	6240	120	0.1	1200	2	0.1	20	-	-	-	-	-	-
DISCHARGE POINT		-	-	-	-	-	-										-	-	-	-	-	-
	TC	-	-	-	-	-	-	TNTC	25	TNTC	272	25	10.88	152	25	6.08	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	25	TNTC	312	25	12.48	88	25	3.52	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	25	TNTC	336	25	13.44	120	25	4.8	-	-	-	-	-	-
	EC	-	-	-	-	-	-	232	25	9.28	144	25	5.76	40	25	1.6	-	-	-	-	-	-
		-	-	-	-	-	-	256	25	10.24	152	25	6.08	28	25	1.12	-	-	-	-	-	-
		-	-	-	-	-	-	288	25	11.52	200	25	8	44	25	1.76	-	-	-	-	-	-
	FC	-	-	-	-	-	-	-	-	-	120	25	2.4	60	25	2.4	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	176	25	3.52	32	25	1.28	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	152	25	3.04	40	25	1.6	-	-	-	-	-	-
	FS	-	-	-	-	-	-	152	25	6.08	44	25	1.76	7	25	0.28	-	-	-	-	-	-
		-	-	-	-	-	-	168	25	6.72	36	25	1.44	10	25	0.4	-	-	-	-	-	-
		-	-	-	-	-	-	176	25	7.04	40	25	1.6	8	25	0.32	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	88	25	3.52	28	25	1.12	2	25	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	96	25	3.84	32	25	1.28	5	25	0.2	-	-	-	-	-	-
		-	-	-	-	-	-	120	25	4.8	28	25	1.12	1	25	0.04	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	688	0.1	6880	128	0.1	1280	5	0.1	50	-	-	-	-	-	-
		-	-	-	-	-	-	752	0.1	7520	48	0.1	480	3	0.1	30	-	-	-	-	-	-
		-	-	-	-	-	-	624	0.1	6240	112	0.1	1120	11	0.1	110	-	-	-	-	-	-

Table IV (24): Microbial indicators enumerated upstream and downstream of the Umgeni River for the Northern WWTP during February2013 (Month 12)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	**TC**	-	-	-	-	-	-	TNTC	50	TNTC	608	50	12.16	224	50	4.48	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	528	50	10.56	304	50	6.08	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	560	50	11.2	208	50	4.16	-	-	-	-	-	-
	EC	-	-	-	-	-	-	64	50	1.28	20	50	0.4	4	50	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	28	50	0.56	32	50	0.64	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	44	50	0.88	36	50	0.72	2	50	0.04	-	-	-	-	-	-
	FC	-	-	-	-	-	-	-	-	-	72	50	1.44	16	50	0.32	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	56	50	1.12	12	50	0.24	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	64	50	1.28	16	50	0.32	-	-	-	-	-	-
	FS	-	-	-	-	-	-	24	50	0.48	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	32	50	0.64	5	50	0.1	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	28	50	0.56	4	50	0.08	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	28	50	0.56	3	50	0.06	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	20	50	0.4	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	24	50	0.48	1	50	0.02	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	1024	0.1	10240	424	0.1	4240	248	0.1	2480	-	-	-	-	-	-	-	-	-
		-	-	-	1008	0.1	10080	472	0.1	4720	272	0.1	2720	-	-	-	-	-	-	-	-	-
		-	-	-	1072	0.1	10720	436	0.1	4360	296	0.1	2960	-	-	-	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	-	-	-	280	50	5.6	104	50	2.08	20	50	0.4	-	-	-	-	-	-
		-	-	-	-	-	-	224	50	4.48	108	50	2.16	24	50	0.48	-	-	-	-	-	-
		-	-	-	-	-	-	264	50	5.28	52	50	1.04	24	50	0.48	-	-	-	-	-	-
	EC	-	-	-	-	-	-	88	50	1.76	12	50	0.24	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	120	50	2.4	16	50	0.32	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	144	50	2.88	12	50	0.24	0	50	0	-	-	-	-	-	-
	FC	-	-	-	-	-	-	40	50	0.8	32	50	0.64	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	44	50	0.88	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	20	50	0.4	-	-	-	-	-	-	-	-	-
	FS	-	-	-	-	-	-	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	5	50	0.1	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	3	50	0.06	1	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	5	50	0.1	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	480	0.1	4800	120	0.1	1200	1	0.1	10	-	-	-	-	-	-	-	-	-
		-	-	-	528	0.1	5280	264	0.1	2640	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	672	0.1	6720	128	0.1	1280	0	0.1	0	-	-	-	-	-	-	-	-	-

Table

IV (25): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during March 2012 (Month 1)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	968	50	19.36	336	50	6.72	48	50	0.96	100	50	2	60	50	1.2	-	-	-
		-	-	-	1136	50	22.72	408	50	8.16	72	50	1.44	144	50	2.88	48	50	0.96	-	-	-
		-	-	-	840	50	16.8	440	50	8.8	84	50	1.68	48	50	0.96	40	50	0.8	-	-	-
	EC	-	-	-	552	50	11.04	136	50	2.72	24	50	0.48	12	50	0.24	4	50	0.08	-	-	-
		-	-	-	568	50	11.36	152	50	3.04	28	50	0.56	12	50	0.24	3	50	0.06	-	-	-
		-	-	-	672	50	13.44	368	50	7.36	40	50	0.8	8	50	0.16	0	50	0	-	-	-
	FC	-	-	-	336	50	6.72	88	50	1.76	20	50	0.4	1	50	0.02	-	-	-	-	-	-
		-	-	-	384	50	7.68	128	50	2.56	28	50	0.56	3	50	0.06	-	-	-	-	-	-
		-	-	-	292	50	5.84	112	50	2.24	16	50	0.32	4	50	0.08	-	-	-	-	-	-
	FS	-	-	-	100	50	2	36	50	0.72	5	50	0.1	1	50	0.02	-	-	-	-	-	-
		-	-	-	96	50	1.92	40	50	0.8	4	50	0.08	0	50	0	-	-	-	-	-	-
		-	-	-	108	50	2.16	32	50	0.64	2	50	0.04	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	128	50	2.56	28	50	0.56	4	50	0.08	2	50	0.04	-	-	-	-	-	-
		-	-	-	96	50	1.92	40	50	0.8	5	50	0.1	3	50	0.06	-	-	-	-	-	-
		-	-	-	112	50	2.24	48	50	0.96	6	50	0.12	2	50	0.04	-	-	-	-	-	-
	HPC	-	-	-	232	0.1	2320	72	0.1	720	5	0.1	50	-	-	-	-	-	-	-	-	-
		-	-	-	272	0.1	2720	48	0.1	480	6	0.1	60	-	-	-	-	-	-	-	-	-
		-	-	-	248	0.1	2480	64	0.1	640	6	0.1	60	-	-	-	-	-	-	-	-	-
DISCHARGE POINT	TC	88	50	1.76	44	50	0.88	52	50	1.04	-	-	-	-	-	-	-	-	-	-	-	-
		112	50	2.24	48	50	0.96	104	50	2.08	-	-	-	-	-	-	-	-	-	-	-	-
		128	50	2.56	52	50	1.04	48	50	0.96	-	-	-	-	-	-	-	-	-	-	-	-
	EC	36	50	0.72	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		40	50	0.8	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		32	50	0.64	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FC	12	50	0.24	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5	50	0.1	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FS	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	2	0.1	20	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	0.1	10	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	0.1	10	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-

Table IV (26): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during March 2012 (Month 1)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	**TC**	-	-	-	-	-	-	304	50	6.08	72	50	1.44	24	50	0.48	3	50	0.06	-	-	-
		-	-	-	-	-	-	512	50	10.24	56	50	1.12	28	50	0.56	2	50	0.04	-	-	-
		-	-	-	-	-	-	224	50	4.48	108	50	2.16	28	50	0.56	6	50	0.12	-	-	-
	EC	-	-	-	-	-	-	144	50	2.88	20	50	0.4	4	50	0.08	0	50	0	-	-	-
		-	-	-	-	-	-	152	50	3.04	24	50	0.48	1	50	0.02	0	50	0	-	-	-
		-	-	-	-	-	-	112	50	2.24	44	50	0.88	1	50	0.02	0	50	0	-	-	-
	FC	-	-	-	224	50	4.48	152	50	3.04	32	50	0.64	-	-	-	-	-	-	-	-	-
		-	-	-	304	50	6.08	168	50	3.36	48	50	0.96	-	-	-	-	-	-	-	-	-
		-	-	-	264	50	5.28	192	50	3.84	24	50	0.48	-	-	-	-	-	-	-	-	-
	FS	108	50	2.16	16	50	0.32	3	50	0.06	-	-	-	-	-	-	-	-	-	-	-	-
		92	50	1.84	20	50	0.4	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		56	50	1.12	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	152	50	3.04	32	50	0.64	7	50	0.14	-	-	-	-	-	-	-	-	-
		-	-	-	176	50	3.52	24	50	0.48	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	176	50	3.52	28	50	0.56	3	50	0.06	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	84	0.1	840	36	0.1	360	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	96	0.1	960	28	0.1	280	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	88	0.1	880	32	0.1	320	0	0.1	0	-	-	-	-	-	-	-	-	-
DOWNSTREAM																				-	-	-
	TC	96	50	1.92	-	-	-	6	50	0.12	1	50	0.02	0	50	0	0	50	0	-	-	-
		92	50	1.84	-	-	-	5	50	0.1	1	50	0.02	0	50	0	0	50	0	-	-	-
		96	50	1.92	-	-	-	9	50	0.18	0	50	0	0	50	0	0	50	0	-	-	-
	EC	0	50	0	-	-	-	0	50	0	0	50	0	0	50	0	0	50	0	-	-	-
		0	50	0	-	-	-	0	50	0	0	50	0	0	50	0	0	50	0	-	-	-
		0	50	0	-	-	-	0	50	0	0	50	0	0	50	0	0	50	0	-	-	-
	FC	40	50	0.8	2	50	0.04	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		32	50	0.64	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		28	50	0.56	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FS	0	50	0	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	0	50	0	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	32	0.1	320	1	0.1	10	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-
		48	0.1	480	1	0.1	10	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-
		44	0.1	440	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (27): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during April 2012 (Month 2)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	124	50	2.48	44	50	0.88	13	50	0.26	1	50	0.02	-	-	-
		-	-	-	-	-	-	108	50	2.16	32	50	0.64	16	50	0.32	1	50	0.02	-	-	-
		-	-	-	-	-	-	116	50	2.32	36	50	0.72	20	50	0.4	1	50	0.02	-	-	-
	EC	-	-	-	-	-	-	16	50	0.32	8	50	0.16	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	32	50	0.64	8	50	0.16	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	24	50	0.48	6	50	0.12	0	50	0	0	50	0	-	-	-
	FC	-	-	-	92	50	1.84	48	50	0.96	6	50	0.12	1	50	0.02	-	-	-	-	-	-
		-	-	-	94	50	1.88	48	50	0.96	4	50	0.08	0	50	0	-	-	-	-	-	-
		-	-	-	98	50	1.96	56	50	1.12	5	50	0.1	0	50	0	-	-	-	-	-	-
	FS	-	-	-	20	50	0.4	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	16	50	0.32	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	20	50	0.4	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	7	50	0.14	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	12	50	0.24	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	8	50	0.16	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	140	0.1	1400	32	0.1	320	1	0.1	10	-	-	-	-	-	-	-	-	-
		-	-	-	100	0.1	1000	36	0.1	360	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	120	0.1	1200	44	0.1	440	0	0.1	0	-	-	-	-	-	-	-	-	-
DISCHARGE POINT	**TC**	44	50	0.88	28	50	0.56	10	50	0.2	-	-	-	-	-	-	-	-	-	-	-	-
		48	50	0.96	16	50	0.32	8	50	0.16	-	-	-	-	-	-	-	-	-	-	-	-
		36	50	0.72	20	50	0.4	6	50	0.12	-	-	-	-	-	-	-	-	-	-	-	-
	EC	5	50	0.1	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		2	50	0.04	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FC	20	50	0.4	3	50	0.06	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		16	50	0.32	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		24	50	0.48	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FS	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	16	0.1	160	4	0.1	40	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-
		15	0.1	150	1	0.1	10	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-
		19	0.1	190	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (28): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during April 2012 (Month 2)

		DILUTIONS																				
		1×10^0			1×10^1			1×10^2			1×10^3			1×10^4			1×10^5			1×10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	-	-	-	392	50	7.84	100	50	2	24	50	0.48	3	50	0.06	-	-	-
		-	-	-	-	-	-	408	50	8.16	88	50	1.76	28	50	0.56	3	50	0.06	-	-	-
		-	-	-	-	-	-	360	50	7.2	92	50	1.84	36	50	0.72	1	50	0.02	-	-	-
	EC	-	-	-	-	-	-	224	50	4.48	48	50	0.96	6	50	0.12	0	50	0	-	-	-
		-	-	-	-	-	-	264	50	5.28	28	50	0.56	2	50	0.04	0	50	0	-	-	-
		-	-	-	-	-	-	248	50	4.96	36	50	0.72	4	50	0.08	0	50	0	-	-	-
	FC	-	-	-	TNTC	50	TNTC	148	50	2.96	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	132	50	2.64	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	168	50	3.36	28	50	0.56	-	-	-	-	-	-	-	-	-
	FS	-	-	-	48	50	0.96	16	50	0.32	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	20	50	0.4	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	48	50	0.96	20	50	0.4	1	50	0.02	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	144	50	2.88	36	50	0.72	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	136	50	2.72	28	50	0.56	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	160	50	3.2	32	50	0.64	3	50	0.06	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	152	0.1	1520	7	0.1	70	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	136	0.1	1360	8	0.1	80	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	192	0.1	1920	8	0.1	80	0	0.1	0	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	28	50	0.56	12	50	0.24	16	50	0.32	0	50	0	0	50	0	-	-	-	-	-	-
		32	50	0.64	11	50	0.22	12	50	0.24	0	50	0	0	50	0	-	-	-	-	-	-
		48	50	0.96	15	50	0.3	20	50	0.4	0	50	0	0	50	0	-	-	-	-	-	-
	EC	5	50	0.1	2	50	0.04	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-
		3	50	0.06	1	50	0.02	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
		2	50	0.04	1	50	0.02	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
	FC	-	-	-	9	50	0.18	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	11	50	0.22	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	12	50	0.24	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	3	0.1	30	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	0.1	10	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	0.1	10	0	0.1	0	0	0.1	0	-	-	-	-	-	-	-	-	-

Table IV (29): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during May 2012 (Month 3)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	TNTC	50	TNTC	504	50	10.08	136	50	2.72	48	50	0.96	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	624	50	12.48	120	50	2.4	40	50	0.8	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	520	50	10.4	128	50	2.56	52	50	1.04	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	440	50	8.8	80	50	1.6	32	50	0.64	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	400	50	8	64	50	1.28	24	50	0.48	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	392	50	7.84	80	50	1.6	28	50	0.56	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	216	50	4.32	80	50	1.6	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	248	50	4.96	88	50	1.76	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	280	50	5.6	96	50	1.92	-	-	-	-	-	-	-	-	-
	FS	-	-	-	232	50	4.64	88	50	1.76	48	50	0.96	-	-	-	-	-	-	-	-	-
		-	-	-	256	50	5.12	96	50	1.92	48	50	0.96	-	-	-	-	-	-	-	-	-
		-	-	-	272	50	5.44	96	50	1.92	40	50	0.8	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	TNTC	50	TNTC	288	50	5.76	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	256	50	5.12	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	264	50	5.28	32	50	0.64	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	1056	0.1	10560	336	0.1	3360	264	0.1	2640	-	-	-	-	-	-	-	-	-
		-	-	-	928	0.1	9280	352	0.1	3520	248	0.1	2480	-	-	-	-	-	-	-	-	-
		-	-	-	1024	0.1	10240	304	0.1	3040	280	0.1	2800	-	-	-	-	-	-	-	-	-
DISCHARGE POINT	TC	TNTC	50	TNTC	TNTC	50	TNTC	848	50	16.96	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	896	50	17.92	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	960	50	19.2	-	-	-	-	-	-	-	-	-	-	-	-
	EC	TNTC	50	TNTC	TNTC	50	TNTC	656	50	13.12	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	736	50	14.72	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	696	50	13.92	-	-	-	-	-	-	-	-	-	-	-	-
	FC	TNTC	50	TNTC	768	50	15.36	624	50	12.48	208	50	4.16	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	704	50	14.08	560	50	11.2	236	50	4.72	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	736	50	14.72	600	50	12	248	50	4.96	-	-	-	-	-	-	-	-	-
	FS	-	-	-	TNTC	50	TNTC	336	50	6.72	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	288	50	5.76	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	312	50	6.24	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	TNTC	50	TNTC	608	50	12.16	432	50	8.64	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	544	50	10.88	344	50	6.88	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	616	50	12.32	352	50	7.04	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	TNTC	0.1	TNTC	1296	0.1	12960	320	0.1	3200	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	0.1	TNTC	1056	0.1	10560	336	0.1	3360	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	0.1	TNTC	1232	0.1	12320	332	0.1	3320	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (30): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during May 2012 (Month 3)

		DILUTIONS																				
		1 X 10^{0}			1 X 10^{1}			1 X 10^{2}			1 X 10^{3}			1 X 10^{4}			1 X 10^{5}			1 X 10^{6}		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^{1}$)**	**COUNT**	**V**	**CFU/ml ($x10^{2}$)**	**COUNT**	**V**	**CFU/ml ($x10^{3}$)**	**COUNT**	**V**	**CFU/ml ($x10^{4}$)**	**COUNT**	**V**	**CFU/ml ($x10^{5}$)**	**COUNT**	**V**	**CFU/ml ($x10^{6}$)**
UPSTREAM	**TC**	-	-	-	-	-	-	136	50	2.72	5	50	0.1	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	144	50	2.88	7	50	0.14	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	152	50	3.04	6	50	0.12	4	50	0.08	-	-	-	-	-	-
	EC	-	-	-	-	-	-	40	50	0.8	3	50	0.06	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	32	50	0.64	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	64	50	1.28	1	50	0.02	0	50	0	-	-	-	-	-	-
	FC	-	-	-	44	50	0.88	16	50	0.32	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	8	50	0.16	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	36	50	0.72	2	50	0.04	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	44	50	0.88	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	28	50	0.56	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	80	50	1.6	16	50	0.32	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	96	50	1.92	24	50	0.48	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	104	50	2.08	24	50	0.48	5	50	0.1	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	128	0.1	1280	64	0.1	640	16	0.1	160	12	0.1	120	-	-	-	-	-	-
		-	-	-	144	0.1	1440	56	0.1	560	28	0.1	280	8	0.1	80	-	-	-	-	-	-
		-	-	-	136	0.1	1360	48	0.1	480	20	0.1	200	12	0.1	120	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	TNTC	50	TNTC	504	50	10.08	100	50	2	56	50	1.12	8	50	0.16	-	-	-
		-	-	-	TNTC	50	TNTC	536	50	10.72	116	50	2.32	128	50	2.56	6	50	0.12	-	-	-
		-	-	-	TNTC	50	TNTC	544	50	10.88	128	50	2.56	6	50	0.4	7	50	0.14	-	-	-
	EC	-	-	-	TNTC	50	TNTC	352	50	7.04	76	50	1.52	64	50	1.28	4	50	0.08	-	-	-
		-	-	-	TNTC	50	TNTC	384	50	7.68	84	50	1.68	88	50	1.76	4	50	0.08	-	-	-
		-	-	-	TNTC	50	TNTC	416	50	8.32	104	50	2.08	13	50	0.87	4	50	0.08	-	-	-
	FC	-	-	-	TNTC	50	TNTC	224	50	4.48	152	50	3.04	16	50	1.07	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	256	50	5.12	120	50	2.4	24	50	1.60	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	272	50	5.44	128	50	2.56	20	50	1.33	-	-	-	-	-	-
	FS	-	-	-	256	50	5.12	128	50	2.56	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	288	50	5.76	112	50	2.24	36	50	0.72	-	-	-	-	-	-	-	-	-
		-	-	-	360	50	7.2	144	50	2.88	48	50	0.96	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	TNTC	50	TNTC	208	50	4.16	52	50	1.04	2	50	0.13	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	256	50	5.12	68	50	1.36	2	50	0.13	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	232	50	4.64	24	50	0.48	1	50	0.07	-	-	-	-	-	-
	HPC	-	-	-	376	0.1	3760	128	0.1	1280	52	0.1	520	-	-	-	-	-	-	-	-	-
		-	-	-	472	0.1	4720	140	0.1	1400	92	0.1	920	-	-	-	-	-	-	-	-	-
		-	-	-	416	0.1	4160	136	0.1	1360	104	0.1	1040	-	-	-	-	-	-	-	-	-

Table IV (31): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during June 2012 (Month 4)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	256	50	5.12	152	50	3.04	40	50	0.8	10	50	0.2	-	-	-
		-	-	-	-	-	-	208	50	4.16	136	50	2.72	44	50	0.88	15	50	0.3	-	-	-
		-	-	-	-	-	-	232	50	4.64	152	50	3.04	36	50	0.72	6	50	0.12	-	-	-
	EC	-	-	-	-	-	-	24	50	0.48	8	50	0.16	1	50	0.02	0	50	0	-	-	-
		-	-	-	-	-	-	28	50	0.56	5	50	0.1	1	50	0.02	0	50	0	-	-	-
		-	-	-	-	-	-	36	50	0.72	3	50	0.06	0	50	0	0	50	0	-	-	-
	FC	-	-	-	-	-	-	36	50	0.72	4	50	0.08	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	32	50	0.64	6	50	0.12	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	24	50	0.48	7	50	0.14	0	50	0	-	-	-	-	-	-
	FS	-	-	-	-	-	-	9	50	0.18	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	12	50	0.24	1	50	0.02	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	11	50	0.22	0	50	0	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	16	50	0.32	1	50	0.02	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	20	50	0.4	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	12	50	0.24	0	50	0	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	52	0.1	520	40	0.1	400	20	0.1	200	-	-	-	-	-	-
		-	-	-	-	-	-	64	0.1	640	48	0.1	480	32	0.1	320	-	-	-	-	-	-
		-	-	-	-	-	-	72	0.1	720	52	0.1	520	48	0.1	480	-	-	-	-	-	-
DISCHARGE POINT	**TC**	58	50	1.16	44	50	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		76	50	1.52	32	50	0.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		72	50	1.44	64	50	1.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	EC	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FC	48	50	0.96	3	50	0.06	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		44	50	0.88	3	50	0.06	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		32	50	0.64	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FS	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	9	50	0.18	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6	50	0.12	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7	50	0.14	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	40	0.1	400	28	0.1	280	7	0.1	70	-	-	-	-	-	-	-	-	-	-	-	-
		44	0.1	440	24	0.1	240	6	0.1	60	-	-	-	-	-	-	-	-	-	-	-	-
		32	0.1	320	20	0.1	200	4	0.1	40	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (32): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during June 2012 (Month 4)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml (x10^1)	COUNT	V	CFU/ml (x10^2)	COUNT	V	CFU/ml (x10^3)	COUNT	V	CFU/ml (x10^4)	COUNT	V	CFU/ml (x10^5)	COUNT	V	CFU/ml (x10^6)
UPSTREAM	TC	-	-	-	320	50	6.4	56	50	1.12	36	50	0.72	4	50	0.08	-	-	-	-	-	-
		-	-	-	448	50	8.96	56	50	1.12	28	50	0.56	4	50	0.08	-	-	-	-	-	-
		-	-	-	360	50	7.2	64	50	1.28	20	50	0.4	1	50	0.02	-	-	-	-	-	-
	EC	-	-	-	24	50	0.48	6	50	0.12	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	36	50	0.72	3	50	0.06	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	160	50	3.2	11	50	0.22	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	176	50	3.52	12	50	0.24	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	152	50	3.04	10	50	0.2	7	50	0.14	-	-	-	-	-	-	-	-	-
	FS	-	-	-	24	50	0.48	10	50	0.2	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	15	50	0.3	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	16	50	0.32	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	56	50	1.12	6	50	0.12	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	60	50	1.2	8	50	0.16	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	80	50	1.6	10	50	0.2	2	50	0.04	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	336	0.1	3360	52	0.1	520	28	0.1	280	-	-	-	-	-	-	-	-	-
		-	-	-	384	0.1	3840	64	0.1	640	16	0.1	160	-	-	-	-	-	-	-	-	-
		-	-	-	416	0.1	4160	60	0.1	600	32	0.1	320	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	-	-	-	44	50	0.88	28	50	0.56	2	50	0.04	16	50	0.32	-	-	-
		-	-	-	-	-	-	40	50	0.8	24	50	0.48	1	50	0.02	16	50	0.32	-	-	-
		-	-	-	-	-	-	28	50	0.56	40	50	0.8	0	50	0	8	50	0.53	-	-	-
	EC	-	-	-	-	-	-	8	50	0.16	1	50	0.02	0	50	0	2	50	0.04	-	-	-
		-	-	-	-	-	-	8	50	0.16	1	50	0.02	0	50	0	1	50	0.02	-	-	-
		-	-	-	-	-	-	8	50	0.16	0	50	0	0	50	0	0	50	0	-	-	-
	FC	-	-	-	20	50	0.4	2	50	0.04	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	24	50	0.48	5	50	0.1	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	28	50	0.56	3	50	0.06	1	50	0.02	-	-	-	-	-	-	-	-	-
	FS	-	-	-	10	50	0.2	2	50	0.04	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	13	50	0.26	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	24	50	0.48	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	28	50	0.56	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	24	50	0.48	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	84	0.1	840	60	0.1	600	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	82	0.1	820	48	0.1	480	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	78	0.1	780	40	0.1	400	0	0.1	0	-	-	-	-	-	-	-	-	-

Table IV (33): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during July 2012 (Month 5)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	TNTC	50	TNTC	880	50	17.6	160	50	3.2	44	50	0.88	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	928	50	18.56	192	50	3.84	56	50	1.12	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	784	50	15.68	296	50	5.92	52	50	1.04	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	-	-	-	32	50	0.64	12	50	0.24	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	-	-	-	40	50	0.8	12	50	0.24	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	-	-	-	48	50	0.96	8	50	0.16	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	232	50	4.64	56	50	1.12	5	50	0.1	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	280	50	5.6	32	50	0.64	4	50	0.08	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	240	50	4.8	20	50	0.4	4	50	0.08	-	-	-	-	-	-
	FS	-	-	-	72	50	1.44	40	50	0.8	20	50	0.4	-	-	-	-	-	-	-	-	-
		-	-	-	88	50	1.76	48	50	0.96	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	64	50	1.28	56	50	1.12	16	50	0.32	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	544	50	10.88	192	50	3.84	32	50	0.64	2	50	0.04	-	-	-	-	-	-
		-	-	-	576	50	11.52	232	50	4.64	36	50	0.72	2	50	0.04	-	-	-	-	-	-
		-	-	-	672	50	13.44	224	50	4.48	28	50	0.56	1	50	0.02	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	400	0.1	4000	84	0.1	840	32	0.1	320	-	-	-	-	-	-
		-	-	-	-	-	-	456	0.1	4560	116	0.1	1160	44	0.1	440	-	-	-	-	-	-
		-	-	-	-	-	-	392	0.1	3920	120	0.1	1200	60	0.1	600	-	-	-	-	-	-
DISCHARGE POINT	TC	52	50	1.04	28	50	0.56	36	50	0.72	-	-	-	-	-	-	-	-	-	-	-	-
		48	50	0.96	32	50	0.64	32	50	0.64	-	-	-	-	-	-	-	-	-	-	-	-
		40	50	0.8	36	50	0.72	28	50	0.56	-	-	-	-	-	-	-	-	-	-	-	-
	EC	24	50	0.48	12	50	0.24	4	50	0.08	-	-	-	-	-	-	-	-	-	-	-	-
		16	50	0.32	32	50	0.64	8	50	0.16	-	-	-	-	-	-	-	-	-	-	-	-
		16	50	0.32	36	50	0.72	4	50	0.08	-	-	-	-	-	-	-	-	-	-	-	-
	FC	12	50	0.24	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7	50	0.14	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		8	50	0.16	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FS	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	128	0.1	1280	32	0.1	320	7	0.1	70	-	-	-	-	-	-	-	-	-	-	-	-
		144	0.1	1440	44	0.1	440	10	0.1	100	-	-	-	-	-	-	-	-	-	-	-	-
		168	0.1	1680	36	0.1	360	12	0.1	120	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (34): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during July 2012 (Month 5)

		DILUTIONS																				
		1 X 10⁰			1 X 10¹			1 X 10²			1 X 10³			1 X 10⁴			1 X 10⁵			1 X 10⁶		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	0	50	0	256	50	5.12	48	50	0.96	28	50	0.56	-	-	-	-	-	-
		-	-	-	0	50	0	216	50	4.32	68	50	1.36	16	50	0.32	-	-	-	-	-	-
		-	-	-	0	50	0	224	50	4.48	60	50	1.2	16	50	0.32	-	-	-	-	-	-
	EC	-	-	-	0	50	0	36	50	0.72	8	50	0.16	0	50	0	-	-	-	-	-	-
		-	-	-	0	50	0	32	50	0.64	16	50	0.32	0	50	0	-	-	-	-	-	-
		-	-	-	0	50	0	28	50	0.56	12	50	0.24	0	50	0	-	-	-	-	-	-
	FC	-	-	-	168	50	3.36	36	50	0.72	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	192	50	3.84	32	50	0.64	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	176	50	3.52	40	50	0.8	1	50	0.02	-	-	-	-	-	-	-	-	-
	FS	-	-	-	28	50	0.56	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	40	50	0.8	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	48	50	0.96	3	50	0.06	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	40	50	0.8	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	44	50	0.88	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	52	50	1.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	672	0.1	6720	384	0.1	3840	32	0.1	320	-	-	-	-	-	-	-	-	-
		-	-	-	640	0.1	6400	352	0.1	3520	48	0.1	480	-	-	-	-	-	-	-	-	-
		-	-	-	624	0.1	6240	392	0.1	3920	60	0.1	600	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	-	-	-	2	50	0.04	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
	EC	-	-	-	-	-	-	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	216	0.1	2160	44	0.1	440	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	256	0.1	2560	36	0.1	360	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	272	0.1	2720	92	0.1	920	-	-	-	-	-	-	-	-	-

Table IV (35): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during August 2012 (Month 6)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml (x10^1)	COUNT	V	CFU/ml (x10^2)	COUNT	V	CFU/ml (x10^3)	COUNT	V	CFU/ml (x10^4)	COUNT	V	CFU/ml (x10^5)	COUNT	V	CFU/ml (x10^6)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	176	50	3.52	104	50	2.08	68	50	1.36	12	50	0.24	-	-	-
		-	-	-	-	-	-	264	50	5.28	136	50	2.72	36	50	0.72	20	50	0.4	-	-	-
		-	-	-	-	-	-	208	50	4.16	112	50	2.24	80	50	1.6	24	50	0.48	-	-	-
	EC	-	-	-	-	-	-	68	50	1.36	12	50	0.24	0	50	0	1	50	0.02	-	-	-
		-	-	-	-	-	-	76	50	1.52	16	50	0.32	2	50	0.04	2	50	0.04	-	-	-
		-	-	-	-	-	-	96	50	1.92	20	50	0.4	2	50	0.04	2	50	0.04	-	-	-
	FC	-	-	-	192	50	3.84	76	50	1.52	12	50	0.24	2	50	0.04	-	-	-	-	-	-
		-	-	-	216	50	4.32	88	50	1.76	16	50	0.32	3	50	0.06	-	-	-	-	-	-
		-	-	-	208	50	4.16	100	50	2	12	50	0.24	2	50	0.04	-	-	-	-	-	-
	FS	-	-	-	128	50	2.56	16	50	0.32	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	88	50	1.76	20	50	0.4	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	120	50	2.4	28	50	0.56	2	50	0.04	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	176	50	3.52	40	50	0.8	24	50	0.48	-	-	-	-	-	-	-	-	-
		-	-	-	184	50	3.68	32	50	0.64	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	200	50	4	28	50	0.56	20	50	0.4	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	7	0.1	70	2	0.1	20	2	0.1	20	-	-	-
		-	-	-	-	-	-	-	-	-	9	0.1	90	1	0.1	10	1	0.1	10	-	-	-
		-	-	-	-	-	-	-	-	-	4	0.1	40	0	0.1	0	0	0.1	0	-	-	-
DISCHARGE POINT	TC	-	-	-	112	50	2.24	28	50	0.56	4	50	0.08	-	-	-	-	-	-	-	-	-
		-	-	-	68	50	1.36	32	50	0.64	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	88	50	1.76	24	50	0.48	3	50	0.06	-	-	-	-	-	-	-	-	-
	EC	-	-	-	5	50	0.1	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	7	50	0.14	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	6	50	0.12	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
	FC	24	50	0.48	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		32	50	0.64	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		20	50	0.4	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	4	50	0.08	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	4	50	0.08	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	5	50	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4	50	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9	50	0.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	24	0.1	240	2	0.1	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		20	0.1	200	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		16	0.1	160	0	0.1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (36): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during August 2012 (Month 6)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	416	50	8.32	280	50	5.6	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	368	50	7.36	336	50	6.72	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	480	50	9.6	200	50	4	-	-	-
	EC	-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	304	50	6.08	80	50	1.6	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	352	50	7.04	192	50	3.84	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	392	50	7.84	56	50	1.12	-	-	-
	FC	TNTC	50	TNTC	TNTC	50	TNTC	720	50	14.4	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	896	50	17.92	-	-	-	-	-	-	-	-	-	-	-	-
		TNTC	50	TNTC	TNTC	50	TNTC	768	50	15.36	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	336	50	6.72	208	50	4.16	72	50	1.44	-	-	-	-	-	-	-	-	-
		-	-	-	384	50	7.68	184	50	3.68	44	50	0.88	-	-	-	-	-	-	-	-	-
		-	-	-	344	50	6.88	176	50	3.52	60	50	1.2	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	TNTC	50	TNTC	992	50	19.84	480	50	9.6	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	960	50	19.2	400	50	8	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	928	50	18.56	352	50	7.04	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	328	0.1	3280	68	0.1	680	24	0.1	0.48	-	-	-	-	-	-
		-	-	-	-	-	-	432	0.1	4320	80	0.1	800	20	0.1	0.4	-	-	-	-	-	-
		-	-	-	-	-	-	368	0.1	3680	52	0.1	520	16	0.1	0.32	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	288	50	5.76	44	50	0.88	36	50	0.72	-	-	-	-	-	-	-	-	-
		-	-	-	336	50	6.72	32	50	0.64	40	50	0.8	-	-	-	-	-	-	-	-	-
		-	-	-	304	50	6.08	36	50	0.72	28	50	0.56	-	-	-	-	-	-	-	-	-
	EC	-	-	-	3	50	0.06	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	2	50	0.04	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	76	20	3.8	20	50	0.4	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	64	50	1.28	32	50	0.64	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	72	50	1.44	36	50	0.72	2	50	0.04	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	352	50	7.04	56	50	1.12	7	50	0.14	-	-	-	-	-	-	-	-	-
		-	-	-	448	50	8.96	56	50	1.12	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	512	50	10.24	40	50	0.8	8	50	0.16	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	3	0.1	30	1	0.1	10	20	0.1	200	-	-	-	-	-	-	-	-	-
		-	-	-	5	0.1	50	2	0.1	20	24	0.1	240	-	-	-	-	-	-	-	-	-
		-	-	-	2	0.1	20	0	0.1	0	24	0.1	240	-	-	-	-	-	-	-	-	-

Table IV (37): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during September 2012 (Month 7)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	84	50	1.68	42	50	0.84	4	50	0.08	1	50	0.02	-	-	-
		-	-	-	-	-	-	72	50	1.44	52	50	1.04	2	50	0.04	1	50	0.02	-	-	-
		-	-	-	-	-	-	76	50	1.52	36	50	0.72	1	50	0.02	1	50	0.02	-	-	-
	EC	-	-	-	-	-	-	40	50	0.8	4	50	0.08	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	36	50	0.72	8	50	0.16	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	40	50	0.8	4	50	0.08	0	50	0	0	50	0	-	-	-
	FC	-	-	-	-	-	-	44	50	0.88	5	50	0.1	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	36	50	0.72	6	50	0.12	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	3	50	0.06	0	50	0	-	-	-	-	-	-
	FS	-	-	-	-	-	-	72	50	1.44	3	50	0.06	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	64	50	1.28	4	50	0.08	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
	HPC	672	0.1	6720	-	-	-	-	-	-	5	0.1	50	-	-	-	-	-	-	-	-	-
		624	0.1	6240	-	-	-	-	-	-	2	0.1	20	-	-	-	-	-	-	-	-	-
		838	0.1	8380	-	-	-	-	-	-	4	0.1	40	-	-	-	-	-	-	-	-	-
DISCHARGE POINT	TC	-	-	-	184	50	3.68	120	50	2.4	4	50	0.08	2	50	0.04	1	50	0.02	-	-	-
		-	-	-	200	50	4	152	50	3.04	2	50	0.04	3	50	0.06	1	50	0.02	-	-	-
		-	-	-	256	50	5.12	144	50	2.88	3	50	0.06	4	50	0.08	0	50	0	-	-	-
	EC	-	-	-	72	50	1.44	32	50	0.64	0	50	0	1	50	0.02	0	50	0	-	-	-
		-	-	-	88	50	1.76	20	50	0.4	0	50	0	0	50	0	0	50	0	-	-	-
		-	-	-	104	50	2.08	16	50	0.32	0	50	0	0	50	0	0	50	0	-	-	-
	FC	-	-	-	184	50	3.68	48	50	0.96	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	168	50	3.36	60	50	1.2	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	208	50	4.16	40	50	0.8	-	-	-	-	-	-	-	-	-	-	-	-
	FS	52	50	1.04	-	-	-	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		56	50	1.12	-	-	-	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		40	50	0.8	-	-	-	2	50	0.04	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	5	50	0.1	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		4	50	0.08	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		9	50	0.18	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	768	0.1	7680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		752	0.1	7520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		624	0.1	6240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (38): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during September 2012 (Month 7)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	560	50	22.4	224	50	8.96	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	496	50	19.84	168	50	6.72	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	536	50	21.44	256	50	10.24	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	264	50	10.56	136	50	5.44	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	246	50	9.84	152	50	6.08	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	248	50	9.92	168	50	6.72	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	912	50	36.48	304	50	12.16	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	768	50	30.72	288	50	11.52	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	720	50	28.8	328	50	13.12	-	-	-	-	-	-	-	-	-
	FS	-	-	-	-	-	-	120	50	4.8	44	50	1.76	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	136	50	5.44	64	50	2.56	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	128	50	5.12	60	50	2.4	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	TNTC	50	TNTC	368	50	14.72	72	50	2.88	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	312	50	12.48	76	50	3.04	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	344	50	13.76	70	50	2.8	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	232	0.1	2320	160	0.1	1600	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	224	0.1	2240	120	0.1	1200	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	200	0.1	2000	114	0.1	1140	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	344	50	13.76	232	50	9.28	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	304	50	12.16	256	50	10.24	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	256	50	10.24	288	50	11.52	-	-	-	-	-	-
	EC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	192	50	7.68	88	50	3.52	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	176	50	7.04	120	50	4.8	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	232	50	9.28	144	50	5.76	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	736	50	29.44	272	50	10.88	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	883	50	35.32	280	50	11.2	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	768	50	30.72	296	50	11.84	-	-	-	-	-	-	-	-	-
	FS	-	-	-	-	-	-	184	50	7.36	108	50	4.32	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	144	50	5.76	100	50	4	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	192	50	7.68	84	50	3.36	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	704	50	28.16	152	50	6.08	272	50	10.88	-	-	-	-	-	-	-	-	-
		-	-	-	864	50	34.56	288	50	11.52	280	50	11.2	-	-	-	-	-	-	-	-	-
		-	-	-	784	50	31.36	184	50	7.36	296	50	11.84	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	280	0.1	2800	60	0.1	600	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	312	0.1	3120	72	0.1	720	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	336	0.1	3360	88	0.1	880	-	-	-	-	-	-	-	-	-

Table IV (39): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during October 2012 (Month 8)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	208	50	4.16	84	50	1.68	32	50	0.64	5	50	0.1	-	-	-
		-	-	-	-	-	-	216	50	4.32	104	50	2.08	36	50	0.72	2	50	0.04	-	-	-
		-	-	-	-	-	-	216	50	4.32	88	50	1.76	28	50	0.56	2	50	0.04	-	-	-
	EC	-	-	-	-	-	-	80	50	1.6	12	50	0.24	3	50	0.06	1	50	0.02	-	-	-
		-	-	-	-	-	-	56	50	1.12	24	50	0.48	0	50	0	1	50	0.02	-	-	-
		-	-	-	-	-	-	72	50	1.44	24	50	0.48	0	50	0	0	50	0	-	-	-
	FC	-	-	-	-	-	-	84	50	1.68	36	50	0.72	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	92	50	1.84	24	50	0.48	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	72	50	1.44	28	50	0.56	0	50	0	-	-	-	-	-	-
	FS	-	-	-	-	-	-	32	50	0.64	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	36	50	0.72	1	50	0.02	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	20	50	0.4	0	50	0	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	6	50	0.12	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	72	0.1	720	40	0.1	400	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	76	0.1	760	38	0.1	380	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	68	0.1	680	24	0.1	240	-	-	-	-	-	-	-	-	-
DISCHARGE POINT	TC	-	-	-	8	50	0.16	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	6	50	0.12	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	EC	-	-	-	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FC	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	232	50	4.64	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	256	50	5.12	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	224	50	4.48	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	2	0.1	20	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	0.1	10	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	0.1	10	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (40): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during October 2012 (Month 8)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	**TC**	-	-	-	-	-	-	TNTC	50	TNTC	216	50	4.32	100	50	2	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	192	50	3.84	104	50	2.08	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	208	50	4.16	92	50	1.84	-	-	-	-	-	-
	EC	-	-	-	-	-	-	72	50	1.44	24	25	0.96	12	50	0.24	-	-	-	-	-	-
		-	-	-	-	-	-	148	50	2.96	28	25	1.12	8	50	0.16	-	-	-	-	-	-
		-	-	-	-	-	-	128	50	2.56	16	25	0.64	12	50	0.24	-	-	-	-	-	-
	FC	-	-	-	-	-	-	368	50	7.36	120	50	2.4	48	50	0.96	-	-	-	-	-	-
		-	-	-	-	-	-	336	50	6.72	152	50	3.04	44	50	0.88	-	-	-	-	-	-
		-	-	-	-	-	-	352	50	7.04	168	50	3.36	40	50	0.8	-	-	-	-	-	-
	FS	-	-	-	-	-	-	-	-	-	64	50	1.28	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	28	25	1.12	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	32	25	1.28	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	440	50	8.8	52	50	1.04	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	392	50	7.84	32	25	1.28	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	360	50	7.2	34	25	1.36	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	16	0.1	160	4	0.1	40	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	28	0.1	280	3	0.1	30	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	20	0.1	200	6	0.1	60	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	96	50	1.92	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	24	50	0.48	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	EC	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	4	50	0.08	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	4	50	0.08	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	3	50	0.06	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	3	0.1	30	2	0.1	20	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	2	0.1	20	2	0.1	20	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	0.1	10	0	0.1	0	-	-	-	-	-	-	-	-	-

Table IV (41): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during November 2012 (Month 9)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^1$)**	**COUNT**	**V**	**CFU/ml ($x10^2$)**	**COUNT**	**V**	**CFU/ml ($x10^3$)**	**COUNT**	**V**	**CFU/ml ($x10^4$)**	**COUNT**	**V**	**CFU/ml ($x10^5$)**	**COUNT**	**V**	**CFU/ml ($x10^6$)**
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	TNTC	50	TNTC	832	50	16.64	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	672	50	13.44	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	784	50	15.68	0	50	0	0	50	0	-	-	-
	EC	-	-	-	-	-	-	288	50	5.76	136	50	2.72	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	272	50	5.44	176	50	3.52	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	304	50	6.08	224	50	4.48	0	50	0	0	50	0	-	-	-
	FC	-	-	-	-	-	-	TNTC	50	TNTC	64	50	1.28	32	50	0.64	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	60	50	1.2	40	50	0.8	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	52	50	1.04	24	50	0.48	-	-	-	-	-	-
	FS	-	-	-	104	50	2.08	52	50	1.04	1	50	0.02	0	50	0	-	-	-	-	-	-
		-	-	-	136	50	2.72	36	50	0.72	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	120	50	2.4	60	50	1.2	2	50	0.04	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	64	50	1.28	20	50	0.4	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	76	50	1.52	28	50	0.56	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	104	50	2.08	32	50	0.64	4	50	0.08	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	816	50	8160	184	50	1840	36	50	360	-	-	-
		-	-	-	-	-	-	-	-	-	1040	50	10400	272	50	2720	68	50	680	-	-	-
		-	-	-	-	-	-	-	-	-	784	50	7840	280	50	2800	56	50	560	-	-	-
DISCHARGE POINT	**TC**	-	-	-	TNTC	50	TNTC	1312	50	26.24	400	50	8	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	704	50	14.08	336	50	6.72	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	736	50	14.72	384	50	7.68	-	-	-	-	-	-	-	-	-
	EC	-	-	-	36	50	0.72	12	50	0.24	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	32	50	0.64	12	50	0.24	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	24	50	0.48	8	50	0.16	1	50	0.02	-	-	-	-	-	-	-	-	-
	FC	-	-	-	160	50	3.2	24	50	0.48	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	144	50	2.88	16	50	0.32	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	160	50	3.2	28	50	0.56	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	624	0.1	6240	336	0.1	3360	72	0.1	720	-	-	-	-	-	-	-	-	-	-	-	-
		672	0.1	6720	416	0.1	4160	112	0.1	1120	-	-	-	-	-	-	-	-	-	-	-	-
		784	0.1	7840	312	0.1	3120	88	0.1	880	-	-	-	-	-	-	-	-	-	-	-	-

Table IV (42): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during November 2012 (Month 9)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	**TC**	-	-	-	-	-	-	336	50	TNTC	216	50	4.32	92	50	1.84	-	-	-	-	-	-
		-	-	-	-	-	-	416	50	TNTC	224	50	4.48	72	50	1.44	-	-	-	-	-	-
		-	-	-	-	-	-	496	50	TNTC	192	50	3.84	148	50	2.96	-	-	-	-	-	-
	EC	-	-	-	-	-	-	104	50	2.08	16	50	0.32	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	80	50	1.6	12	50	0.24	2	50	0.04	-	-	-	-	-	-
		-	-	-	-	-	-	56	50	1.12	16	50	0.32	1	50	0.02	-	-	-	-	-	-
	FC	-	-	-	-	-	-	TNTC	50	TNTC	48	50	0.96	14	50	0.28	-	-	-	-	-	-
		-	-	-	-	-	-	144	25	5.76	36	50	0.72	12	50	0.24	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	24	50	0.48	12	50	0.24	-	-	-	-	-	-
	FS	-	-	-	32	50	0.64	2	50	0.04	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	40	50	0.8	7	50	0.14	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	36	50	0.72	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	24	50	0.48	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	20	50	0.4	4	50	0.08	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	24	50	0.48	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	376	0.1	3760	44	0.1	440	3	0.1	30	-	-	-	-	-	-
		-	-	-	-	-	-	248	0.1	2480	72	0.1	720	4	0.1	40	-	-	-	-	-	-
		-	-	-	-	-	-	344	0.1	3440	80	0.1	800	8	0.1	80	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	736	50	14.72	344	50	6.88	264	50	5.28	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	784	50	15.68	392	50	7.84	280	50	5.6	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	832	50	16.64	416	50	8.32	336	50	6.72	-	-	-
	EC	-	-	-	-	-	-	192	50	3.84	76	50	1.52	68	50	1.36	4	50	0.08	-	-	-
		-	-	-	-	-	-	152	50	3.04	84	50	1.68	72	50	1.44	7	50	0.14	-	-	-
		-	-	-	-	-	-	176	50	3.52	92	50	1.84	84	50	1.68	0	50	0	-	-	-
	FC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	64	50	1.28	32	50	0.64	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	60	50	1.2	20	50	0.4	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	52	50	1.04	28	50	0.56	-	-	-	-	-	-
	FS	-	-	-	120	50	2.4	16	50	0.32	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	80	50	1.6	12	50	0.24	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	96	50	1.92	24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	104	50	2.08	24	50	0.48	2	50	0.04	1	50	0.02	-	-	-	-	-	-
		-	-	-	128	50	2.56	12	50	0.24	1	50	0.02	0	50	0	-	-	-	-	-	-
		-	-	-	136	50	2.72	8	50	0.16	1	50	0.02	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	760	0.1	7600	376	0.1	3760	152	0.1	1520	-	-	-	-	-	-
		-	-	-	-	-	-	64	0.1	640	312	0.1	3120	160	0.1	1600	-	-	-	-	-	-
		-	-	-	-	-	-	712	0.1	7120	328	0.1	3280	144	0.1	1440	-	-	-	-	-	-

Table IV (43): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during December 2012 (Month 10)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	352	50	7.04	128	50	2.56	20	50	0.4	2	50	0.04	-	-	-
		-	-	-	-	-	-	312	50	6.24	116	50	2.32	12	50	0.24	3	50	0.06	-	-	-
		-	-	-	-	-	-	360	50	7.2	132	50	2.64	16	50	0.32	3	50	0.06	-	-	-
	EC	-	-	-	-	-	-	48	50	0.96	8	50	0.16	4	50	0.08	0	50	0	-	-	-
		-	-	-	-	-	-	32	50	0.64	12	50	0.24	0	50	0	0	50	0	-	-	-
		-	-	-	-	-	-	40	50	0.8	16	50	0.32	4	50	0.08	0	50	0	-	-	-
	FC	-	-	-	-	-	-	64	50	1.28	5	50	0.1	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	68	50	1.36	11	50	0.22	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	60	50	1.2	12	50	0.24	0	50	0	-	-	-	-	-	-
	FS	-	-	-	-	-	-	16	50	0.32	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	20	50	0.4	2	50	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	24	50	0.48	2	50	0.04	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	24	50	0.48	1	50	0.02	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	20	50	0.4	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	12	50	0.24	0	50	0	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	2	0.1	20	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	1	0.1	10	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	3	0.1	30	-	-	-	-	-	-	-	-	-
DISCHARGE POINT	TC	-	-	-	-	-	-	72	50	1.44	4	50	0.08	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	88	50	1.76	7	50	0.14	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	5	50	0.1	1	50	0.02	-	-	-	-	-	-
	EC	-	-	-	-	-	-	24	50	0.48	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	12	50	0.24	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	16	50	0.32	0	50	0	0	50	0	-	-	-	-	-	-
	FC	-	-	-	-	-	-	3	50	0.06	1.00	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	5	50	0.1	1.00	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	10	50	0.2	1	50	0.02	-	-	-	-	-	-	-	-	-
	FS	-	-	-	-	-	-	2	50	0.04	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	4	0.1	40	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	5	0.1	50	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	3	0.1	30	-	-	-	-	-	-	-	-	-

Table IV (44): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during December 2012 (Month 10)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM		-	-	-	-	-	-															
	TC	-	-	-	-	-	-	TNTC	50	TNTC	616	50	12.32	352	50	7.04	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	704	50	14.08	256	50	5.12	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	656	50	13.12	312	50	6.24	-	-	-	-	-	-
	EC	-	-	-	-	-	-	784	50	15.68	312	50	6.24	80	50	1.6	-	-	-	-	-	-
		-	-	-	-	-	-	832	50	16.64	336	50	6.72	64	50	1.28	-	-	-	-	-	-
		-	-	-	-	-	-	880	50	17.6	328	50	6.56	88	50	1.76	-	-	-	-	-	-
	FC	-	-	-	-	-	-	976	50	19.52	240	50	4.8	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	864	50	17.28	224	50	4.48	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	928	50	18.56	248	50	4.96	-	-	-	-	-	-	-	-	-
	FS	-	-	-	368	50	7.36	216	50	4.32	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	376	50	7.52	256	50	5.12	20	50	0.4	-	-	-	-	-	-	-	-	-
		-	-	-	416	50	8.32	224	50	4.48	16	50	0.32	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	336	50	6.72	72	50	1.44	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	312	50	6.24	84	50	1.68	12	50	0.24	-	-	-	-	-	-	-	-	-
		-	-	-	328	50	6.56	88	50	1.76	4	50	0.08	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	376	0.1	3760	72	0.1	720	2	0.1	20	-	-	-	-	-	-
		-	-	-	-	-	-	416	0.1	4160	60	0.1	600	2	0.1	20	-	-	-	-	-	-
		-	-	-	-	-	-	464	0.1	4640	68	0.1	680	3	0.1	30	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	-	-	-	-	-	-	1344	50	26.88	544	50	10.88	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	1472	50	29.44	576	50	11.52	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	1312	50	26.24	600	50	12	-	-	-	-	-	-
	EC	-	-	-	-	-	-	-	-	-	632	50	12.64	312	50	6.24	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	672	50	13.44	232	50	4.64	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	736	50	14.72	272	50	5.44	-	-	-	-	-	-
	FC	-	-	-	-	-	-	784	50	15.68	240	50	4.8	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	832	50	16.64	224	50	4.48	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	976	50	19.52	200	50	4	-	-	-	-	-	-	-	-	-
	FS	-	-	-	352	25	14.08	144	50	2.88	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	376	25	15.04	160	50	3.2	36	50	0.72	-	-	-	-	-	-	-	-	-
		-	-	-	384	25	15.36	152	50	3.04	32	50	0.64	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	912	25	36.48	144	50	2.88	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	1008	25	40.32	176	50	3.52	32	50	0.64	-	-	-	-	-	-	-	-	-
		-	-	-	1024	25	40.96	168	50	3.36	20	50	0.4	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	472	0.1	4720	64	0.1	640	20	0.1	200	-	-	-	-	-	-
		-	-	-	-	-	-	616	0.1	6160	52	0.1	520	12	0.1	120	-	-	-	-	-	-
		-	-	-	-	-	-	504	0.1	5040	56	0.1	560	24	0.1	240	-	-	-	-	-	-

Table IV (45): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during January 2012 (Month 11)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	TC	-	-	-	-	-	-	TNTC	50	TNTC	168	50	3.36	96	50	1.92	16	50	0.32	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	264	50	5.28	116	50	2.32	28	50	0.56	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	328	50	6.56	104	50	2.08	36	50	0.72	-	-	-
	EC	-	-	-	-	-	-	264	50	5.28	96	50	1.92	20	50	0.4	3	50	0.06	-	-	-
		-	-	-	-	-	-	336	50	6.72	104	50	2.08	24	50	0.48	0	50	0	-	-	-
		-	-	-	-	-	-	232	50	4.64	160	50	3.2	16	50	0.32	0	50	0	-	-	-
	FC	-	-	-	-	-	-	TNTC	50	TNTC	208	50	4.16	24	50	0.48	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	112	50	2.24	48	50	0.96	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	144	50	2.88	44	50	0.88	-	-	-	-	-	-
	FS	-	-	-	-	-	-	60	50	1.2	5	50	0.1	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	2	50	0.04	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	56	50	1.12	3	50	0.06	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	72	50	1.44	3	50	0.06	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	36	50	0.72	3	50	0.06	1	50	0.02	-	-	-	-	-	-
		-	-	-	-	-	-	68	50	1.36	2	50	0.04	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	-	-	-	68	0.1	680	60	0.1	48	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	20	0.1	200	36	0.1	24	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	52	0.1	520	42	0.1	12	-	-	-	-	-	-
DISCHARGE POINT	TC	-	-	-	13	50	0.26	4	50	0.08	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	7	50	0.14	2	50	0.04	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	14	50	0.28	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	EC	-	-	-	2	50	0.04	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FC	-	-	-	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	92	0.1	920	88	0.1	880	52	0.1	520	-	-	-	-	-	-	-	-	-
		-	-	-	88	0.1	880	76	0.1	760	52	0.1	520	-	-	-	-	-	-	-	-	-
		-	-	-	76	0.1	760	72	0.1	720	44	0.1	440	-	-	-	-	-	-	-	-	-

Table IV (46): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during January 2012 (Month 11)

		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	**V**	**CFU/ml**	**COUNT**	**V**	**CFU/ml ($x10^1$)**	**COUNT**	**V**	**CFU/ml ($x10^2$)**	**COUNT**	**V**	**CFU/ml ($x10^3$)**	**COUNT**	**V**	**CFU/ml ($x10^4$)**	**COUNT**	**V**	**CFU/ml ($x10^5$)**	**COUNT**	**V**	**CFU/ml ($x10^6$)**
UPSTREAM	**TC**	-	-	-	-	-	-	7	50	TNTC	1	50	0.02	28	50	0.56	-	-	-	-	-	-
		-	-	-	-	-	-	4	50	TNTC	0	50	0	4	50	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	5	50	TNTC	0	50	0	0	50	0	-	-	-	-	-	-
	EC	-	-	-	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-
	FC	-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	544	0.1	5440	168	0.1	1680	40	0.1	400	-	-	-	-	-	-
		-	-	-	-	-	-	496	0.1	4960	184	0.1	1840	52	0.1	520	-	-	-	-	-	-
		-	-	-	-	-	-	464	0.1	4640	192	0.1	1920	60	0.1	600	-	-	-	-	-	-
DOWNSTREAM	**TC**	-	-	-	-	-	0	TNTC	50	TNTC	344	50	6.88	128	50	2.56	-	-	-	-	-	-
		-	-	-	-	-	0	TNTC	50	TNTC	352	50	7.04	136	50	2.72	-	-	-	-	-	-
		-	-	-	-	-	0	TNTC	50	TNTC	392	50	7.84	144	50	2.88	-	-	-	-	-	-
	EC	-	-	-	-	-	0	168	50	3.36	88	50	1.76	8	50	0.16	-	-	-	-	-	-
		-	-	-	-	-	0	232	50	4.64	120	50	2.4	8	50	0.16	-	-	-	-	-	-
		-	-	-	-	-	0	216	50	4.32	136	50	2.72	8	50	0.16	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	160	50	3.2	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	128	50	2.56	-	-	-	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	152	50	3.04	-	-	-	-	-	-	-	-	-
	FS	-	-	-	280	50	5.6	136	50	2.72	32	50	0.64	-	-	-	-	-	-	-	-	-
		-	-	-	298	50	5.96	168	50	3.36	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	336	50	6.72	104	50	2.08	20	50	0.4	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	344	50	6.88	168	50	3.36	28	50	-	-	-	-	-	-	-
		-	-	-	-	-	-	376	50	7.52	144	50	2.88	20	50	-	-	-	-	-	-	-
		-	-	-	-	-	-	392	50	7.84	152	50	3.04	12	50	-	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	40	0.1	400	28	0.1	280	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	48	0.1	480	16	0.1	160	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	36	0.1	360	12	0.1	120	-	-	-	-	-	-	-	-	-

Table IV (47): Microbial indicators enumerated before chlorination and at the discharge point for the New Germany TW during February 2012 (Month 12)

		DILUTIONS																				
		$1 X 10^0$			$1 X 10^1$			$1 X 10^2$			$1 X 10^3$			$1 X 10^4$			$1 X 10^5$			$1 X 10^6$		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
BEFORE CHLORINATION	**TC**	-	-	-	-	-	-	TNTC	50	TNTC	528	50	10.56	184	50	3.68	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	672	50	13.44	256	50	5.12	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	464	50	9.28	232	50	4.64	-	-	-	-	-	-
	EC	-	-	-	-	-	-	192	50	3.84	48	50	0.96	12	50	0.24	-	-	-	-	-	-
		-	-	-	-	-	-	200	50	4	88	50	1.76	12	50	0.24	-	-	-	-	-	-
		-	-	-	-	-	-	216	50	4.32	72	50	1.44	16	50	0.32	-	-	-	-	-	-
	FC	-	-	-	-	-	-	TNTC	50	TNTC	128	50	2.56	44	50	0.88	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	136	50	2.72	64	50	1.28	-	-	-	-	-	-
		-	-	-	-	-	-	TNTC	50	TNTC	120	50	2.4	52	50	1.04	-	-	-	-	-	-
	FS	-	-	-	-	-	-	3	50	0.06	1	50	0.02	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-
	ENT	-	-	-	-	-	-	2	50	0.04	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-
		-	-	-	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-
	HPC	-	-	-	-	-	-	608	0.1	6080	144	0.1	1440	24	0.1	240	-	-	-	-	-	-
		-	-	-	-	-	-	528	0.1	5280	112	0.1	1120	20	0.1	200	-	-	-	-	-	-
		-	-	-	-	-	-	672	0.1	6720	232	0.1	2320	24	0.1	240	-	-	-	-	-	-
DISCHARGE POINT	**TC**	-	-	-	20	25	0.8	4	25	0.16	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	28	25	1.12	6	25	0.24	1	25	0.04	-	-	-	-	-	-	-	-	-
		-	-	-	32	25	1.28	5	25	0.2	0	25	0	-	-	-	-	-	-	-	-	-
	EC	-	-	-	4	25	0.16	1	25	0.04	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	-	-	-	16	25	0.32	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	6	25	0.12	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	4	25	0.08	0	25	0	-	-	-	-	-	-	-	-	-
	FS	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	25	0	0	25	0	0	25	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	20	0.1	200	0	0.1	0	0	0.1	0	0	0.1	0	-	-	-	-	-	-
		-	-	-	16	0.1	160	0	0.1	0	0	0.1	0	0	0.1	0	-	-	-	-	-	-
		-	-	-	24	0.1	240	0	0.1	0	0	0.1	0	0	0.1	0	-	-	-	-	-	-

Table IV (48): Microbial indicators enumerated upstream and downstream of the Aller River for the New Germany TW during February 2012 (Month 12)

		DILUTIONS																				
		1 X 10^0			1 X 10^1			1 X 10^2			1 X 10^3			1 X 10^4			1 X 10^5			1 X 10^6		
		COUNT	V	CFU/ml	COUNT	V	CFU/ml ($x10^1$)	COUNT	V	CFU/ml ($x10^2$)	COUNT	V	CFU/ml ($x10^3$)	COUNT	V	CFU/ml ($x10^4$)	COUNT	V	CFU/ml ($x10^5$)	COUNT	V	CFU/ml ($x10^6$)
UPSTREAM	TC	-	-	-				1120	50	22.4	496	50	9.92	224	50	4.48	-	-	-	-	-	-
		-	-	-	-	-	-	1312	50	26.24	368	50	7.36	304	50	6.08	-	-	-	-	-	-
		-	-	-	-	-	-	1232	50	24.64	464	50	9.28	208	50	4.16	-	-	-	-	-	-
	EC	-	-	-	-	-	-	32	50	0.64	6	50	0.12	4	50	0.08	-	-	-	-	-	-
		-	-	-	-	-	-	36	50	0.72	7	50	0.14	3	50	0.06	-	-	-	-	-	-
		-	-	-	-	-	-	48	50	0.96	13	50	0.26	2	50	0.04	-	-	-	-	-	-
	FC	-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	72	50	1.44	16	50	0.32	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	80	50	1.6	12	50	0.24	-	-	-	-	-	-
		-	-	-	TNTC	50	TNTC	TNTC	50	TNTC	56	50	1.12	16	50	0.32	-	-	-	-	-	-
	FS	-	-	-	184	50	3.68	32	50	0.64	6	50	0.12	-	-	-	-	-	-	-	-	-
		-	-	-	200	50	4	40	50	0.8	8	50	0.16	-	-	-	-	-	-	-	-	-
		-	-	-	152	50	3.04	44	50	0.88	4	50	0.08	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	176	50	3.52	20	50	0.4	1	50	0.02	-	-	-	-	-	-	-	-	-
		-	-	-	144	50	2.88	24	50	0.48	3	50	0.06	-	-	-	-	-	-	-	-	-
		-	-	-	200	50	4	28	50	0.56	1	50	0.02	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	848	0.1	8480	208	0.1	2080	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	784	0.1	7840	112	0.1	1120	0	0.1	0	-	-	-	-	-	-	-	-	-
		-	-	-	1024	0.1	10240	72	0.1	720	0	0.1	0	-	-	-	-	-	-	-	-	-
DOWNSTREAM	TC	-	-	-	296	50	5.92	168	50	3.36	52	50	1.04	-	-	-	-	-	-	-	-	-
		-	-	-	336	50	6.72	112	50	2.24	28	50	0.56	-	-	-	-	-	-	-	-	-
		-	-	-	312	50	6.24	152	50	3.04	32	50	0.64	-	-	-	-	-	-	-	-	-
	EC	-	-	-	5	50	0.1	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	11	50	0.22	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	7	50	0.14	1	50	0.02	0	50	0	-	-	-	-	-	-	-	-	-
	FC	-	-	-	224	50	4.48	136	50	2.72	20	50	0.4	-	-	-	-	-	-	-	-	-
		-	-	-	256	50	5.12	96	50	1.92	16	50	0.32	-	-	-	-	-	-	-	-	-
		-	-	-	280	50	5.6	80	50	1.6	24	50	0.48	-	-	-	-	-	-	-	-	-
	FS	-	-	-	1	50	0.02	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	ENT	-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
		-	-	-	0	50	0	0	50	0	0	50	0	-	-	-	-	-	-	-	-	-
	HPC	-	-	-	592	0.1	5920	248	0.1	2480	104	0.1	1040	-	-	-	-	-	-	-	-	-
		-	-	-	757	0.1	7570	280	0.1	2800	96	50	960	-	-	-	-	-	-	-	-	-
		-	-	-	784	0.1	7840	264	0.1	2640	88	50	880	-	-	-	-	-	-	-	-	-

Table 1: FC/FS Ratios for all water samples collected at the NWWTP and receiving river

	BC			DP			US			DS		
MONTH	**FC**	**FS**	**FC/FS**	**FC**	**FS**	**FC/FS**	**FC**	**FS**	**FC/FS**	**FC**	**FS**	**FC/FS**
MAR	0.20	0.01	21.67	0.19	0.01	13.79	0.01	0.01	1	0.01	0.00	0
APR	1.81	0.88	2.06	3.97	0.29	13.69	0.25	0.01	25	4.21	0.17	24.76
MAY	7.86	1.04	7.56	0.58	0.27	2.15	0.93	0.11	8.45	0.21	0.09	2.33
JUN	0.75	0.87	0.86	1.11	1.52	0.73	0.12	0.12	1	0.13	0.43	0.31
JUL	0.77	0.14	5.45	0.16	0.00	0	0.49	0.07	7.03	0.26	0.10	2.58
AUG	1.73	2.45	0.71	1.06	0.28	3.82	0.07	0.08	0.84	0.05	0.01	6.99
SEPT	1.95	0.37	5.23	0.07	0.01	13.00	0.24	0.01	18.46	0.83	0.03	27.67
OCT	1.55	0.29	5.34	0.00	0.00	0	0.01	0.00	0	0.01	0.00	10.37
NOV	4.59	0.96	4.78	1.64	0.22	7.33	1.52	0.13	11.97	0.51	0.03	18.77
DEC	0.40	0.01	43.01	1.28	0.00	0	0.19	0.00	0	0.37	0.00	0
JAN	7.04	1.39	5.08	0.91	0.26	3.54	0.98	0.00	0	0.06	0.03	2.22
FEB	2.83	0.00	0.00	2.99	1.60	1.87	1.28	0.07	17.53	0.51	0.01	51

FC: faecal coliforms; FS: faecal streptococci; BC: before chlorination; DP: discharge point; US: upstream; DS: downstream

Table 2: FC/FS Ratios for all water samples collected at the NGTW and receiving river

	BC			DP			US			DS		
MONTH	**FC**	**FS**	**FC/FS**	**FC**	**FS**	**FC/FS**	**FC**	**FS**	**FC/FS**	**FC**	**FS**	**FC/FS**
MAR	0.67	0.72	0.93	0.00	0	0	0.53	0.03	16.50	0	0	0
APR	1.12	0.04	28.00	0.01	0	0	2.99	0.37	8.08	0.03	0	0
MAY	5.00	1.90	2.63	11.89	6.24	1.91	0.24	0.03	7.27	26.70	7.20	3.71
JUN	0.61	0.21	2.88	0.00	0	0	0.22	0.27	0.81	0.07	0.03	2.23
JUL	5.01	4.00	1.25	0.00	0	0	0.72	0.06	12.00	0	0	0
AUG	1.76	0.43	4.09	0.40	0.13	3.08	15.83	3.79	4.18	0	0.59	0
SEPT	0.85	1.23	0.69	0.99	0.03	33.00	122.7	224	0.55	31.8	6.93	4.59
OCT	1.65	0.59	2.80	0	0.05	0	7.04	12.27	0.57	0.01	0	0
NOV	11.73	0.33	35.55	0.45	0	0	7.20	0.09	82.76	16.00	0.35	46.24
DEC	1.28	0.40	3.20	0.12	0.02	6	18.45	4.64	3.98	17.28	3.04	5.68
JAN	30.93	1.09	28.38	0	0	0	0	0	0	29.33	2.72	10.78
FEB	25.60	0.03	853.33	0.17	0	0	13.87	0.12	115.58	2.08	0	0

FC: faecal coliforms; FS: faecal streptococci; BC: before chlorination; DP: discharge point; US: upstream; DS: downstream

APPENDIX V: SOMATIC AND F-RNA COLIPHAGE COUNTS

Table V (1): Somatic coliphage populations for the Northern WWTP between March 2012 – February 2013

SOMATIC COLIPHAGES (PFU/ml)		BEFORE CHLORINATION			AVG	SD	DISCHARGE POINT			AVG	SD
	MARCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	68.00	76.00	84.00	76.00	8.00	72.00	116.00	132.00	106.67	31.07
	MAY	144.00	184.00	168.00	165.33	20.13	296.00	304.00	328.00	309.33	16.65
	JUNE	80.00	44.00	72.00	65.33	18.90	8.00	14.00	24.00	15.33	8.08
	JULY	360.00	208.00	256.00	274.67	77.70	440.00	520.00	80.00	346.67	234.38
	AUGUST	172.00	16.00	80.00	89.33	78.42	264.00	88.00	28.00	126.67	122.66
	SEPTEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OCTOBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NOVEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	DECEMBER	72.00	64.00	92.00	76.00	14.42	0.00	0.00	0.00	0.00	0.00
	JANUARY	424.00	416.00	360.00	400.00	34.87	472.00	224.00	440.00	378.67	134.90
	FEBRUARY	288.00	272.00	256.00	272.00	16.00	168.00	192.00	224.00	194.67	28.10
		UPSTREAM			**AVG**	**SD**	**DOWNSTREAM**			**AVG**	**SD**
	MARCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	0.00	0.00	0.00	0.00	0.00	2320.00	800.00	1200.00	1440.00	787.91
	MAY	1040.00	1160.00	20.00	740.00	626.42	720.00	640.00	0.00	453.33	394.63
	JUNE	720.00	680.00	480.00	626.67	128.58	192.00	144.00	40.00	125.33	77.70
	JULY	0.00	0.00	0.00	0.00	0.00	51.00	64.00	0.00	38.33	33.83
	AUGUST	160.00	120.00	0.00	93.33	83.27	76.00	160.00	10.00	82.00	75.18
	SEPTEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OCTOBER	0.00	0.00	0.00	0.00	0.00	2.00	1.00	0.00	1.00	1.00
	NOVEMBER	100.00	4.00	160.00	88.00	78.69	2.00	1.00	0.00	1.00	1.00
	DECEMBER	84.00	124.00	92.00	100.00	21.17	320.00	232.00	312.00	288.00	48.66
	JANUARY	68.00	80.00	156.00	101.33	47.72	148.00	320.00	200.00	222.67	88.21
	FEBRUARY	0.00	0.00	0.00	0.00	0.00	120.00	128.00	192.00	146.67	39.46

Table V (2): F-RNA coliphage populations for the Northern WWTP between March 2012 – February 2013

F-RNA COLIPHAGES (PFU/ml)		BEFORE CHLORINATION			AVG	SD	DISCHARGE POINT			AVG	SD
	MARCH										
	APRIL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MAY	144.00	80.00	0.00	74.67	72.15	76.00	68.00	64.00	69.33	6.11
	JUNE	68.00	108.00	108.00	94.67	23.09	144.00	152.00	92.00	129.33	32.58
	JULY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	AUGUST	1.00	1.00	0.00	0.67	0.58	0.00	0.00	0.00	0.00	0.00
	SEPTEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OCTOBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NOVEMBER	14.00	4.00	15.00	11.00	6.08	0.00	0.00	0.00	0.00	0.00
	DECEMBER	136.00	216.00	64.00	138.67	76.04	0.00	0.00	0.00	0.00	0.00
	JANUARY	232.00	192.00	216.00	213.33	20.13	112.00	64.00	0.00	58.67	56.19
	FEBRUARY	160.00	256.00	192.00	202.67	48.88	120.00	112.00	288.00	173.33	99.38
		UPSTREAM			**AVG**	**SD**	**DOWNSTREAM**			**AVG**	**SD**
	MARCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	148.00	108.00	36.00	97.33	56.76	256.00	224.00	148.00	209.33	55.47
	MAY	132.00	200.00	136.00	156.00	38.16	92.00	84.00	88.00	88.00	4.00
	JUNE	5.00	4.00	3.00	4.00	1.00	76.00	24.00	44.00	48.00	26.23
	JULY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	AUGUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SEPTEMBER	0.00	0.00	0.00	0.00	0.00	2.00	1.00	0.00	1.00	1.00
	OCTOBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NOVEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	DECEMBER	240.00	320.00	88.00	216.00	117.85	480.00	312.00	480.00	424.00	96.99
	JANUARY	28.00	80.00	216.00	108.00	97.08	360.00	424.00	504.00	429.33	72.15
	FEBRUARY	40.00	48.00	112.00	66.67	39.46	120.00	144.00	72.00	112.00	36.66

Table V (3): Somatic coliphage populations for the New Germany TW between March 2012 – February 2013

		BEFORE CHLORINATION			AVG	SD	DISCHARGE POINT			AVG	SD
SOMATIC COLIPHAGES (PFU/ml)	**MARCH**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	6.00	6.00	8.00	6.67	1.15	2.00	1.00	0.00	1.00	1.00
	MAY	248.00	224.00	208.00	226.67	20.13	448.00	496.00	528.00	490.67	40.27
	JUNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JULY	184.00	192.00	216.00	197.33	16.65	7.00	7.00	6.00	6.67	0.58
	AUGUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SEPTEMBER	24.00	36.00	28.00	29.33	0.00	36.00	40.00	28.00	34.67	6.11
	OCTOBER	8.00	11.00	8.00	0.00	0.00	2.00	1.00	0.00	0.00	0.00
	NOVEMBER	40.00	32.00	36.00	36.00	4.00	0.00	0.00	0.00	0.00	0.00
	DECEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JANUARY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	FEBRUARY	288.00	272.00	256.00	272.00	16.00	168.00	192.00	224.00	194.67	28.10
		UPSTREAM			**AVG**	**SD**	**DOWNSTREAM**			**AVG**	**SD**
	MARCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	232.00	344.00	376.00	317.33	75.61	224.00	296.00	256.00	258.67	36.07
	MAY	44.00	68.00	72.00	61.33	15.14	400.00	488.00	544.00	477.33	72.59
	JUNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JULY	120.00	136.00	176.00	144.00	28.84	20.00	68.00	36.00	41.33	24.44
	AUGUST	104.00	80.00	72.00	85.33	16.65	0.00	0.00	0.00	0.00	0.00
	SEPTEMBER	1920.00	2640.00	2800.00	2453.33	468.76	384.00	280.00	296.00	320.00	56.00
	OCTOBER	11.00	9.00	6.00	8.67	2.52	9.00	6.00	5.00	6.67	2.08
	NOVEMBER	48.00	240.00	240.00	176.00	110.85	256.00	368.00	472.00	365.33	108.02
	DECEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JANUARY	3.00	1.00	1.00	1.67	1.15	0.00	0.00	0.00	0.00	0.00
	FEBRUARY	0.00	0.00	0.00	0.00	0.00	120.00	128.00	192.00	146.67	39.46

Table V (4): F-RNA coliphage populations for the New Germany TW between March 2012 – February 2013

		BEFORE CHLORINATION			AVG	SD	DISCHARGE POINT			AVG	SD
F-RNA COLIPHAGES (PFU/ml)	**MARCH**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MAY	0.00	0.00	0.00	0.00	0.00	32.00	56.00	44.00	44.00	12.00
	JUNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JULY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	AUGUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SEPTEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OCTOBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NOVEMBER	176.00	160.00	640.00	325.33	272.63	0.00	0.00	0.00	0.00	0.00
	DECEMBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JANUARY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	FEBRUARY	160.00	256.00	192.00	202.67	48.88	120.00	112.00	288.00	173.33	99.38
		UPSTREAM			**AVG**	**SD**	**DOWNSTREAM**			**AVG**	**SD**
	MARCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	APRIL	824.00	624.00	656.00	701.33	107.43	0.00	0.00	0.00	0.00	0.00
	MAY	0.00	0.00	0.00	0.00	0.00	16.00	12.00	24.00	17.33	6.11
	JUNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JULY	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
	AUGUST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SEPTEMBER	72.00	56.00	56.00	61.33	9.24	48.00	40.00	56.00	48.00	8.00
	OCTOBER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NOVEMBER	736.00	760.00	632.00	0.00	68.04	800.00	512.00	560.00	624.00	154.30
	DECEMBER	0.00	0.00	0.00	0.00	0.00	20.00	24.00	20.00	21.33	2.31
	JANUARY	24.00	1.00	1.00	8.67	13.28	4.00	3.00	1.00	2.67	1.53
	FEBRUARY	40.00	48.00	112.00	66.67	39.46	120.00	114.00	72.00	102.00	26.15

APPENDIX VI: VIRAL ANALYSES

Table VI (1): RNA concentrations (ng/ul) for samples collected for the Northern WWTP and receiving Umgeni River between March 2012 and February 2013

	NORTHERN WWTP							
	Sample ID	**N. Acid Conc.**	**Unit**	**A260**	**A280**	**260/280**	**260/230**	**Sample Type**
AUTUMN	BC	87.3	ng/µl	2.182	1.428	1.53	0.27	RNA
	BC	88.8	ng/µl	2.22	1.449	1.53	0.26	RNA
	BC	90.3	ng/µl	2.257	1.465	1.54	0.26	RNA
	DP	177.8	ng/µl	4.444	2.796	1.59	0.32	RNA
	DP	181.2	ng/µl	4.53	2.837	1.6	0.32	RNA
	DP	185.2	ng/µl	4.631	2.881	1.61	0.32	RNA
	US	107.2	ng/µl	2.681	1.753	1.53	0.28	RNA
	US	109.2	ng/µl	2.731	1.789	1.53	0.28	RNA
	US	111	ng/µl	2.776	1.801	1.54	0.28	RNA
	DS	46.4	ng/µl	1.161	0.811	1.43	0.26	RNA
	DS	48.2	ng/µl	1.204	0.83	1.45	0.26	RNA
	DS	49.6	ng/µl	1.24	0.856	1.45	0.26	RNA
WINTER	BC	401.4	ng/µl	10.035	5.514	1.82	0.73	RNA
	BC	410.4	ng/µl	10.26	5.567	1.84	0.76	RNA
	BC	417.9	ng/µl	10.448	5.616	1.86	0.8	RNA
	DP	332	ng/µl	8.299	4.91	1.69	0.55	RNA
	DP	340.9	ng/µl	8.524	4.952	1.72	0.57	RNA
	DP	348.6	ng/µl	8.715	5.003	1.74	0.59	RNA
	US	416.8	ng/µl	10.421	5.87	1.78	0.75	RNA
	US	425.8	ng/µl	10.645	5.898	1.8	0.78	RNA
	US	437.1	ng/µl	10.928	5.958	1.83	0.82	RNA
	DS	306.5	ng/µl	7.663	4.629	1.66	0.51	RNA
	DS	315.6	ng/µl	7.889	4.675	1.69	0.52	RNA
	DS	322.8	ng/µl	8.07	4.723	1.71	0.54	RNA
SPRING	BC	602.4	ng/µl	15.06	11.217	1.34	0.38	RNA
	BC	623.2	ng/µl	15.581	11.317	1.38	0.38	RNA
	BC	647.2	ng/µl	16.18	11.423	1.42	0.38	RNA
	DP	532	ng/µl	13.299	9.401	1.41	0.35	RNA
	DP	595	ng/µl	14.874	9.931	1.5	0.35	RNA
	DP	619.8	ng/µl	15.495	10.158	1.53	0.35	RNA
	US	529.4	ng/µl	13.234	9.65	1.37	0.36	RNA
	US	543.1	ng/µl	13.577	9.759	1.39	0.36	RNA
	US	575.6	ng/µl	14.389	10.056	1.43	0.36	RNA
	DS	433.9	ng/µl	10.848	6.194	1.75	0.74	RNA
	DS	449.7	ng/µl	11.243	6.247	1.8	0.77	RNA
	DS	463.3	ng/µl	11.583	6.287	1.84	0.81	RNA
SUMMER	BC	524.5	ng/µl	13.112	9.402	1.39	0.35	RNA
	BC	548	ng/µl	13.701	9.489	1.44	0.35	RNA
	BC	584.9	ng/µl	14.622	9.874	1.48	0.34	RNA
	DP	392.8	ng/µl	9.821	5.953	1.65	0.65	RNA
	DP	409.1	ng/µl	10.227	6.001	1.7	0.68	RNA
	DP	424.8	ng/µl	10.619	6.037	1.76	0.71	RNA
	US	752.3	ng/µl	18.807	13.218	1.42	0.39	RNA
	US	793.3	ng/µl	19.832	13.48	1.47	0.39	RNA
	US	813.8	ng/µl	20.345	13.583	1.5	0.39	RNA
	DS	637.4	ng/µl	15.934	11.501	1.39	0.4	RNA
	DS	656	ng/µl	16.399	11.469	1.43	0.4	RNA
	DS	672.9	ng/µl	16.823	11.605	1.45	0.4	RNA
CONTROL	coxsackie B6	831.4	ng/µl	20.786	15.329	1.36	0.4	RNA
	coxsackie B6	868.4	ng/µl	21.71	15.626	1.39	0.41	RNA
	coxsackie B6	862.9	ng/µl	21.573	15.288	1.41	0.42	RNA

Table VI (2): RNA concentrations (ng/ul) for samples collected for the New Germany TW and receiving Aller River between March 2012 and February 2013

	NEW GERMANY TW							
	Sample ID	**N. Acid Conc.**	**Unit**	**A260**	**A280**	**260/280**	**260/230**	**Sample Type**
AUTUMN	BC	649.2	ng/µl	16.231	10.891	1.49	0.31	RNA
	BC	813.3	ng/µl	20.332	12.357	1.65	0.34	RNA
	BC	597.5	ng/µl	14.938	10.434	1.43	0.31	RNA
	DP	301.1	ng/µl	7.528	4.538	1.66	0.5	RNA
	DP	311.3	ng/µl	7.784	4.612	1.69	0.53	RNA
	DP	288.5	ng/µl	7.213	4.45	1.62	0.47	RNA
	US	397.5	ng/µl	9.938	5.768	1.72	0.71	RNA
	US	391.4	ng/µl	9.784	5.759	1.7	0.69	RNA
	US	406.1	ng/µl	10.152	5.821	1.74	0.74	RNA
	DS	341.8	ng/µl	8.546	4.971	1.72	0.58	RNA
	DS	357	ng/µl	8.924	5.064	1.76	0.62	RNA
	DS	378.9	ng/µl	9.473	5.209	1.82	0.69	RNA
WINTER	BC	145	ng/µl	3.626	2.416	1.5	0.28	RNA
	BC	148.7	ng/µl	3.719	2.459	1.51	0.28	RNA
	BC	137.6	ng/µl	3.441	2.341	1.47	0.29	RNA
	DP	214.9	ng/µl	5.373	3.408	1.58	0.36	RNA
	DP	222.7	ng/µl	5.568	3.466	1.61	0.37	RNA
	DP	232.2	ng/µl	5.804	3.543	1.64	0.38	RNA
	US	387.4	ng/µl	9.685	5.581	1.74	0.66	RNA
	US	399	ng/µl	9.975	5.638	1.77	0.7	RNA
	US	409.9	ng/µl	10.246	5.683	1.8	0.73	RNA
	DS	904.4	ng/µl	22.61	16.069	1.41	0.41	RNA
	DS	945.8	ng/µl	23.644	16.196	1.46	0.43	RNA
	DS	969.3	ng/µl	24.232	16.271	1.49	0.44	RNA
SPRING	BC	609.3	ng/µl	15.234	11.372	1.34	0.39	RNA
	BC	634.5	ng/µl	15.863	11.373	1.39	0.39	RNA
	BC	658.7	ng/µl	16.467	11.617	1.42	0.4	RNA
	DP	664.9	ng/µl	16.623	11.792	1.41	0.38	RNA
	DP	692.4	ng/µl	17.309	11.86	1.46	0.38	RNA
	DP	736.1	ng/µl	18.403	12.21	1.51	0.38	RNA
	US	552.7	ng/µl	13.819	10.297	1.34	0.35	RNA
	US	583.2	ng/µl	14.58	10.383	1.4	0.34	RNA
	US	596.5	ng/µl	14.912	10.509	1.42	0.34	RNA
	DS	1336.7	ng/µl	33.418	22.312	1.5	0.57	RNA
	DS	1403.6	ng/µl	35.089	22.537	1.56	0.61	RNA
	DS	1453	ng/µl	36.326	22.655	1.6	0.64	RNA
SUMMER	BC	642.2	ng/µl	16.056	11.958	1.34	0.4	RNA
	BC	688.5	ng/µl	17.212	12.271	1.4	0.4	RNA
	BC	715	ng/µl	17.875	12.417	1.44	0.4	RNA
	DP	540.9	ng/µl	13.522	10.254	1.32	0.38	RNA
	DP	582.7	ng/µl	14.567	10.431	1.4	0.38	RNA
	DP	616.2	ng/µl	15.405	10.794	1.43	0.38	RNA
	US	716.4	ng/µl	17.909	13.845	1.29	0.41	RNA
	US	746.3	ng/µl	18.659	13.899	1.34	0.42	RNA
	US	816.3	ng/µl	20.407	14.329	1.42	0.41	RNA
	DS	639.9	ng/µl	15.998	11.462	1.4	0.37	RNA
	DS	666.3	ng/µl	16.657	11.423	1.46	0.37	RNA
	DS	714.6	ng/µl	17.866	11.832	1.51	0.37	RNA
CONTROL	coxsackie B6	831.4	ng/µl	20.786	15.329	1.36	0.4	RNA
	coxsackie B6	868.4	ng/µl	21.71	15.626	1.39	0.41	RNA
	coxsackie B6	862.9	ng/µl	21.573	15.288	1.41	0.42	RNA

Table VI (3): cDNA concentrations (ng/ul) for samples collected for the Northern WWTP and receiving Umgeni River between March 2012 and February 2013

	NORTHERN WWTP							
	Sample ID	**N. Acid Conc.**	**Unit**	**A260**	**A280**	**260/280**	**260/230**	**Sample Type**
AUTUMN	BC	4043.7	ng/µl	80.873	47.21	1.71	2.09	DNA
	BC	4045.8	ng/µl	80.915	47.156	1.72	2.1	DNA
	BC	4060.8	ng/µl	81.216	47.365	1.71	2.1	DNA
	DP	70.2	ng/µl	1.404	0.825	1.7	0.45	DNA
	DP	70.6	ng/µl	1.412	0.836	1.69	0.45	DNA
	DP	71.7	ng/µl	1.434	0.849	1.69	0.45	DNA
	US	1940	ng/µl	38.799	23.796	1.63	1.72	DNA
	US	1953	ng/µl	39.06	24.015	1.63	1.66	DNA
	US	1947.8	ng/µl	38.957	23.835	1.63	1.72	DNA
	DS	2602.7	ng/µl	52.053	31.706	1.64	1.88	DNA
	DS	2576	ng/µl	51.521	31.358	1.64	1.87	DNA
	DS	2586.3	ng/µl	51.726	31.631	1.64	1.87	DNA
WINTER	BC	2391.1	ng/µl	47.821	29.302	1.63	1.63	DNA
	BC	2358.4	ng/µl	47.168	28.91	1.63	1.63	DNA
	BC	2357.9	ng/µl	47.158	28.889	1.63	1.65	DNA
	DP	3601.9	ng/µl	72.039	42.846	1.68	1.91	DNA
	DP	3595.5	ng/µl	71.911	42.774	1.68	1.9	DNA
	DP	3596.9	ng/µl	71.937	43.051	1.67	1.9	DNA
	US	3416.7	ng/µl	68.335	41.009	1.67	1.84	DNA
	US	3402.8	ng/µl	68.055	40.73	1.67	1.85	DNA
	US	3408.4	ng/µl	68.168	40.884	1.67	1.83	DNA
	DS	2834.5	ng/µl	56.691	34.422	1.65	1.85	DNA
	DS	2799.2	ng/µl	55.983	34.126	1.64	1.85	DNA
	DS	2819.8	ng/µl	56.396	34.341	1.64	1.86	DNA
SPRING	BC	1976.1	ng/µl	39.522	22.437	1.76	1.94	DNA
	BC	2033.5	ng/µl	40.67	23.118	1.76	1.91	DNA
	BC	2086.6	ng/µl	41.733	23.714	1.76	1.9	DNA
	DP	2302.5	ng/µl	46.049	26.307	1.75	1.89	DNA
	DP	2265.3	ng/µl	45.307	25.817	1.75	1.96	DNA
	DP	2270.8	ng/µl	45.417	25.663	1.77	1.97	DNA
	US	5802.9	ng/µl	116.058	63.969	1.81	2.09	DNA
	US	5972.3	ng/µl	119.447	65.55	1.82	2.1	DNA
	US	6610	ng/µl	132.2	73.106	1.81	2.1	DNA
	DS	4256.2	ng/µl	85.123	48.812	1.74	1.99	DNA
	DS	4246.2	ng/µl	84.923	48.799	1.74	1.99	DNA
	DS	4244.8	ng/µl	84.896	48.735	1.74	1.98	DNA
SUMMER	BC	2043.9	ng/µl	40.879	23.224	1.76	1.96	DNA
	BC	2039.3	ng/µl	40.786	23.124	1.76	1.99	DNA
	BC	2045.9	ng/µl	40.917	23.18	1.77	1.99	DNA
	DP	2034.2	ng/µl	40.684	22.98	1.77	2.02	DNA
	DP	2044.9	ng/µl	40.898	23.083	1.77	2.02	DNA
	DP	2050.1	ng/µl	41.002	23.201	1.77	2.02	DNA
	US	3352.8	ng/µl	67.056	38.063	1.76	1.88	DNA
	US	3401.3	ng/µl	68.027	38.753	1.76	1.81	DNA
	US	3393.7	ng/µl	67.875	38.667	1.76	1.87	DNA
	DS	1873	ng/µl	37.46	21.191	1.77	1.81	DNA
	DS	1871.9	ng/µl	37.438	21.126	1.77	1.78	DNA
	DS	1880.4	ng/µl	37.608	21.289	1.77	1.79	DNA
CONTROL	coxsackie B6	2917.2	ng/µl	58.344	34.783	1.68	1.74	DNA
	coxsackie B6	2911.1	ng/µl	58.221	34.745	1.68	1.72	DNA
	coxsackie B6	2933.2	ng/µl	58.664	34.885	1.68	1.74	DNA

Table VI (4): cDNA concentrations (ng/ul) for samples collected for the New Germany TW and receiving Aller River between March 2012 and February 2013

	NEW GERMANY TW							
	Sample ID	**N. Acid Conc.**	**Unit**	**A260**	**A280**	**260/280**	**260/230**	**Sample Type**
AUTUMN	BC	3832	ng/µl	76.639	44.891	1.71	1.84	DNA
	BC	3850.2	ng/µl	77.004	45.019	1.71	1.83	DNA
	BC	3957.8	ng/µl	79.156	46.573	1.7	1.82	DNA
	DP	4232.7	ng/µl	84.653	49.199	1.72	2.01	DNA
	DP	4227.8	ng/µl	84.556	49.39	1.71	2	DNA
	DP	4229.7	ng/µl	84.594	49.378	1.71	1.99	DNA
	US	3121.8	ng/µl	62.436	36.928	1.69	1.88	DNA
	US	3126.7	ng/µl	62.533	36.942	1.69	1.84	DNA
	US	3132.5	ng/µl	62.651	37.14	1.69	1.82	DNA
	DS	3556.5	ng/µl	71.131	43.408	1.64	1.84	DNA
	DS	4781.1	ng/µl	95.622	55.351	1.73	1.97	DNA
	DS	4935.4	ng/µl	98.707	57.11	1.73	1.93	DNA
WINTER	BC	3546.7	ng/µl	70.935	41.71	1.7	2.01	DNA
	BC	3543.6	ng/µl	70.872	41.5	1.71	2.02	DNA
	BC	3563	ng/µl	71.26	41.931	1.7	1.97	DNA
	DP	3946	ng/µl	78.92	45.927	1.72	2.03	DNA
	DP	3925.8	ng/µl	78.516	45.823	1.71	2.03	DNA
	DP	3943.2	ng/µl	78.864	46.151	1.71	2.01	DNA
	US	3654.5	ng/µl	73.09	43.09	1.7	1.91	DNA
	US	3668.9	ng/µl	73.378	43.072	1.7	1.91	DNA
	US	3643.5	ng/µl	72.87	42.827	1.7	1.95	DNA
	DS	4230.7	ng/µl	84.613	49.652	1.7	1.82	DNA
	DS	4239.2	ng/µl	84.785	49.436	1.72	1.83	DNA
	DS	4264.8	ng/µl	85.296	50.067	1.7	1.82	DNA
SPRING	BC	1407.5	ng/µl	28.15	16.536	1.7	1.79	DNA
	BC	1425.4	ng/µl	28.508	16.797	1.7	1.8	DNA
	BC	1439.5	ng/µl	28.79	16.848	1.71	1.83	DNA
	DP	1651	ng/µl	33.019	19.321	1.71	1.71	DNA
	DP	1641.8	ng/µl	32.836	19.336	1.7	1.71	DNA
	DP	1644.7	ng/µl	32.895	19.249	1.71	1.72	DNA
	US	2425.4	ng/µl	48.509	28.835	1.68	1.69	DNA
	US	2385.8	ng/µl	47.716	28.308	1.69	1.73	DNA
	US	2374.4	ng/µl	47.488	28.371	1.67	1.72	DNA
	DS	2349.1	ng/µl	46.983	27.85	1.69	1.49	DNA
	DS	2338	ng/µl	46.759	27.772	1.68	1.48	DNA
	DS	2340	ng/µl	46.8	27.709	1.69	1.49	DNA
SUMMER	BC	1534.1	ng/µl	30.682	17.97	1.71	1.82	DNA
	BC	1530.1	ng/µl	30.602	18.037	1.7	1.79	DNA
	BC	1534.6	ng/µl	30.692	18.071	1.7	1.82	DNA
	DP	1338.7	ng/µl	26.773	15.819	1.69	1.78	DNA
	DP	1336	ng/µl	26.72	15.737	1.7	1.78	DNA
	DP	1324.7	ng/µl	26.494	15.63	1.7	1.81	DNA
	US	2664.9	ng/µl	53.299	31.996	1.67	1.73	DNA
	US	2645	ng/µl	52.899	31.812	1.66	1.71	DNA
	US	2665.5	ng/µl	53.31	32.06	1.66	1.7	DNA
	DS	2214.3	ng/µl	44.285	26.304	1.68	1.62	DNA
	DS	2206.2	ng/µl	44.124	26.215	1.68	1.61	DNA
	DS	2209.4	ng/µl	44.188	26.334	1.68	1.61	DNA
CONTROL	coxsackie B6	2917.2	ng/µl	58.344	34.783	1.68	1.74	DNA
	coxsackie B6	2911.1	ng/µl	58.221	34.745	1.68	1.72	DNA
	coxsackie B6	2933.2	ng/µl	58.664	34.885	1.68	1.74	DNA

Table VI (5): DNA concentrations (ng/ul) for samples collected for the Northern WWTP and receiving Umgeni River between March 2012 and February 2013

	NORTHERN WWTP							
	Sample ID	**N. Acid Conc.**	**Unit**	**A260**	**A280**	**260/280**	**260/230**	**Sample Type**
AUTUMN	BC	6.1	ng/µl	0.123	0.058	2.13	-0.02	DNA
	BC	7.4	ng/µl	0.147	0.079	1.85	-0.02	DNA
	BC	7.4	ng/µl	0.148	0.072	2.06	-0.02	DNA
	DP	3.8	ng/µl	0.075	0.028	2.65	-0.01	DNA
	DP	4.2	ng/µl	0.083	0.041	2.02	-0.01	DNA
	DP	4.4	ng/µl	0.088	0.035	2.49	-0.01	DNA
	US	6.9	ng/µl	0.138	0.084	1.63	-0.02	DNA
	US	8.5	ng/µl	0.17	0.102	1.67	-0.03	DNA
	US	8.6	ng/µl	0.173	0.096	1.8	-0.03	DNA
	DS	4.7	ng/µl	0.094	0.056	1.67	-0.01	DNA
	DS	5.2	ng/µl	0.104	0.059	1.75	-0.02	DNA
	DS	6.3	ng/µl	0.126	0.069	1.83	-0.02	DNA
WINTER	BC	98.5	ng/µl	1.97	1.345	1.47	-0.46	DNA
	BC	105.7	ng/µl	2.114	1.418	1.49	-0.57	DNA
	BC	106.5	ng/µl	2.131	1.425	1.5	-0.58	DNA
	DP	143.1	ng/µl	2.863	1.918	1.49	-0.95	DNA
	DP	146.4	ng/µl	2.929	1.956	1.5	-1.02	DNA
	DP	148.4	ng/µl	2.968	1.972	1.51	-1.07	DNA
	US	211.6	ng/µl	4.233	2.725	1.55	-2.11	DNA
	US	217.4	ng/µl	4.348	2.783	1.56	-2.42	DNA
	US	220.8	ng/µl	4.417	2.819	1.57	-2.67	DNA
	DS	257.1	ng/µl	5.141	3.221	1.6	-2.56	DNA
	DS	258.7	ng/µl	5.175	3.24	1.6	-2.67	DNA
	DS	261.7	ng/µl	5.234	3.272	1.6	-2.84	DNA
SPRING	BC	4.7	ng/µl	0.095	0.073	1.3	0.28	DNA
	BC	8.8	ng/µl	0.176	0.114	1.54	0.36	DNA
	BC	9.6	ng/µl	0.191	0.12	1.6	0.35	DNA
	DP	5.3	ng/µl	0.106	0.093	1.14	0.2	DNA
	DP	5.1	ng/µl	0.103	0.075	1.37	0.19	DNA
	DP	6.1	ng/µl	0.122	0.094	1.29	0.2	DNA
	US	15.4	ng/µl	0.308	0.245	1.26	0.63	DNA
	US	8.8	ng/µl	0.177	0.142	1.24	0.53	DNA
	US	11.8	ng/µl	0.237	0.165	1.44	0.54	DNA
	DS	2	ng/µl	0.04	0.04	1.02	0.14	DNA
	DS	4.9	ng/µl	0.099	0.065	1.52	0.28	DNA
	DS	6.3	ng/µl	0.126	0.089	1.41	0.32	DNA
SUMMER	BC	5.8	ng/µl	0.115	0.092	1.25	0.2	DNA
	BC	7	ng/µl	0.139	0.103	1.36	0.22	DNA
	BC	6.6	ng/µl	0.133	0.096	1.38	0.2	DNA
	DP	5.3	ng/µl	0.106	0.081	1.32	0.29	DNA
	DP	5.7	ng/µl	0.114	0.081	1.41	0.29	DNA
	DP	7.1	ng/µl	0.142	0.101	1.4	0.33	DNA
	US	1.1	ng/µl	0.022	0.033	0.67	0.12	DNA
	US	2.4	ng/µl	0.049	0.044	1.1	0.2	DNA
	US	3.8	ng/µl	0.076	0.065	1.16	0.26	DNA
	DS	1.3	ng/µl	0.027	0.026	1.03	0.08	DNA
	DS	2.1	ng/µl	0.042	0.037	1.14	0.11	DNA
	DS	2.2	ng/µl	0.044	0.036	1.2	0.11	DNA

Table VI (6): DNA concentrations (ng/ul) for samples collected for the New Germany TW and receiving Aller River between March 2012 and February 2013

	NEW GERMANY TW							
	Sample ID	**N. Acid Conc.**	**Unit**	**A260**	**A280**	**260/280**	**260/230**	**Sample Type**
AUTUMN	BC	150.3	ng/µl	3.007	4.009	0.75	0.54	DNA
	BC	152.6	ng/µl	3.051	4.023	0.76	0.55	DNA
	BC	155	ng/µl	3.1	4.053	0.76	0.55	DNA
	DP	346	ng/µl	6.921	5.264	1.31	0.8	DNA
	DP	474.6	ng/µl	9.492	6.014	1.58	0.63	DNA
	DP	496.3	ng/µl	9.927	6.168	1.61	0.65	DNA
	US	61.8	ng/µl	1.236	0.861	1.44	-0.3	DNA
	US	61.5	ng/µl	1.23	0.847	1.45	-0.3	DNA
	US	63.3	ng/µl	1.267	0.87	1.46	-0.32	DNA
	DS	101.6	ng/µl	2.032	1.428	1.42	-0.61	DNA
	DS	103.1	ng/µl	2.062	1.433	1.44	-0.64	DNA
	DS	104.9	ng/µl	2.099	1.453	1.44	-0.67	DNA
WINTER	BC	79.1	ng/µl	1.583	1.095	1.45	-0.4	DNA
	BC	80.2	ng/µl	1.604	1.096	1.46	-0.41	DNA
	BC	80.7	ng/µl	1.613	1.09	1.48	-0.42	DNA
	DP	267.3	ng/µl	5.347	3.291	1.62	-3.07	DNA
	DP	270.5	ng/µl	5.41	3.311	1.63	-3.22	DNA
	DP	273	ng/µl	5.46	3.332	1.64	-3.38	DNA
	US	104.4	ng/µl	2.088	1.441	1.45	-0.58	DNA
	US	105.3	ng/µl	2.107	1.435	1.47	-0.6	DNA
	US	105.9	ng/µl	2.118	1.443	1.47	-0.61	DNA
	DS	161.4	ng/µl	3.228	2.143	1.51	-1.44	DNA
	DS	163.8	ng/µl	3.276	2.162	1.52	-1.53	DNA
	DS	168.2	ng/µl	3.363	2.205	1.53	-1.79	DNA
SPRING	BC	5.1	ng/µl	0.102	0.119	0.86	0.41	DNA
	BC	6	ng/µl	0.12	0.126	0.96	0.45	DNA
	BC	5.7	ng/µl	0.113	0.12	0.94	0.42	DNA
	DP	6	ng/µl	0.12	0.104	1.16	0.23	DNA
	DP	6.3	ng/µl	0.127	0.109	1.16	0.22	DNA
	DP	5.8	ng/µl	0.117	0.112	1.04	0.28	DNA
	US	2.5	ng/µl	0.051	0.059	0.86	0.18	DNA
	US	3.4	ng/µl	0.069	0.057	1.2	0.22	DNA
	US	9.3	ng/µl	0.186	0.114	1.63	0.33	DNA
	DS	3.2	ng/µl	0.063	0.052	1.22	0.14	DNA
	DS	4.6	ng/µl	0.092	0.07	1.33	0.18	DNA
	DS	3.8	ng/µl	0.077	0.061	1.25	0.2	DNA
SUMMER	BC	3.5	ng/µl	0.069	0.054	1.28	0.22	DNA
	BC	5.2	ng/µl	0.103	0.065	1.59	0.27	DNA
	BC	7.8	ng/µl	0.156	0.092	1.69	0.32	DNA
	DP	4.2	ng/µl	0.083	0.076	1.09	0.18	DNA
	DP	4.8	ng/µl	0.095	0.064	1.49	0.19	DNA
	DP	5.1	ng/µl	0.103	0.087	1.18	0.19	DNA
	US	12.7	ng/µl	0.254	0.227	1.12	0.23	DNA
	US	4.8	ng/µl	0.095	0.071	1.34	0.27	DNA
	US	7.1	ng/µl	0.142	0.097	1.46	0.31	DNA
	DS	4.7	ng/µl	0.095	0.069	1.38	0.28	DNA
	DS	11.3	ng/µl	0.226	0.141	1.6	0.39	DNA
	DS	14.8	ng/µl	0.295	0.201	1.47	0.4	DNA

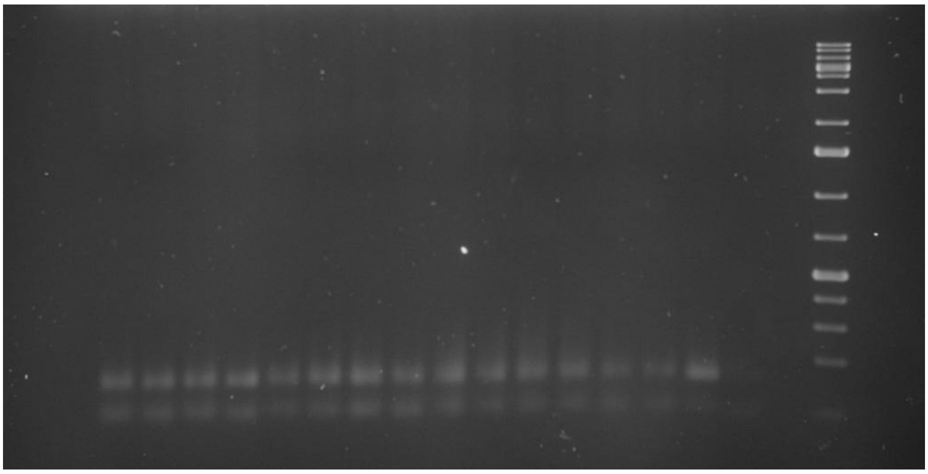


Figure VI (1): Result of conventional enteroviral PCR detection from all samples collected during Autumn and Winter for the NWWTP and NGTW and respective receiving rivers (Umgeni River and Aller River). Lane 2: NW BC Autumn, 3: NW US Autumn, 4 NW DS Autumn, : 5: NW BC Winter, 6: NW DP Winter, 7: NW DS Winter, 8: NG BC Autumn, 9: NG DP Autumn, 10: NG US Autumn, 11: NG DS Autumn, 12: NG BC Winter, 13: NG DP Winter, 14: NG US Winter, 15: NG DS Winter, 16: Human Adenovirus positive control, 17: Negative control, 19: 1 KB Plus Ladder. Expected amplicon size is 128 base pairs.

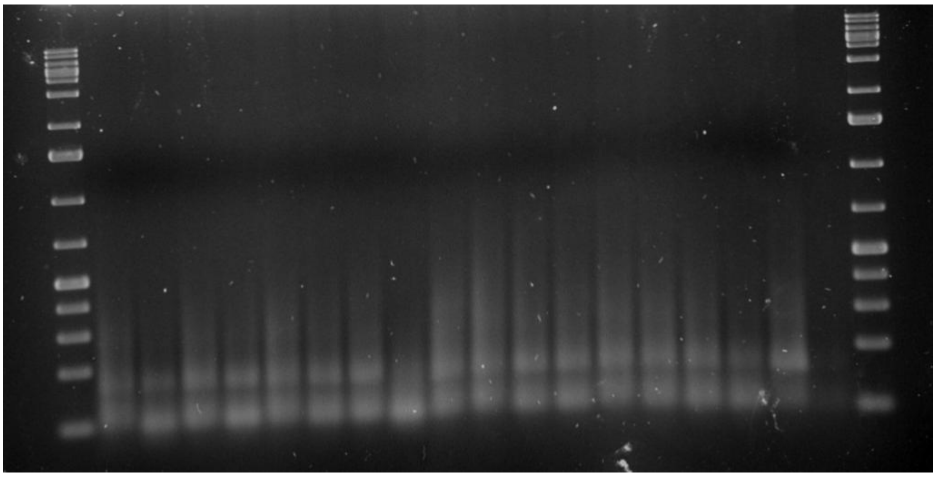


Figure VI (2): Result of conventional enteroviral PCR detection for all samples collected during Spring and Summer for the NWWTP and NGTW and respective receiving rivers (Umgeni River and Aller River). Lane 1: 1 KB Plus Ladder, 2: NG BC Spring, 3: NG DP Spring, 4: NG US Spring, : 5: NG DS Spring, 6: NG BC Summer, 7: NG DP Summer, 8: NG US Summer, 9: NG DS Summer, 10: NW BC Spring, 11: NW DP Spring, 12: NW US Spring, 13: NW DS Spring, 14: NW BC Summer, 15: NW DP Summer, 16: NW US Summer, 17: NW DS Summer, 18: Enteroviral control, 19: Negative control, 20: 1 KB Plus Ladder. Expected amplicon size is 128 base pairs.

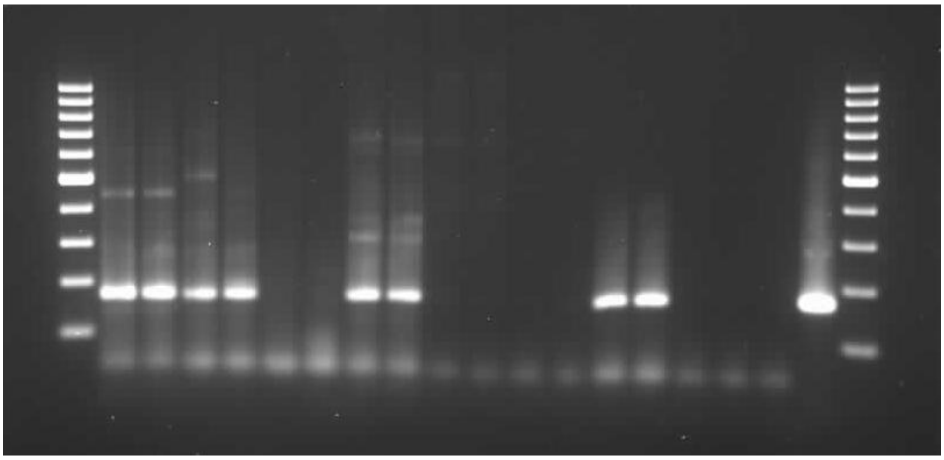


Figure VI (3): Result of conventional adenoviral PCR detection for all samples collected during Autumn and Winter for the NGTW and receiving Aller River. Lane 1: 100 bp Ladder, 2-3: BC Autumn, 4-5: DP Autumn, 6-7: US Autumn (not detected), 8-9: DS Autumn, 10-11: BC Winter (not detected), 12-13: DP Winter (not detected), 14-15: US Winter, 16-17: DS Winter (not detected), 18, Negative Control, 19: Adenovirus Positive Control, 20: 100 bp Ladder. Expected amplicon size is 168 base pairs.

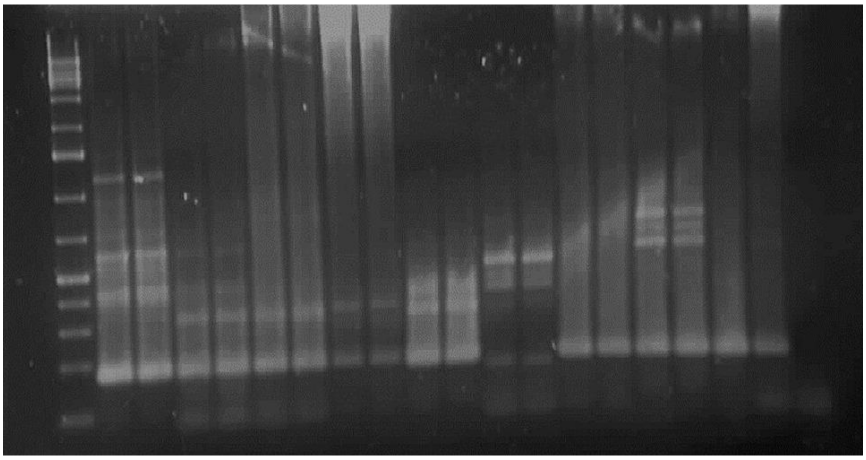


Figure VI (4): Result of conventional adenoviral PCR detection for all samples collected during Spring and Summer for the NWWTP and receiving Umgeni River. Lane 1: 1 KB Plus Ladder, 2-3: BC Spring, 4-5: DP Spring, 6-7: US Spring, 8-9: DS Spring, 10-11: BC Summer, 12-13: DP Summer (not detected), 14-15: US Summer, 16-17: DS Summer, 18-19: Adenovirus Positive Control, 20: Negative Control. Expected amplicon size is 168 base pairs.

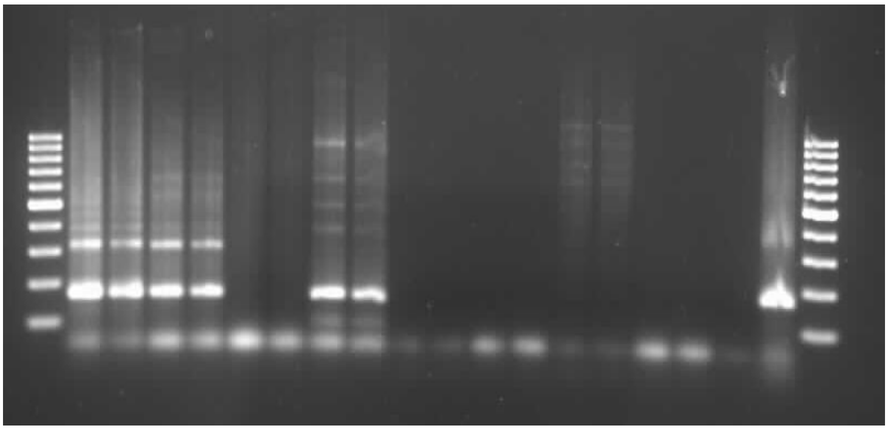


Figure VI (5): Result of conventional adenoviral PCR detection for all samples collected during Autumn and Winter for the NWWTP and receiving Umgeni River. Lane 1: 100 bp Ladder, 2-3: BC Autumn, 4-5: DP Autumn, 6-7: US Autumn (not detected), 8-9: DS Autumn, 10-11: BC Winter (not detected), 12-13: DP Winter (not detected), 14-15: US Winter (not detected), 16-17: DS Winter (not detected), 18, Negative Control, 19: Adenovirus Positive Control, 20: 100 bp Ladder. Expected amplicon size is 168 base pairs.

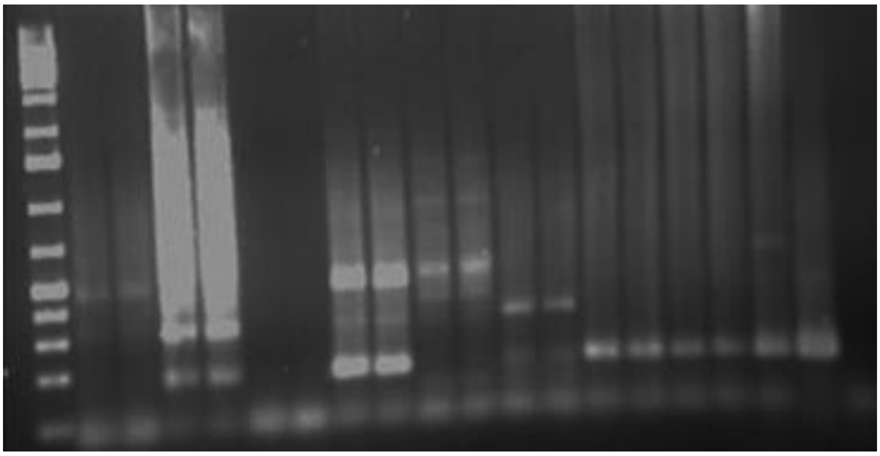


Figure VI (6): Result of conventional adenoviral PCR detection for all samples collected during Spring and Summer for the NGTW and receiving Aller River. Lane 1: 1 KB Plus Ladder, 2-3: BC Spring (not detected), 4-5: DP Spring, 6-7: US Spring (not detected), 8-9: DS Spring, 10-11: BC Summer (not detected), 12-13: DP Summer, 14-15: US Summer, 16-17: DS Summer, 18-19: Adenovirus Positive Control, 20: Negative Control. Expected amplicon size is 168 base pairs.

Table VI (7): Edited sequences and BLAST search results for all positive Adenovirus samples for the NWWTP, NGTW and receiving rivers

	SAMPLE	EDITED SEQUENCE	% SIMILARITY	ACCESSION NUMBER
NORTHERN WWTP ADENOVIRUS	NW BC SPRING	AACGGCCGCTACGTGCCTTTCCCACATTCAGTGCCCCAGAAATTTTTCGCCATTAAAAA TCTCCTCCTCCTGCCCGGCTCCTACACCTATGAGGGAACTTCCGCAAGGATGTA	99	AB330121.1
	NW US SPRING	CGTATACACCACTAGCCCTATACTACATGAACAGTTTTCCCCCAAATGAACCAGCCCCC TTTGCCCTTTGAACCTGCTACTGCTCCCGGGCTCCTACACCTACGAATGGAACTTCCGA AAGGATGT	98	HQ883276.1
	NW BC SUMMER	ACGGCAGCTACGTGCCCTTTCACATCCAGTGCCCCAAAAGTTTTTTGCCATTAAGAACC TGCTCCTGCTGCCGGGCTCCTACACCTATGAATGGAACTTCCGGAAGGATGT	91	AB746853.1
	NW US SUMMER	GCTACGTGCCCTTTCAATTCAGGTGCCCCAAAAGTTTTTTGCCATTAAAAACCTCCTCC TCCTGCCAGGCTCATATACATATGAATGGAACTTCCGAAAGGATGTAA	98	GU048702.1
	NW DS SUMMER	AACGGCCGCTACGTGCCCTTTCACATTCAGGTGCCCCAAAAGTTTTTTGCCATTAAAAA CCTCCTCCTCCTGCCAGGCTCATATACATATGAATGGAACTTCCGAAAGGATGTTA	99	GU048702.1
	NW BC AUTUMN	CGGTGCCCCAAAAGTTTTTTGAAAAAAAAACCTCCTCCTCCTGCCAGGCTCATATACAT ATGAATGGAACTTCCGCAAGGATGT	93	JX173084.1
	NW DP AUTUMN	GCTACGTGCCCTTTCACATTCAGGTGCCCCAAAAGTTTTTTCCCATTAAAAACCTCCTC CTCCTGCCAGGCTCATATACATATGAATGGAACTTCCGAAAGGATGT	98	GU048702.1
NEW GERMANY TW ADENOVIRUS	NG DS SPRING	CACGGCCGCTACGTGCCCTTCCCATCCAAGTGCCCCAAAAGTTCTTTGCCATCAAGAAC CTGCTCCTGCTCCCGGGCTCCTACACCTACGAGTGGAACTTCCGAAAGGATGTAG	98	JN226758.1
	NG US SUMMER	GTGCACTTTCACATTCAGGTGCCCCAAAAGTTTTTTGCCATTAAAAACCTCCTCCTCCT GCCAGGCTCATATACATATGAATGGAACTTCCGAAAGGATGTAAAG	98	GU048702.1
	NG DS SUMMER	GACGACATGAACACTTTCACTTCATGTGCCCCAAAAGTTTTTTGCCATTAAAAACCTCC TCCTCCTGCCAGGCTCATATACATATGAATGGAACTTCCGAAAGGATGTA	97	GU048702.1
	NG DS AUTUMN	GCCCTTTCACATTCAGGTGCCCCAAAAGTTTTTTGCAAAAAAAACCTCCTCCTCCTGCC AGGCTCATATACATATGAATGGAACTTCCGCAAGGATGT	95	JX173084.1

Table VI (8): Edited sequences and BLAST search results for all positive Enteroviral samples for the NWWTP and receiving Umgeni River

	SAMPLE	EDITED SEQUENCE	% SIMILARITY	ACCESSION NUMBER
NORTHERN WWTP ENTEROVIRUS	NW BC AUTUMN	ACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGCTTATGGTGACAATAA	98	KC570453.1
	NW US AUTUMN	GCTCTGTCGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCT GCTTATGGTGACAACCAWGCTTAKGGT	93	JX390655.1
	NW DS AUTUMN	GCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGCCTGCTTATGGT GACAACCAT	95	JX390655.1
	NW BC WINTER	GTGGCGGAACCGACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGCTTA TGGTGACAACAA	99	JX390655.1
	NW DP WINTER	ACAATGAAAGCTCTGGCGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTT ATCTTGGCTGCTTATGGTGACAATCATGCTAGGGTGACAACCA	95	EF015021.1
	NW DS WINTER	AGCTCTGGCGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGC TGCTTATGGTGACAACCATGCTTAGGGTGACAA	94	JX390655.1
	NW BC SPRING	CTTTGGGGGACATCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGC TTATGGTGACAATCATGCTTATGGTGACAATCA	98	EF015021.1
	NW US SPRING	GCTTGGGGCGGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGC TTATGGTGACAATAATGCTTATGGTGACAATCA	96	EF107097.1
	NW DS SPRING	GCTTGGGGGACATCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGC TTATGGGGACAATCATGCTTAGGGTGACAACAA	97	EF015021.1
	NW BC SUMMER	GCTCTGGGGCACACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGCCTG CTTATGGTGACAATAATGCTTATGGTGACAATAA	95	KC570453.1
	NW DP SUMMER	GCTTGGGGGACATCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGC TTATGGTGACAATCATGCTTATGGTGACAATAA	98	EF015021.1
	NW US SUMMER	GCTTGGGGGACACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGC TTATGGTGACAATCATGCTTATGGTGACAATCA	95	EF015021.1

Table VI (9): Edited sequences and BLAST search results for all positive Enteroviral samples for the NGTW and receiving Aller River

	SAMPLE	EDITED SEQUENCE	% SIMILARITY	ACCESSION NUMBER
NEW GERMANY TW ENTEROVIRUSES	NG BC AUTUMN	AGCTCTGGCGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGC TGCTTATGGTGACAATCATGC	95	EF015021.1
	NG DP WINTER	GGCGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGCTTA TGGTGACAACCA	95	EF015021.1
	NG US WINTER	AGCTCTGGGAGCGGAACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCATGG CTGCTTATGGTGACAATCAAGCTAAGGGTGACAA	96	JX390655.1
	NG DS WINTER	AGCTCTGGGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCT GCTTATGGTGACAACCATGCTTAGGGTGACAATCA	91	JX390655.1
	NG BC WINTER	GCTCTGCCGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCT GCTTATGGTGACAATCA	97	EF015021.1
	NG DP SPRING	CTTCGCAGCAGAATCAGCTACTTTGGGTGTCCCTCGTTTCCTATTTCCTTTACACTGGCT GCTTATGGTGACAATCA	92	JQ41368.1
	NG US SPRING	ACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGCCTGCTTATGGTGACA ATCATG	95	EF015021.1
	NG DS SPRING	CTTGGGGCAGACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGCT TATGGTGACAATAATGCTTAGGGTGACAATAA	97	KC570453.1
	NG DP SUMMER	GCTTTGGGGACATCAACTTCTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGCCTGC TTTTGGTGACAATCATTTTTAGG	94	EF015021.1
	NG US SUMMER	CTTGGGGGACACCAACTACTTTGGGTGTCCGTGTTTCCTTTTATTTTTATCTTGGCTGCT TATGGGGACAATCATGCTTATGGTGACAATCA	93	EF015021.1

APPENDIX VII: STATISTICAL ANALYSES

All statistical analyses were performed using The Statistical Package for Social Sciences Version 21.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.) All data were analyzed using descriptive statistical analysis (95% confidence limit). Continuous variables were tested for normality prior to parametric testing by assessing the skewness, kurtosis, Kolmogorov-Smirnov and Shapiro-Wilk values. In addition histograms, stem and leaf plots and normal Q-Q plots were also assessed. If skewed, data was normalized using the log transformation method.

Table VII (a): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured before chlorination for the NWTTP between March 2012 and February 2013

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMPERATURE	0.2666	36.0000	0.0000	0.8115	36.0000	0.0000
TURBIDITY	0.1991	36.0000	0.0009	0.8993	36.0000	0.0033
TDS	0.1388	36.0000	0.0771	0.9431	36.0000	0.0636
TSS	0.1464	36.0000	0.0494	0.8965	36.0000	0.0027
pH	0.1992	36.0000	0.0009	0.8962	36.0000	0.0027
DO	0.0917	36.0000	.200*	0.9864	36.0000	0.9295
BOD	0.1641	36.0000	0.0153	0.9278	36.0000	0.0214
COD	0.2297	36.0000	0.0000	0.8547	36.0000	0.0002
SAL	0.1364	36.0000	0.0882	0.9466	36.0000	0.0816
EC	0.1886	36.0000	0.0023	0.9305	36.0000	0.0260
RES	0.1555	36.0000	0.0277	0.8194	36.0000	0.0000
Log10_Res	0.1466	36.0000	0.0487	0.8706	36.0000	0.0006
Temp_RLog10	0.2554	36.0000	0.0000	0.9065	36.0000	0.0051
Log10_TSS	0.1410	36.0000	0.0679	0.9055	36.0000	0.0049
ECOLI	0.2635	36.0000	0.0000	0.8306	36.0000	0.0001
FC	0.3102	36.0000	0.0000	0.6753	36.0000	0.0000
FS	0.2085	36.0000	0.0004	0.7342	36.0000	0.0000
ENT	0.3814	36.0000	0.0000	0.5841	36.0000	0.0000
TC	0.3477	36.0000	0.0000	0.6339	36.0000	0.0000
HPC	0.3543	36.0000	0.0000	0.6802	36.0000	0.0000
Log10_FC	0.2316	36.0000	0.0000	0.8456	36.0000	0.0002
Log10_FS	0.1448	36.0000	0.0541	0.8971	36.0000	0.0028
Log10_ENT	0.2561	36.0000	0.0000	0.7100	36.0000	0.0000
Log10_TC	0.1588	36.0000	0.0222	0.8937	36.0000	0.0023

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (b): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured at the discharge point for the NWTTP between March 2012 and February 2013

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMP	0.1963	36.0000	0.0012	0.8588	36.0000	0.0003
TURB	0.1644	36.0000	0.0151	0.8997	36.0000	0.0033
TDS	0.1351	36.0000	0.0947	0.9110	36.0000	0.0069
TSS	0.1460	36.0000	0.0506	0.9293	36.0000	0.0239
pH	0.1662	36.0000	0.0132	0.9111	36.0000	0.0070
DO	0.1176	36.0000	.200*	0.9593	36.0000	0.2046
BOD	0.1274	36.0000	0.1482	0.9082	36.0000	0.0058
COD	0.1968	36.0000	0.0011	0.8480	36.0000	0.0002
EC	0.1507	36.0000	0.0376	0.9212	36.0000	0.0136
SAL	0.1462	36.0000	0.0499	0.9225	36.0000	0.0149
RES	0.2879	36.0000	0.0000	0.6944	36.0000	0.0000
Log10_Turb	0.0946	36.0000	.200*	0.9582	36.0000	0.1892
Log10_TSS	0.1430	36.0000	0.0605	0.9341	36.0000	0.0333
Log10_Res	0.2637	36.0000	0.0000	0.7658	36.0000	0.0000
BOD_RLog10	0.0856	36.0000	.200*	0.9712	36.0000	0.4604
Temp_RLog10	0.1830	36.0000	0.0037	0.9093	36.0000	0.0062
ECOLI	0.2166	36.0000	0.0002	0.8665	36.0000	0.0005
FC	0.1832	36.0000	0.0036	0.8303	36.0000	0.0001
FS	0.3251	36.0000	0.0000	0.6799	36.0000	0.0000
ENT	0.3206	36.0000	0.0000	0.6627	36.0000	0.0000
TC	0.1841	36.0000	0.0034	0.8221	36.0000	0.0000
HPC	0.2391	36.0000	0.0000	0.7787	36.0000	0.0000
FC_Log10	0.1553	36.0000	0.0279	0.9240	36.0000	0.0166

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (c): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured upstream of the Umgeni River for the NWTTP between March 2012 and February 2013

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMP	0.2345	36.0000	0.0000	0.8766	36.0000	0.0008
TURB	0.1885	36.0000	0.0023	0.9141	36.0000	0.0085
TDS	0.2202	36.0000	0.0001	0.8217	36.0000	0.0000
TSS	0.1024	36.0000	.200*	0.9612	36.0000	0.2336
pH	0.1212	36.0000	.200*	0.9442	36.0000	0.0688
DO	0.1958	36.0000	0.0012	0.9005	36.0000	0.0035
COD	0.1882	36.0000	0.0024	0.8727	36.0000	0.0007
BOD	0.2067	36.0000	0.0005	0.8012	36.0000	0.0000
EC	0.1842	36.0000	0.0033	0.8971	36.0000	0.0028
RES	0.1584	36.0000	0.0228	0.9057	36.0000	0.0049
SAL	0.5314	36.0000	0.0000	0.3134	36.0000	0.0000
Log10turbidity	0.1217	36.0000	0.1976	0.9606	36.0000	0.2240
Log10tds	0.1904	36.0000	0.0020	0.9202	36.0000	0.0128
Log10EC	0.1905	36.0000	0.0020	0.9202	36.0000	0.0127
Log10sal	0.2126	36.0000	0.0003	0.8641	36.0000	0.0004
Log10bod	0.1290	36.0000	0.1373	0.9440	36.0000	0.0679
Temp_R_Log10	0.1992	36.0000	0.0009	0.9150	36.0000	0.0090
ECOLI	0.2257	36.0000	0.0001	0.8055	36.0000	0.0000
FC	0.2674	36.0000	0.0000	0.7892	36.0000	0.0000
FS	0.2157	36.0000	0.0002	0.8501	36.0000	0.0002
ENT	0.1985	36.0000	0.0010	0.8536	36.0000	0.0002
TC	0.2563	36.0000	0.0000	0.6097	36.0000	0.0000
HPC	0.3135	36.0000	0.0000	0.6756	36.0000	0.0000
Ecoli_Log10	0.1848	36.0000	0.0032	0.8424	36.0000	0.0001

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (d): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured downstream of the Umgeni River for the NWTTP between March 2012 and February 2013

Tests of Normality						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMP	0.151	36.000	0.036	0.916	36.000	0.009
TURB	0.228	36.000	0.000	0.910	36.000	0.007
TDS	0.106	36.000	.200*	0.944	36.000	0.069
TSS	0.080	36.000	.200*	0.979	36.000	0.703
pH	0.138	36.000	0.083	0.908	36.000	0.006
DO	0.112	36.000	.200*	0.955	36.000	0.153
BOD	0.112	36.000	.200*	0.960	36.000	0.219
COD	0.243	36.000	0.000	0.833	36.000	0.000
EC	0.112	36.000	.200*	0.946	36.000	0.077
SAL	0.144	36.000	0.058	0.938	36.000	0.043
RES	0.243	36.000	0.000	0.826	36.000	0.000
Log10_Turbidity	0.150	36.000	0.039	0.955	36.000	0.146
Log10_TSS	0.470	36.000	0.000	0.398	36.000	0.000
Log10_Resistivity	0.227	36.000	0.000	0.870	36.000	0.001
Temp_RLog10	0.165	36.000	0.014	0.908	36.000	0.006
ECOLI	0.4755	36.0000	0.0000	0.3737	36.0000	0.0000
FC	0.3184	36.0000	0.0000	0.5078	36.0000	0.0000
FS	0.2763	36.0000	0.0000	0.6422	36.0000	0.0000
ENT	0.2882	36.0000	0.0000	0.6221	36.0000	0.0000
TC	0.4754	36.0000	0.0000	0.3580	36.0000	0.0000
HPC	0.2796	36.0000	0.0000	0.6526	36.0000	0.0000
ECOLI_LOG10	0.3421	36.0000	0.0000	0.5323	36.0000	0.0000
FC_LOG10	0.2248	36.0000	0.0001	0.6882	36.0000	0.0000
FS_LOG10	0.2696	36.0000	0.0000	0.6747	36.0000	0.0000
ENT_LOG10	0.2778	36.0000	0.0000	0.6484	36.0000	0.0000
TC_LOG10	0.2780	36.0000	0.0000	0.6325	36.0000	0.0000
HPC_LOG10	0.0767	36.0000	.200*	0.9764	36.0000	0.6219

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (e): Descriptive statistics for physicochemical and microbial parameters measured before chlorination for the NWTTP between March 2012 and February 2013

DESCRIPTIVES

			Statistic	Std. Error
TEMPERATURE	Mean		21.6472	0.6106
	95% Confidence Interval for Mean	Lower Bound	20.4076	
		Upper Bound	22.8869	
	5% Trimmed Mean		21.8858	
	Median		22.0000	
	Variance		13.4231	
	Std. Deviation		3.6638	
	Minimum		13.0000	
	Maximum		26.0000	
	Range		13.0000	
	Interquartile Range		3.5500	
	Skewness		-1.2425	0.3925
	Kurtosis		0.8969	0.7681
TUBIDITY	Mean		29.2842	2.7104
	95% Confidence Interval for Mean	Lower Bound	23.7818	
		Upper Bound	34.7865	
	5% Trimmed Mean		28.9585	
	Median		25.6000	
	Variance		264.4596	
	Std. Deviation		16.2622	
	Minimum		7.5300	
	Maximum		56.7000	
	Range		49.1700	
	Interquartile Range		25.7500	
	Skewness		0.4280	0.3925
	Kurtosis		-1.0425	0.7681
TOTAL DISSOLVED SOLIDS	Mean		402.1667	5.7759
	95% Confidence Interval for Mean	Lower Bound	390.4410	
		Upper Bound	413.8924	
	5% Trimmed Mean		402.6605	
	Median		409.5000	
	Variance		1201.0000	
	Std. Deviation		34.6554	
	Minimum		340.0000	
	Maximum		455.0000	
	Range		115.0000	
	Interquartile Range		52.7500	
	Skewness		-0.3449	0.3925
	Kurtosis		-0.8482	0.7681

DESCRIPTIVES

			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0364	0.0040
	95% Confidence Interval for Mean	Lower Bound	0.0282	
		Upper Bound	0.0446	
	5% Trimmed Mean		0.0343	
	Median		0.0325	
	Variance		0.0006	
	Std. Deviation		0.0242	
	Minimum		0.0005	
	Maximum		0.1145	
	Range		0.1140	
	Interquartile Range		0.0285	
	Skewness		1.3898	0.3925
	Kurtosis		2.4669	0.7681
pH	Mean		7.0928	0.0643
	95% Confidence Interval for Mean	Lower Bound	6.9623	
		Upper Bound	7.2232	
	5% Trimmed Mean		7.0819	
	Median		7.0000	
	Variance		0.1487	
	Std. Deviation		0.3856	
	Minimum		6.5400	
	Maximum		7.8100	
	Range		1.2700	
	Interquartile Range		0.6650	
	Skewness		0.5799	0.3925
	Kurtosis		-1.0214	0.7681
DISSOLVED OXYGEN	Mean		7.0615	0.0999
	95% Confidence Interval for Mean	Lower Bound	6.8586	
		Upper Bound	7.2644	
	5% Trimmed Mean		7.0646	
	Median		7.0350	
	Variance		0.3596	
	Std. Deviation		0.5997	
	Minimum		5.7150	
	Maximum		8.2500	
	Range		2.5350	
	Interquartile Range		0.8763	
	Skewness		-0.1138	0.3925
	Kurtosis		-0.5515	0.7681

DESCRIPTIVES

			Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean		2.7314	0.1993
	95% Confidence Interval for Mean	Lower Bound	2.3268	
		Upper Bound	3.1360	
	5% Trimmed Mean		2.7211	
	Median		2.5125	
	Variance		1.4298	
	Std. Deviation		1.1957	
	Minimum		0.7761	
	Maximum		4.8134	
	Range		4.0373	
	Interquartile Range		2.1779	
	Skewness		0.2559	0.3925
	Kurtosis		-1.3177	0.7681
CHEMICAL OXYGEN DEMAND	Mean		192.7497	18.2890
	95% Confidence Interval for Mean	Lower Bound	155.6212	
		Upper Bound	229.8783	
	5% Trimmed Mean		196.3598	
	Median		198.0000	
	Variance		12041.4860	
	Std. Deviation		109.7337	
	Minimum		10.0000	
	Maximum		310.6667	
	Range		300.6667	
	Interquartile Range		193.9192	
	Skewness		-0.2973	0.3925
	Kurtosis		-1.4367	0.7681
SALINITY	Mean		821.9444	11.3102
	95% Confidence Interval for Mean	Lower Bound	798.9835	
		Upper Bound	844.9054	
	5% Trimmed Mean		822.7963	
	Median		836.0000	
	Variance		4605.1397	
	Std. Deviation		67.8612	
	Minimum		702.0000	
	Maximum		927.0000	
	Range		225.0000	
	Interquartile Range		106.2500	
	Skewness		-0.2921	0.3925
	Kurtosis		-0.9069	0.7681

DESCRIPTIVES

			Statistic	Std. Error
ELECTRICAL CONDUCTIVITY	Mean		0.4006	0.0059
	95% Confidence Interval for Mean	Lower Bound	0.3886	
		Upper Bound	0.4125	
	5% Trimmed Mean		0.4009	
	Median		0.4100	
	Variance		0.0013	
	Std. Deviation		0.0354	
	Minimum		0.3400	
	Maximum		0.4600	
	Range		0.1200	
	Interquartile Range		0.0550	
	Skewness		-0.4054	0.3925
	Kurtosis		-0.8524	0.7681
RESISTIVITY	Mean		1274.9722	29.8490
	95% Confidence Interval for Mean	Lower Bound	1214.3756	
		Upper Bound	1335.5689	
	5% Trimmed Mean		1258.7222	
	Median		1222.5000	
	Variance		32074.5992	
	Std. Deviation		179.0938	
	Minimum		1079.0000	
	Maximum		1763.0000	
	Range		684.0000	
	Interquartile Range		189.2500	
	Skewness		1.6171	0.3925
	Kurtosis		2.5396	0.7681
Log10_Res	Mean		3.1018	0.0094
	95% Confidence Interval for Mean	Lower Bound	3.0828	
		Upper Bound	3.1208	
	5% Trimmed Mean		3.0976	
	Median		3.0872	
	Variance		0.0032	
	Std. Deviation		0.0562	
	Minimum		3.0330	
	Maximum		3.2463	
	Range		0.2132	
	Interquartile Range		0.0653	
	Skewness		1.2848	0.3925
	Kurtosis		1.5616	0.7681

DESCRIPTIVES			Statistic	Std. Error
E.coli	Mean		2.4238	0.2991
	95% Confidence Interval for Mean	Lower Bound	1.8165	
		Upper Bound	3.0311	
	5% Trimmed Mean		2.3703	
	Median		2.3200	
	Variance		3.2213	
	Std. Deviation		1.7948	
	Minimum		0.1040	
	Maximum		5.9200	
	Range		5.8160	
	Interquartile Range		3.6360	
	Skewness		0.1867	0.3925
	Kurtosis		-1.1923	0.7681
FAECAL COLIFORMS	Mean		2.6069	0.4100
	95% Confidence Interval for Mean	Lower Bound	1.7746	
		Upper Bound	3.4392	
	5% Trimmed Mean		2.4459	
	Median		1.7600	
	Variance		6.0506	
	Std. Deviation		2.4598	
	Minimum		0.1760	
	Maximum		8.0000	
	Range		7.8240	
	Interquartile Range		3.3080	
	Skewness		1.1654	0.3925
	Kurtosis		0.0754	0.7681
FAECAL STREPTOCOCCI	Mean		0.7012	0.1196
	95% Confidence Interval for Mean	Lower Bound	0.4585	
		Upper Bound	0.9439	
	5% Trimmed Mean		0.6359	
	Median		0.6800	
	Variance		0.5145	
	Std. Deviation		0.7173	
	Minimum		-	
	Maximum		2.7200	
	Range		2.7200	
	Interquartile Range		0.9215	
	Skewness		1.2026	0.3925
	Kurtosis		1.1645	0.7681

DESCRIPTIVES			Statistic	Std. Error
ENTEROCOCCI	Mean		0.4152	0.0656
	95% Confidence Interval for Mean	Lower Bound	0.2821	
		Upper Bound	0.5483	
	5% Trimmed Mean		0.3800	
	Median		0.3800	
	Variance		0.1547	
	Std. Deviation		0.3933	
	Minimum		-	
	Maximum		1.6000	
	Range		1.6000	
	Interquartile Range		0.6500	
	Skewness		1.0386	0.3925
	Kurtosis		1.0318	0.7681
TOTAL HETEROTROPHIC BACTERIA	Mean		6.6711	0.6383
	95% Confidence Interval for Mean	Lower Bound	5.3753	
		Upper Bound	7.9669	
	5% Trimmed Mean		6.6359	
	Median		7.0000	
	Variance		14.6663	
	Std. Deviation		3.8297	
	Minimum		0.1520	
	Maximum		14.0800	
	Range		13.9280	
	Interquartile Range		6.3200	
	Skewness		0.0253	0.3925
	Kurtosis		-0.9613	0.7681
TOTAL COLIFORMS	Mean		942.2222	106.4910
	95% Confidence Interval for Mean	Lower Bound	726.0340	
		Upper Bound	1 158.4105	
	5% Trimmed Mean		917.2222	
	Median		740.0000	
	Variance		408 252.0635	
	Std. Deviation		638.9461	
	Minimum		50.0000	
	Maximum		2 560.0000	
	Range		2 510.0000	
	Interquartile Range		1 060.0000	
	Skewness		0.5614	0.3925
	Kurtosis		-0.6113	0.7681

DESCRIPTIVES			Statistic	Std. Error
FS_Log10	Mean		0.1975	0.0281
	95% Confidence Interval for Mean	Lower Bound	0.1405	
		Upper Bound	0.2545	
	5% Trimmed Mean		0.1887	
	Median		0.2242	
	Variance		0.0284	
	Std. Deviation		0.1685	
	Minimum		-	
	Maximum		0.5705	
	Range		0.5705	
	Interquartile Range		0.2762	
	Skewness		0.4655	0.3925
	Kurtosis		-0.6810	0.7681

Table VII (f): Descriptive statistics for physicochemical and microbial parameters measured at the discharge point for the NWWTP between March 2012 and February 2013

Descriptives			Statistic	Std. Error
TEMPERATURE	Mean		20.7222	0.6218
	95% Confidence Interval for Mean	Lower Bound	19.4598	
		Upper Bound	21.9846	
	5% Trimmed Mean		20.9691	
	Median		21.5000	
	Variance		13.9206	
	Std. Deviation		3.7310	
	Minimum		12.0000	
	Maximum		25.0000	
	Range		13.0000	
	Interquartile Range		3.7500	
	Skewness		-1.1419	0.3925
	Kurtosis		0.6606	0.7681
TURBIDITY	Mean		34.9131	3.4218
	95% Confidence Interval for Mean	Lower Bound	27.9664	
		Upper Bound	41.8597	
	5% Trimmed Mean		34.0430	
	Median		31.7000	
	Variance		421.5184	
	Std. Deviation		20.5309	
	Minimum		8.8700	
	Maximum		76.6000	
	Range		67.7300	
	Interquartile Range		27.8750	
	Skewness		0.7961	0.3925
	Kurtosis		-0.3499	0.7681
TOTAL DISSOLVED SOLIDS	Mean		428.3611	6.5354
	95% Confidence Interval for Mean	Lower Bound	415.0936	
		Upper Bound	441.6287	
	5% Trimmed Mean		430.3457	
	Median		426.5000	
	Variance		1 537.6087	
	Std. Deviation		39.2124	
	Minimum		342.0000	
	Maximum		479.0000	
	Range		137.0000	
	Interquartile Range		60.0000	
	Skewness		-0.5791	0.3925
	Kurtosis		-0.1461	0.7681

DESCRIPTIVES			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0364	0.0040
	95% Confidence Interval for Mean	Lower Bound	0.0282	
		Upper Bound	0.0446	
	5% Trimmed Mean		0.0343	
	Median		0.0325	
	Variance		0.0006	
	Std. Deviation		0.0242	
	Minimum		0.0005	
	Maximum		0.1145	
	Range		0.1140	
	Interquartile Range		0.0285	
	Skewness		1.3898	0.3925
	Kurtosis		2.4669	0.7681
pH	Mean		7.0928	0.0643
	95% Confidence Interval for Mean	Lower Bound	6.9623	
		Upper Bound	7.2232	
	5% Trimmed Mean		7.0819	
	Median		7.0000	
	Variance		0.1487	
	Std. Deviation		0.3856	
	Minimum		6.5400	
	Maximum		7.8100	
	Range		1.2700	
	Interquartile Range		0.6650	
	Skewness		0.5799	0.3925
	Kurtosis		-1.0214	0.7681
DISSOLVED OXYGEN	Mean		7.0615	0.0999
	95% Confidence Interval for Mean	Lower Bound	6.8586	
		Upper Bound	7.2644	
	5% Trimmed Mean		7.0646	
	Median		7.0350	
	Variance		0.3596	
	Std. Deviation		0.5997	
	Minimum		5.7150	
	Maximum		8.2500	
	Range		2.5350	
	Interquartile Range		0.8763	
	Skewness		-0.1138	0.3925
	Kurtosis		-0.5515	0.7681

DESCRIPTIVES			Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean		2.7314	0.1993
	95% Confidence Interval for Mean	Lower Bound	2.3268	
		Upper Bound	3.1360	
	5% Trimmed Mean		2.7211	
	Median		2.5125	
	Variance		1.4298	
	Std. Deviation		1.1957	
	Minimum		0.7761	
	Maximum		4.8134	
	Range		4.0373	
	Interquartile Range		2.1779	
	Skewness		0.2559	0.3925
	Kurtosis		-1.3177	0.7681
CHEMICAL OXYGEN DEMAND	Mean		192.7497	18.2890
	95% Confidence Interval for Mean	Lower Bound	155.6212	
		Upper Bound	229.8783	
	5% Trimmed Mean		196.3598	
	Median		198.0000	
	Variance		12041.4860	
	Std. Deviation		109.7337	
	Minimum		10.0000	
	Maximum		310.6667	
	Range		300.6667	
	Interquartile Range		193.9192	
	Skewness		-0.2973	0.3925
	Kurtosis		-1.4367	0.7681
SALINITY	Mean		821.9444	11.3102
	95% Confidence Interval for Mean	Lower Bound	798.9835	
		Upper Bound	844.9054	
	5% Trimmed Mean		822.7963	
	Median		836.0000	
	Variance		4605.1397	
	Std. Deviation		67.8612	
	Minimum		702.0000	
	Maximum		927.0000	
	Range		225.0000	
	Interquartile Range		106.2500	
	Skewness		-0.2921	0.3925
	Kurtosis		-0.9069	0.7681

DESCRIPTIVES			Statistic	Std. Error
ELECTRICAL CONDUCTIVITY	Mean		0.4006	0.0059
	95% Confidence Interval for Mean	Lower Bound	0.3886	
		Upper Bound	0.4125	
	5% Trimmed Mean		0.4009	
	Median		0.4100	
	Variance		0.0013	
	Std. Deviation		0.0354	
	Minimum		0.3400	
	Maximum		0.4600	
	Range		0.1200	
	Interquartile Range		0.0550	
	Skewness		-0.4054	0.3925
	Kurtosis		-0.8524	0.7681
RESISTIVITY	Mean		1274.9722	29.8490
	95% Confidence Interval for Mean	Lower Bound	1214.3756	
		Upper Bound	1335.5689	
	5% Trimmed Mean		1258.7222	
	Median		1222.5000	
	Variance		32074.5992	
	Std. Deviation		179.0938	
	Minimum		1079.0000	
	Maximum		1763.0000	
	Range		684.0000	
	Interquartile Range		189.2500	
	Skewness		1.6171	0.3925
	Kurtosis		2.5396	0.7681
Log10_Res	Mean		3.1018	0.0094
	95% Confidence Interval for Mean	Lower Bound	3.0828	
		Upper Bound	3.1208	
	5% Trimmed Mean		3.0976	
	Median		3.0872	
	Variance		0.0032	
	Std. Deviation		0.0562	
	Minimum		3.0330	
	Maximum		3.2463	
	Range		0.2132	
	Interquartile Range		0.0653	
	Skewness		1.2848	0.3925
	Kurtosis		1.5616	0.7681

Descriptives				
			Statistic	Std. Error
E. coli	Mean		3.3021	0.5684
	95% Confidence Interval for Mean	Lower Bound	2.1481	
		Upper Bound	4.4561	
	5% Trimmed Mean		3.0626	
	Median		2.4000	
	Variance		11.6318	
	Std. Deviation		3.4105	
	Minimum		-	
	Maximum		11.2000	
	Range		11.2000	
	Interquartile Range		5.9140	
	Skewness		0.7468	0.3925
	Kurtosis		-0.5004	0.7681
FAECAL COLIFORMS	Mean		1.1623	0.2003
	95% Confidence Interval for Mean	Lower Bound	0.7556	
		Upper Bound	1.5691	
	5% Trimmed Mean		1.0554	
	Median		0.9900	
	Variance		1.4450	
	Std. Deviation		1.2021	
	Minimum		-	
	Maximum		4.3200	
	Range		4.3200	
	Interquartile Range		1.3481	
	Skewness		1.3393	0.3925
	Kurtosis		1.0948	0.7681
FAECAL STREPTOCOCCI	Mean		0.4067	0.0904
	95% Confidence Interval for Mean	Lower Bound	0.2232	
		Upper Bound	0.5902	
	5% Trimmed Mean		0.3581	
	Median		0.2650	
	Variance		0.2943	
	Std. Deviation		0.5425	
	Minimum		-	
	Maximum		1.7600	
	Range		1.7600	
	Interquartile Range		0.3670	
	Skewness		1.6378	0.3925
	Kurtosis		1.2464	0.7681

Descriptives				
			Statistic	Std. Error
ENTEROCOCCI	Mean		0.2213	0.0582
	95% Confidence Interval for Mean	Lower Bound	0.1031	
		Upper Bound	0.3395	
	5% Trimmed Mean		0.1787	
	Median		0.0615	
	Variance		0.1220	
	Std. Deviation		0.3493	
	Minimum		-	
	Maximum		1.2800	
	Range		1.2800	
	Interquartile Range		0.2469	
	Skewness		1.9627	0.3925
	Kurtosis		2.9136	0.7681
TOTAL COLIFORMS	Mean		11.3366	2.0635
	95% Confidence Interval for Mean	Lower Bound	7.1475	
		Upper Bound	15.5256	
	5% Trimmed Mean		10.0884	
	Median		8.1600	
	Variance		153.2852	
	Std. Deviation		12.3808	
	Minimum		0.1970	
	Maximum		46.0800	
	Range		45.8830	
	Interquartile Range		16.2800	
	Skewness		1.4393	0.3925
	Kurtosis		1.6782	0.7681
HETEROTROPHIC BACTERIAL POPULATION	Mean		727.5000	130.9442
	95% Confidence Interval for Mean	Lower Bound	461.6692	
		Upper Bound	993.3308	
	5% Trimmed Mean		649.6543	
	Median		440.0000	
	Variance		617 269.3429	
	Std. Deviation		785.6649	
	Minimum		18.0000	
	Maximum		3 280.0000	
	Range		3 262.0000	
	Interquartile Range		756.0000	
	Skewness		1.6513	0.3925
	Kurtosis		2.2154	0.7681

Descriptives				
			Statistic	Std. Error
FC_Log10	Mean		0.2792	0.0362
	95% Confidence Interval for Mean	Lower Bound	0.2057	
		Upper Bound	0.3526	
	5% Trimmed Mean		0.2702	
	Median		0.2988	
	Variance		0.0471	
	Std. Deviation		0.2170	
	Minimum		-	
	Maximum		0.7259	
	Range		0.7259	
	Interquartile Range		0.3290	
	Skewness		0.4882	0.3925
	Kurtosis		-0.6289	0.7681

Table VII (g): Descriptive statistics for physicochemical and microbial parameters measured upstream of the Umgeni River between March 2012 and February 2013

DESCRIPTIVES			Statistic	Std. Error
TEMPERATURE	Mean		20.9556	0.6361
	95% Confidence Interval for Mean	Lower Bound	19.6643	
		Upper Bound	22.2468	
	5% Trimmed Mean		21.1451	
	Median		21.0000	
	Variance		14.5643	
	Std. Deviation		3.8163	
	Minimum		12.5000	
	Maximum		26.0000	
	Range		13.5000	
	Interquartile Range		4.0000	
	Skewness		-0.9042	0.3925
	Kurtosis		0.2115	0.7681
TURBIDITY	Mean		14.9811	0.9878
	95% Confidence Interval for Mean	Lower Bound	12.9758	
		Upper Bound	16.9865	
	5% Trimmed Mean		14.6946	
	Median		12.9500	
	Variance		35.1274	
	Std. Deviation		5.9268	
	Minimum		6.3600	
	Maximum		28.8000	
	Range		22.4400	
	Interquartile Range		8.2500	
	Skewness		0.8821	0.3925
	Kurtosis		0.4333	0.7681
TOTAL DISSOLVED SOLIDS	Mean		401.3944	44.1009
	95% Confidence Interval for Mean	Lower Bound	311.8649	
		Upper Bound	490.9240	
	5% Trimmed Mean		378.1111	
	Median		308.0000	
	Variance		70 015.9211	
	Std. Deviation		264.6052	
	Minimum		152.8000	
	Maximum		1 069.0000	
	Range		916.2000	
	Interquartile Range		321.2750	
	Skewness		1.3414	0.3925
	Kurtosis		1.2402	0.7681

DESCRIPTIVES			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0122	0.0013
	95% Confidence Interval for Mean	Lower Bound	0.0097	
		Upper Bound	0.0148	
	5% Trimmed Mean		0.0119	
	Median		0.0124	
	Variance		0.0001	
	Std. Deviation		0.0075	
	Minimum		0.0004	
	Maximum		0.0323	
	Range		0.0319	
	Interquartile Range		0.0099	
	Skewness		0.6368	0.3925
	Kurtosis		0.2691	0.7681
pH	Mean		7.1244	0.0574
	95% Confidence Interval for Mean	Lower Bound	7.0079	
		Upper Bound	7.2410	
	5% Trimmed Mean		7.1367	
	Median		7.0750	
	Variance		0.1187	
	Std. Deviation		0.3445	
	Minimum		6.3700	
	Maximum		7.6500	
	Range		1.2800	
	Interquartile Range		0.5450	
	Skewness		-0.3192	0.3925
	Kurtosis		-0.3169	0.7681
DISSOLVED OXYGEN	Mean		7.9217	0.0650
	95% Confidence Interval for Mean	Lower Bound	7.7896	
		Upper Bound	8.0537	
	5% Trimmed Mean		7.9184	
	Median		7.8800	
	Variance		0.1523	
	Std. Deviation		0.3903	
	Minimum		7.3650	
	Maximum		8.5500	
	Range		1.1850	
	Interquartile Range		0.7513	
	Skewness		0.1777	0.3925
	Kurtosis		-1.5173	0.7681

DESCRIPTIVES			Statistic	Std. Error
CHEMICAL OXYGEN DEMAND	Mean		199.2223	17.1609
	95% Confidence Interval for Mean	Lower Bound	164.3839	
		Upper Bound	234.0608	
	5% Trimmed Mean		202.9734	
	Median		213.3333	
	Variance		10 601.8587	
	Std. Deviation		102.9653	
	Minimum		18.3300	
	Maximum		312.0000	
	Range		293.6700	
	Interquartile Range		191.7500	
	Skewness		-0.3985	0.3925
	Kurtosis		-1.3287	0.7681
BIOLOGICAL OXYGEN DEMAND	Mean		5.6462	0.7425
	95% Confidence Interval for Mean	Lower Bound	4.1388	
		Upper Bound	7.1535	
	5% Trimmed Mean		5.3129	
	Median		4.5075	
	Variance		19.8473	
	Std. Deviation		4.4550	
	Minimum		0.1100	
	Maximum		17.1500	
	Range		17.0400	
	Interquartile Range		3.6400	
	Skewness		1.6152	0.3925
	Kurtosis		2.1962	0.7681
ELECTRICAL CONDUCTIVITY	Mean		779.0169	93.5006
	95% Confidence Interval for Mean	Lower Bound	589.2006	
		Upper Bound	968.8333	
	5% Trimmed Mean		748.0077	
	Median		632.5000	
	Variance		314 725.1924	
	Std. Deviation		561.0037	
	Minimum		0.2000	
	Maximum		2 116.0000	
	Range		2 115.8000	
	Interquartile Range		713.5000	
	Skewness		1.0017	0.3925
	Kurtosis		0.6958	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
SALINITY	Mean		36.1347	20.0223
	95% Confidence	Lower Bound	-4.5127	
	Interval for Mean	Upper Bound	76.7822	
	5% Trimmed Mean		16.3080	
	Median		0.4050	
	Variance		14 432.1529	
	Std. Deviation		120.1339	
	Minimum		0.1500	
	Maximum		429.0000	
	Range		428.8500	
	Interquartile Range		0.4575	
	Skewness		3.1478	0.3925
	Kurtosis		8.3713	0.7681
Log10turbidity	Mean		1.1435	0.0284
	95% Confidence	Lower Bound	1.0859	
	Interval for Mean	Upper Bound	1.2011	
	5% Trimmed Mean		1.1448	
	Median		1.1122	
	Variance		0.0290	
	Std. Deviation		0.1702	
	Minimum		0.8035	
	Maximum		1.4594	
	Range		0.6559	
	Interquartile Range		0.2454	
	Skewness		-0.0635	0.3925
	Kurtosis		-0.1424	0.7681
Log10tds	Mean		2.5232	0.0437
	95% Confidence	Lower Bound	2.4344	
	Interval for Mean	Upper Bound	2.6120	
	5% Trimmed Mean		2.5139	
	Median		2.4799	
	Variance		0.0689	
	Std. Deviation		0.2625	
	Minimum		2.1841	
	Maximum		3.0290	
	Range		0.8449	
	Interquartile Range		0.4135	
	Skewness		0.3956	0.3925
	Kurtosis		-0.9245	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
Log10EC	Mean		2.8348	0.0426
	95% Confidence	Lower Bound	2.7482	
	Interval for Mean	Upper Bound	2.9214	
	5% Trimmed Mean		2.8259	
	Median		2.7928	
	Variance		0.0654	
	Std. Deviation		0.2558	
	Minimum		2.5038	
	Maximum		3.3255	
	Range		0.8217	
	Interquartile Range		0.4027	
	Skewness		0.3886	0.3925
	Kurtosis		-0.9352	0.7681
Log10sal	Mean		0.1398	0.0127
	95% Confidence	Lower Bound	0.1139	
	Interval for Mean	Upper Bound	0.1656	
	5% Trimmed Mean		0.1342	
	Median		0.1168	
	Variance		0.0058	
	Std. Deviation		0.0764	
	Minimum		0.0607	
	Maximum		0.3181	
	Range		0.2574	
	Interquartile Range		0.1026	
	Skewness		1.0198	0.3925
	Kurtosis		0.3039	0.7681
Log10bod	Mean		0.7375	0.0471
	95% Confidence	Lower Bound	0.6419	
	Interval for Mean	Upper Bound	0.8332	
	5% Trimmed Mean		0.7464	
	Median		0.7409	
	Variance		0.0799	
	Std. Deviation		0.2826	
	Minimum		0.0453	
	Maximum		1.2589	
	Range		1.2136	
	Interquartile Range		0.2826	
	Skewness		-0.3282	0.3925
	Kurtosis		0.9011	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
Temp_R_Log10	Mean		0.6851	0.0526
	95% Confidence	Lower Bound	0.5783	
	Interval for Mean	Upper Bound	0.7920	
	5% Trimmed Mean		0.6967	
	Median		0.7782	
	Variance		0.0998	
	Std. Deviation		0.3158	
	Minimum		-	
	Maximum		1.1614	
	Range		1.1614	
	Interquartile Range		0.3680	
	Skewness		-0.6233	0.3925
	Kurtosis		0.0238	0.7681

DESCRIPTIVES

			Statistic	Std. Error
E. coli	Mean		0.3061	0.0562
	95% Confidence Interval for Mean	Lower Bound	0.1920	
		Upper Bound	0.4202	
	5% Trimmed Mean		0.2775	
	Median		0.1600	
	Variance		0.1138	
	Std. Deviation		0.3373	
	Minimum		0.0080	
	Maximum		1.1200	
	Range		1.1120	
	Interquartile Range		0.5750	
	Skewness		1.2064	0.3925
	Kurtosis		0.3650	0.7681
FAECAL COLIFORMS	Mean		0.4461	0.0844
	95% Confidence Interval for Mean	Lower Bound	0.2747	
		Upper Bound	0.6174	
	5% Trimmed Mean		0.4040	
	Median		0.2400	
	Variance		0.2565	
	Std. Deviation		0.5065	
	Minimum		0.0040	
	Maximum		1.6800	
	Range		1.6760	
	Interquartile Range		0.6660	
	Skewness		1.2535	0.3925
	Kurtosis		0.2597	0.7681
FAECAL STREPTOCOCCI	Mean		0.0508	0.0090
	95% Confidence Interval for Mean	Lower Bound	0.0325	
		Upper Bound	0.0690	
	5% Trimmed Mean		0.0469	
	Median		0.0300	
	Variance		0.0029	
	Std. Deviation		0.0540	
	Minimum		-	
	Maximum		0.1800	
	Range		0.1800	
	Interquartile Range		0.0775	
	Skewness		0.8274	0.3925
	Kurtosis		-0.3619	0.7681

DESCRIPTIVES

			Statistic	Std. Error
ENTEROCOCCI	Mean		0.0293	0.0053
	95% Confidence Interval for Mean	Lower Bound	0.0185	
		Upper Bound	0.0400	
	5% Trimmed Mean		0.0264	
	Median		0.0200	
	Variance		0.0010	
	Std. Deviation		0.0318	
	Minimum		-	
	Maximum		0.1200	
	Range		0.1200	
	Interquartile Range		0.0520	
	Skewness		1.0634	0.3925
	Kurtosis		0.6227	0.7681
TOTAL COLIFORS	Mean		2.1914	0.4962
	95% Confidence Interval for Mean	Lower Bound	1.1842	
		Upper Bound	3.1987	
	5% Trimmed Mean		1.7758	
	Median		0.9120	
	Variance		8.8622	
	Std. Deviation		2.9769	
	Minimum		0.1200	
	Maximum		12.1600	
	Range		12.0400	
	Interquartile Range		1.8160	
	Skewness		2.5712	0.3925
	Kurtosis		6.0235	0.7681
HETEROTROPHIC BACTERIAL COUNT	Mean		653.0556	153.9015
	95% Confidence Interval for Mean	Lower Bound	340.6188	
		Upper Bound	965.4923	
	5% Trimmed Mean		564.5679	
	Median		220.0000	
	Variance		852 684.6825	
	Std. Deviation		923.4093	
	Minimum		10.0000	
	Maximum		2 960.0000	
	Range		2 950.0000	
	Interquartile Range		610.0000	
	Skewness		1.6638	0.3925
	Kurtosis		1.3248	0.7681

DESCRIPTIVES

			Statistic	Std. Error
Ecoli_Log10	Mean		0.1036	0.0170
	95% Confidence Interval for Mean	Lower Bound	0.0692	
		Upper Bound	0.1381	
	5% Trimmed Mean		0.0968	
	Median		0.0645	
	Variance		0.0104	
	Std. Deviation		0.1017	
	Minimum		0.0035	
	Maximum		0.3263	
	Range		0.3229	
	Interquartile Range		0.1903	
	Skewness		0.9402	0.3925
	Kurtosis		-0.3883	0.7681

Table VII (h): Descriptive statistics for physicochemical and microbial parameters measured downstream of the Umgeni River between March 2012 and February 2013

DESCRIPTIVES				Statistic	Std. Error
TEMPERATURE	Mean			21.3333	0.6476
	95% Confidence	Interval for Mean	Lower Bound	20.0185	
			Upper Bound	22.6481	
	5% Trimmed Mean			21.4537	
	Median			22.0000	
	Variance			15.1000	
	Std. Deviation			3.8859	
	Minimum			13.5000	
	Maximum			27.0000	
	Range			13.5000	
	Interquartile Range			4.7500	
	Skewness			-0.6997	0.3925
	Kurtosis			-0.2189	0.7681
TURIDITY	Mean			15.0494	1.0392
	95% Confidence	Interval for Mean	Lower Bound	12.9397	
			Upper Bound	17.1592	
	5% Trimmed Mean			14.7802	
	Median			14.2500	
	Variance			38.8805	
	Std. Deviation			6.2354	
	Minimum			5.8500	
	Maximum			29.1000	
	Range			23.2500	
	Interquartile Range			8.5000	
	Skewness			0.8339	0.3925
	Kurtosis			0.2400	0.7681
TOTAL DISSOLVED SOLIDS	Mean			332.0833	4.2565
	95% Confidence	Interval for Mean	Lower Bound	323.4421	
			Upper Bound	340.7246	
	5% Trimmed Mean			331.1481	
	Median			330.0000	
	Variance			652.2500	
	Std. Deviation			25.5392	
	Minimum			294.0000	
	Maximum			387.0000	
	Range			93.0000	
	Interquartile Range			41.0000	
	Skewness			0.4840	0.3925
	Kurtosis			-0.2443	0.7681

DESCRIPTIVES				Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean			0.0120	0.0009
	95% Confidence	Interval for Mean	Lower Bound	0.0101	
			Upper Bound	0.0139	
	5% Trimmed Mean			0.0119	
	Median			0.0122	
	Variance			0.0000	
	Std. Deviation			0.0055	
	Minimum			0.0004	
	Maximum			0.0280	
	Range			0.0276	
	Interquartile Range			0.0064	
	Skewness			0.3685	0.3925
	Kurtosis			1.0325	0.7681
pH	Mean			7.2044	0.0781
	95% Confidence	Interval for Mean	Lower Bound	7.0458	
			Upper Bound	7.3630	
	5% Trimmed Mean			7.2060	
	Median			7.1700	
	Variance			0.2197	
	Std. Deviation			0.4687	
	Minimum			6.5000	
	Maximum			7.8800	
	Range			1.3800	
	Interquartile Range			0.9575	
	Skewness			0.1310	0.3925
	Kurtosis			-1.3845	0.7681
DISSOLVED OXYGEN	Mean			7.8040	0.0601
	95% Confidence	Interval for Mean	Lower Bound	7.6820	
			Upper Bound	7.9260	
	5% Trimmed Mean			7.7996	
	Median			7.7600	
	Variance			0.1300	
	Std. Deviation			0.3606	
	Minimum			7.2400	
	Maximum			8.5050	
	Range			1.2650	
	Interquartile Range			0.6237	
	Skewness			0.1952	0.3925
	Kurtosis			-1.1091	0.7681

DESCRIPTIVES				Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean			3.9095	0.3055
	95% Confidence	Interval for Mean	Lower Bound	3.2893	
			Upper Bound	4.5296	
	5% Trimmed Mean			3.9613	
	Median			4.0799	
	Variance			3.3597	
	Std. Deviation			1.8329	
	Minimum			-	
	Maximum			6.8500	
	Range			6.8500	
	Interquartile Range			2.5557	
	Skewness			-0.3962	0.3925
	Kurtosis			-0.1687	0.7681
CHEMICAL OXYGEN DEMAND	Mean			213.3706	13.7223
	95% Confidence	Interval for Mean	Lower Bound	185.5128	
			Upper Bound	241.2283	
	5% Trimmed Mean			214.8377	
	Median			202.5000	
	Variance			6 778.8538	
	Std. Deviation			82.3338	
	Minimum			86.0000	
	Maximum			313.0000	
	Range			227.0000	
	Interquartile Range			161.1675	
	Skewness			0.0699	0.3925
	Kurtosis			-1.6557	0.7681
ELECTRICAL CONDUCTIVITY	Mean			681.4167	8.5539
	95% Confidence	Interval for Mean	Lower Bound	664.0514	
			Upper Bound	698.7820	
	5% Trimmed Mean			679.5494	
	Median			676.5000	
	Variance			2 634.0786	
	Std. Deviation			51.3233	
	Minimum			604.0000	
	Maximum			792.0000	
	Range			188.0000	
	Interquartile Range			82.2500	
	Skewness			0.4775	0.3925
	Kurtosis			-0.2492	0.7681

DESCRIPTIVES			Statistic	Std. Error
SALINITY	Mean		0.3322	0.0045
	95% Confidence Interval for Mean	Lower Bound	0.3230	
		Upper Bound	0.3414	
	5% Trimmed Mean		0.3314	
	Median		0.3300	
	Variance		0.0007	
	Std. Deviation		0.0272	
	Minimum		0.2900	
	Maximum		0.3900	
	Range		0.1000	
	Interquartile Range		0.0400	
	Skewness		0.4309	0.3925
	Kurtosis		-0.1561	0.7681
RESISTVITIY	Mean		1 524.5278	29.8937
	95% Confidence Interval for Mean	Lower Bound	1 463.8404	
		Upper Bound	1 585.2152	
	5% Trimmed Mean		1 511.9815	
	Median		1 485.0000	
	Variance		32 170.7706	
	Std. Deviation		179.3621	
	Minimum		1 263.0000	
	Maximum		2 011.0000	
	Range		748.0000	
	Interquartile Range		187.5000	
	Skewness		1.4961	0.3925
	Kurtosis		2.7346	0.7681
Log10_Turbidity	Mean		1.1416	0.0302
	95% Confidence Interval for Mean	Lower Bound	1.0802	
		Upper Bound	1.2030	
	5% Trimmed Mean		1.1444	
	Median		1.1538	
	Variance		0.0329	
	Std. Deviation		0.1815	
	Minimum		0.7672	
	Maximum		1.4639	
	Range		0.6967	
	Interquartile Range		0.2476	
	Skewness		-0.1758	0.3925
	Kurtosis		-0.0742	0.7681

DESCRIPTIVES			Statistic	Std. Error
Log10_TSS	Mean		0.0439	0.0192
	95% Confidence Interval for Mean	Lower Bound	0.0049	
		Upper Bound	0.0828	
	5% Trimmed Mean		0.0246	
	Median		0.0057	
	Variance		0.0133	
	Std. Deviation		0.1151	
	Minimum		0.0002	
	Maximum		0.4619	
	Range		0.4617	
	Interquartile Range		0.0044	
	Skewness		2.9879	0.3925
	Kurtosis		7.8033	0.7681
Log10_Resistivity	Mean		3.1805	0.0080
	95% Confidence Interval for Mean	Lower Bound	3.1642	
		Upper Bound	3.1967	
	5% Trimmed Mean		3.1780	
	Median		3.1717	
	Variance		0.0023	
	Std. Deviation		0.0480	
	Minimum		3.1014	
	Maximum		3.3034	
	Range		0.2020	
	Interquartile Range		0.0541	
	Skewness		1.1069	0.3925
	Kurtosis		1.9138	0.7681
Temp_RLog10	Mean		0.7363	0.0514
	95% Confidence Interval for Mean	Lower Bound	0.6320	
		Upper Bound	0.8405	
	5% Trimmed Mean		0.7535	
	Median		0.7782	
	Variance		0.0950	
	Std. Deviation		0.3082	
	Minimum		-	
	Maximum		1.1614	
	Range		1.1614	
	Interquartile Range		0.3394	
	Skewness		-0.9165	0.3925
	Kurtosis		0.8286	0.7681

DESCRIPTIVES			Statistic	Std. Error
E. coli	Mean		1.1995	0.5399
	95% Confidence Interval for Mean	Lower Bound	0.1035	
		Upper Bound	2.2955	
	5% Trimmed Mean		0.5911	
	Median		0.2550	
	Variance		10.4922	
	Std. Deviation		3.2392	
	Minimum		0.0160	
	Maximum		14.4000	
	Range		14.3840	
	Interquartile Range		0.4280	
	Skewness		3.4219	0.3925
	Kurtosis		10.9416	0.7681
FAECAL COLIFORMS	Mean		0.5971	0.1904
	95% Confidence Interval for Mean	Lower Bound	0.2105	
		Upper Bound	0.9838	
	5% Trimmed Mean		0.4094	
	Median		0.2400	
	Variance		1.3058	
	Std. Deviation		1.1427	
	Minimum		0.0040	
	Maximum		4.6400	
	Range		4.6360	
	Interquartile Range		0.4875	
	Skewness		2.9766	0.3925
	Kurtosis		8.0437	0.7681
FAECAL STREPTOCOCCI	Mean		0.0738	0.0203
	95% Confidence Interval for Mean	Lower Bound	0.0327	
		Upper Bound	0.1150	
	5% Trimmed Mean		0.0564	
	Median		0.0300	
	Variance		0.0148	
	Std. Deviation		0.1216	
	Minimum		-	
	Maximum		0.4800	
	Range		0.4800	
	Interquartile Range		0.0961	
	Skewness		2.3293	0.3925
	Kurtosis		4.9639	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
ENTEROCOCCI	Mean		0.0793	0.0237
	95% Confidence Interval for Mean	Lower Bound	0.0313	
		Upper Bound	0.1274	
	5% Trimmed Mean		0.0590	
	Median		0.0100	
	Variance		0.0202	
	Std. Deviation		0.1420	
	Minimum		-	
	Maximum		0.5600	
	Range		0.5600	
	Interquartile Range		0.0780	
	Skewness		2.2362	0.3925
	Kurtosis		4.4416	0.7681
TOTAL COLIFORMS	Mean		6.8693	3.0543
	95% Confidence Interval for Mean	Lower Bound	0.6687	
		Upper Bound	13.0700	
	5% Trimmed Mean		3.8272	
	Median		1.2800	
	Variance		335.8451	
	Std. Deviation		18.3261	
	Minimum		0.2240	
	Maximum		70.4000	
	Range		70.1760	
	Interquartile Range		1.3400	
	Skewness		3.1444	0.3925
	Kurtosis		8.4151	0.7681
HETEROTROPHIC BACTERIAL COUNT	Mean		618.1111	158.7283
	95% Confidence Interval for Mean	Lower Bound	295.8756	
		Upper Bound	940.3466	
	5% Trimmed Mean		495.6173	
	Median		180.0000	
	Variance		907 007.7587	
	Std. Deviation		952.3695	
	Minimum		10.0000	
	Maximum		3 840.0000	
	Range		3 830.0000	
	Interquartile Range		575.0000	
	Skewness		2.1309	0.3925
	Kurtosis		3.8420	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
ECOLI_LOG10	Mean		0.1795	0.0477
	95% Confidence Interval for Mean	Lower Bound	0.0827	
		Upper Bound	0.2763	
	5% Trimmed Mean		0.1349	
	Median		0.0986	
	Variance		0.0818	
	Std. Deviation		0.2860	
	Minimum		0.0069	
	Maximum		1.1875	
	Range		1.1806	
	Interquartile Range		0.1483	
	Skewness		2.9115	0.3925
	Kurtosis		7.6879	0.7681
FC_LOG10	Mean		0.1468	0.0320
	95% Confidence Interval for Mean	Lower Bound	0.0819	
		Upper Bound	0.2116	
	5% Trimmed Mean		0.1215	
	Median		0.0934	
	Variance		0.0368	
	Std. Deviation		0.1918	
	Minimum		0.0017	
	Maximum		0.7513	
	Range		0.7495	
	Interquartile Range		0.1652	
	Skewness		2.2852	0.3925
	Kurtosis		4.9522	0.7681
FS_LOG10	Mean		0.0286	0.0074
	95% Confidence Interval for Mean	Lower Bound	0.0136	
		Upper Bound	0.0436	
	5% Trimmed Mean		0.0226	
	Median		0.0128	
	Variance		0.0020	
	Std. Deviation		0.0443	
	Minimum		-	
	Maximum		0.1703	
	Range		0.1703	
	Interquartile Range		0.0398	
	Skewness		2.1464	0.3925
	Kurtosis		4.1012	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
ENT_LOG10	Mean		0.0300	0.0085
	95% Confidence Interval for Mean	Lower Bound	0.0128	
		Upper Bound	0.0473	
	5% Trimmed Mean		0.0232	
	Median		0.0043	
	Variance		0.0026	
	Std. Deviation		0.0509	
	Minimum		-	
	Maximum		0.1931	
	Range		0.1931	
	Interquartile Range		0.0326	
	Skewness		2.0487	0.3925
	Kurtosis		3.4721	0.7681
TC_LOG10	Mean		0.4802	0.0732
	95% Confidence Interval for Mean	Lower Bound	0.3316	
		Upper Bound	0.6287	
	5% Trimmed Mean		0.4263	
	Median		0.3579	
	Variance		0.1927	
	Std. Deviation		0.4390	
	Minimum		0.0878	
	Maximum		1.8537	
	Range		1.7659	
	Interquartile Range		0.2416	
	Skewness		2.5344	0.3925
	Kurtosis		5.9238	0.7681
HPC_LOG10	Mean		2.3366	0.1119
	95% Confidence Interval for Mean	Lower Bound	2.1095	
		Upper Bound	2.5637	
	5% Trimmed Mean		2.3422	
	Median		2.2550	
	Variance		0.4505	
	Std. Deviation		0.6712	
	Minimum		1.0414	
	Maximum		3.5844	
	Range		2.5431	
	Interquartile Range		0.9074	
	Skewness		0.0527	0.3925
	Kurtosis		-0.5439	0.7681

Table VII (i): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured before chlorination for the NGTW between March 2012 and February 2013

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMP	0.1691	36.0000	0.0108	0.9411	36.0000	0.0548
TURBIDITY	0.2442	36.0000	0.0000	0.8462	36.0000	0.0002
TDS	0.1363	36.0000	0.0886	0.9546	36.0000	0.1464
TSS	0.3268	36.0000	0.0000	0.3815	36.0000	0.0000
pH	0.1777	36.0000	0.0056	0.8969	36.0000	0.0028
DO	0.1266	36.0000	0.1556	0.9256	36.0000	0.0185
BOD	0.1113	36.0000	.200*	0.9451	36.0000	0.0732
COD	0.1309	36.0000	0.1232	0.9047	36.0000	0.0046
EC	0.1265	36.0000	0.1562	0.9601	36.0000	0.2165
SAL	0.1236	36.0000	0.1807	0.9540	36.0000	0.1401
RES	0.1703	36.0000	0.0098	0.9092	36.0000	0.0062
TSS_Log10	0.3093	36.0000	0.0000	0.4222	36.0000	0.0000
pH_Log10	0.1663	36.0000	0.0132	0.9096	36.0000	0.0063
Resistivity_Log10	0.1341	36.0000	0.1000	0.9486	36.0000	0.0947
E.coli	0.2635	36.0000	0.0000	0.8306	36.0000	0.0001
FC	0.3102	36.0000	0.0000	0.6753	36.0000	0.0000
FS	0.2085	36.0000	0.0004	0.7342	36.0000	0.0000
ENT	0.3814	36.0000	0.0000	0.5841	36.0000	0.0000
TC	0.3477	36.0000	0.0000	0.6339	36.0000	0.0000
HPC	0.3543	36.0000	0.0000	0.6802	36.0000	0.0000
Log10_FC	0.2316	36.0000	0.0000	0.8456	36.0000	0.0002
Log10_FS	0.1448	36.0000	0.0541	0.8971	36.0000	0.0028
Log10_ENT	0.2561	36.0000	0.0000	0.7100	36.0000	0.0000
Log10_TC	0.1588	36.0000	0.0222	0.8937	36.0000	0.0023

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (j): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured at the discharge point for the NGTW between March 2012 and February 2013

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMPERATURE	0.1937	36.0000	0.0015	0.9242	36.0000	0.0168
TURBIDITY	0.1255	36.0000	0.1646	0.9083	36.0000	0.0058
TDS	0.0800	36.0000	.200*	0.9659	36.0000	0.3248
TSS	0.4035	36.0000	0.0000	0.4584	36.0000	0.0000
pH	0.1035	36.0000	.200*	0.9461	36.0000	0.0789
DO	0.0992	36.0000	.200*	0.9764	36.0000	0.6225
BOD	0.1230	36.0000	0.1863	0.9605	36.0000	0.2230
COD	0.1865	36.0000	0.0028	0.8589	36.0000	0.0003
EC	0.0916	36.0000	.200*	0.9649	36.0000	0.3035
SAL	0.0920	36.0000	.200*	0.9657	36.0000	0.3209
RES	0.1668	36.0000	0.0127	0.8839	36.0000	0.0013
Res_Log10	0.1193	36.0000	.200*	0.9400	36.0000	0.0507
ECOLI	0.2635	36.0000	0.0000	0.8306	36.0000	0.0001
FC	0.3102	36.0000	0.0000	0.6753	36.0000	0.0000
FS	0.2085	36.0000	0.0004	0.7342	36.0000	0.0000
ENT	0.3814	36.0000	0.0000	0.5841	36.0000	0.0000
TC	0.3477	36.0000	0.0000	0.6339	36.0000	0.0000
HPC	0.3543	36.0000	0.0000	0.6802	36.0000	0.0000
Log10_FC	0.2316	36.0000	0.0000	0.8456	36.0000	0.0002
Log10_FS	0.1448	36.0000	0.0541	0.8971	36.0000	0.0028
Log10_ENT	0.2561	36.0000	0.0000	0.7100	36.0000	0.0000
Log10_TC	0.1588	36.0000	0.0222	0.8937	36.0000	0.0023
Log10_HPC	0.1543	36.0000	0.0299	0.9304	36.0000	0.0257

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (k): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured upstream of the Aller River between March 2012 and February 2013

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMPERATURE	0.1849	36.0000	0.0031	0.9303	36.0000	0.0256
TURBIDITY	0.3022	36.0000	0.0000	0.7328	36.0000	0.0000
TDS	0.1666	36.0000	0.0129	0.8548	36.0000	0.0002
TSS	0.4560	36.0000	0.0000	0.3482	36.0000	0.0000
pH	0.1657	36.0000	0.0137	0.9247	36.0000	0.0173
DO	0.1550	36.0000	0.0285	0.9337	36.0000	0.0325
BOD	0.2323	36.0000	0.0000	0.7420	36.0000	0.0000
COD	0.3384	36.0000	0.0000	0.7362	36.0000	0.0000
EC	0.1620	36.0000	0.0179	0.8576	36.0000	0.0003
SAL	0.1729	36.0000	0.0081	0.8618	36.0000	0.0004
RES	0.1265	36.0000	0.1560	0.9334	36.0000	0.0317
Turb_Log10	0.1448	36.0000	0.0542	0.9268	36.0000	0.0201
TDS_Log10	0.1201	36.0000	.200*	0.9122	36.0000	0.0075
BOD_Log10	0.1079	36.0000	.200*	0.9381	36.0000	0.0443
EC_Log10	0.1170	36.0000	.200*	0.9129	36.0000	0.0078
TC_Log10	0.1280	36.0000	0.1441	0.9514	36.0000	0.1155
SAL_Log10	0.1631	36.0000	0.0165	0.8748	36.0000	0.0007
TSS_R_Log10	0.4438	36.0000	0.0000	0.3801	36.0000	0.0000
E.coli	0.4379	36.0000	0.0000	0.3954	36.0000	0.0000
FC	0.3724	36.0000	0.0000	0.4808	36.0000	0.0000
FS	0.3515	36.0000	0.0000	0.6075	36.0000	0.0000
ENT	0.3884	36.0000	0.0000	0.5987	36.0000	0.0000
TC	0.3590	36.0000	0.0000	0.5093	36.0000	0.0000
HPC	0.2289	36.0000	0.0001	0.8861	36.0000	0.0015
Log10_Ecoli	0.1862	36.0000	0.0028	0.8102	36.0000	0.0000
Log10_FC	0.1926	36.0000	0.0017	0.8912	36.0000	0.0020
Log10_FS	0.3378	36.0000	0.0000	0.7352	36.0000	0.0000
Log10_ENT	0.2565	36.0000	0.0000	0.7530	36.0000	0.0000
Log10_TC	0.1142	36.0000	.200*	0.9483	36.0000	0.0928

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (l): Normality Test values (Kolmogorov-Smirnov and Shapiro-Wilk) for physicochemical and microbial parameters measured downstream of the Aller River between March 2012 and February 2013

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TEMPERATURE	0.1644	36.0000	0.0150	0.9369	36.0000	0.0408
TURBIDITY	0.1575	36.0000	0.0242	0.8882	36.0000	0.0016
TDS	0.1446	36.0000	0.0550	0.9148	36.0000	0.0089
TSS	0.4557	36.0000	0.0000	0.3516	36.0000	0.0000
pH	0.1480	36.0000	0.0446	0.9250	36.0000	0.0178
DO	0.2275	36.0000	0.0001	0.8889	36.0000	0.0017
BOD	0.1074	36.0000	.200*	0.9711	36.0000	0.4566
COD	0.1629	36.0000	0.0168	0.8807	36.0000	0.0011
EC	0.1424	36.0000	0.0625	0.9168	36.0000	0.0102
SAL	0.1569	36.0000	0.0252	0.9115	36.0000	0.0071
RES	0.1597	36.0000	0.0208	0.9437	36.0000	0.0664
HPC_LOG10	0.2188	36.0000	0.0001	0.8457	36.0000	0.0002
TC_Log10	0.2519	36.0000	0.0000	0.8043	36.0000	0.0000
E.coli	0.3939	36.0000	0.0000	0.5436	36.0000	0.0000
FC	0.3056	36.0000	0.0000	0.7559	36.0000	0.0000
FS	0.3318	36.0000	0.0000	0.6965	36.0000	0.0000
ENT	0.3063	36.0000	0.0000	0.7066	36.0000	0.0000
TC	0.3077	36.0000	0.0000	0.6912	36.0000	0.0000
HPC	0.2248	36.0000	0.0001	0.7999	36.0000	0.0000
Log10_*E.coli*	0.3244	36.0000	0.0000	0.7319	36.0000	0.0000
Log10_FS	0.2683	36.0000	0.0000	0.7421	36.0000	0.0000
Log10_ENT	0.2693	36.0000	0.0000	0.7601	36.0000	0.0000
Log10_TC	0.2567	36.0000	0.0000	0.8048	36.0000	0.0000
Log10_HPC	0.2182	36.0000	0.0002	0.8476	36.0000	0.0002

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table VII (m): Descriptive statistics for physicochemical and microbial parameters measured before chlorination for the NGTW between March 2012 and February 2013

DESCRIPTIVES			Statistic	Std. Error
TEMPERATURE	Mean		20.6083	0.4682
	95% Confidence Interval for Mean	Lower Bound	19.6579	
		Upper Bound	21.5587	
	5% Trimmed Mean		20.5370	
	Median		20.0000	
	Variance		7.8899	
	Std. Deviation		2.8089	
	Minimum		16.5000	
	Maximum		26.0000	
	Range		9.5000	
	Interquartile Range		4.5000	
	Skewness		0.2771	0.3925
	Kurtosis		-0.7152	0.7681
TURBIDITY	Mean		11.2844	1.3933
	95% Confidence Interval for Mean	Lower Bound	8.4559	
		Upper Bound	14.1129	
	5% Trimmed Mean		10.8594	
	Median		8.1200	
	Variance		69.8837	
	Std. Deviation		8.3596	
	Minimum		1.5200	
	Maximum		28.7000	
	Range		27.1800	
	Interquartile Range		15.0250	
	Skewness		0.7931	0.3925
	Kurtosis		-0.6591	0.7681
TOTAL DISSOLVED SOLIDS	Mean		422.1111	13.3826
	95% Confidence Interval for Mean	Lower Bound	394.9429	
		Upper Bound	449.2793	
	5% Trimmed Mean		422.5617	
	Median		423.0000	
	Variance		6 447.4159	
	Std. Deviation		80.2958	
	Minimum		267.0000	
	Maximum		570.0000	
	Range		303.0000	
	Interquartile Range		96.2500	
	Skewness		-0.0401	0.3925
	Kurtosis		-0.1499	0.7681

DESCRIPTIVES			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0359	0.0132
	95% Confidence Interval for Mean	Lower Bound	0.0092	
		Upper Bound	0.0626	
	5% Trimmed Mean		0.0220	
	Median		0.0140	
	Variance		0.0062	
	Std. Deviation		0.0789	
	Minimum		0.0005	
	Maximum		0.4715	
	Range		0.4710	
	Interquartile Range		0.0309	
	Skewness		5.1123	0.3925
	Kurtosis		28.2461	0.7681
pH	Mean		6.9497	0.0643
	95% Confidence Interval for Mean	Lower Bound	6.8192	
		Upper Bound	7.0803	
	5% Trimmed Mean		6.9373	
	Median		6.8700	
	Variance		0.1489	
	Std. Deviation		0.3858	
	Minimum		6.3800	
	Maximum		7.7600	
	Range		1.3800	
	Interquartile Range		0.3800	
	Skewness		0.8239	0.3925
	Kurtosis		-0.0828	0.7681
DISSOLVED OXYGEN	Mean		7.8176	0.0800
	95% Confidence Interval for Mean	Lower Bound	7.6553	
		Upper Bound	7.9800	
	5% Trimmed Mean		7.8494	
	Median		7.8750	
	Variance		0.2302	
	Std. Deviation		0.4798	
	Minimum		6.4550	
	Maximum		8.4500	
	Range		1.9950	
	Interquartile Range		0.6850	
	Skewness		-0.9104	0.3925
	Kurtosis		0.6007	0.7681

DESCRIPTIVES			Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean		4.0101	0.1736
	95% Confidence Interval for Mean	Lower Bound	3.6577	
		Upper Bound	4.3626	
	5% Trimmed Mean		4.0226	
	Median		4.2441	
	Variance		1.0851	
	Std. Deviation		1.0417	
	Minimum		2.1150	
	Maximum		5.7836	
	Range		3.6686	
	Interquartile Range		1.7202	
	Skewness		-0.3430	0.3925
	Kurtosis		-1.0037	0.7681
CHEMICAL OXYGEN DEMAND	Mean		156.5185	14.1022
	95% Confidence Interval for Mean	Lower Bound	127.8894	
		Upper Bound	185.1476	
	5% Trimmed Mean		154.6811	
	Median		142.8333	
	Variance		7 159.4441	
	Std. Deviation		84.6135	
	Minimum		32.6667	
	Maximum		313.0000	
	Range		280.3333	
	Interquartile Range		99.6667	
	Skewness		0.6831	0.3925
	Kurtosis		-0.3865	0.7681
ELECTRICAL CONDUCTIVITY	Mean		863.2778	26.8836
	95% Confidence Interval for Mean	Lower Bound	808.7012	
		Upper Bound	917.8544	
	5% Trimmed Mean		864.5741	
	Median		867.5000	
	Variance		26 018.2063	
	Std. Deviation		161.3016	
	Minimum		551.0000	
	Maximum		1 154.0000	
	Range		603.0000	
	Interquartile Range		215.0000	
	Skewness		-0.0842	0.3925
	Kurtosis		-0.2495	0.7681

DESCRIPTIVES			Statistic	Std. Error
SALINITY	Mean		0.4231	0.0133
	95% Confidence Interval for Mean	Lower Bound	0.3960	
		Upper Bound	0.4501	
	5% Trimmed Mean		0.4234	
	Median		0.4250	
	Variance		0.0064	
	Std. Deviation		0.0799	
	Minimum		0.2700	
	Maximum		0.5700	
	Range		0.3000	
	Interquartile Range		0.0950	
	Skewness		-0.0091	0.3925
	Kurtosis		-0.1218	0.7681
RESISTIVITY	Mean		1 198.8611	39.9221
	95% Confidence Interval for Mean	Lower Bound	1 117.8148	
		Upper Bound	1 279.9074	
	5% Trimmed Mean		1 185.8827	
	Median		1 153.0000	
	Variance		57 376.0087	
	Std. Deviation		239.5329	
	Minimum		867.0000	
	Maximum		1 763.0000	
	Range		896.0000	
	Interquartile Range		299.0000	
	Skewness		0.9413	0.3925
	Kurtosis		0.6032	0.7681
TSS_Log10	Mean		0.0143	0.0047
	95% Confidence Interval for Mean	Lower Bound	0.0047	
		Upper Bound	0.0239	
	5% Trimmed Mean		0.0094	
	Median		0.0060	
	Variance		0.0008	
	Std. Deviation		0.0283	
	Minimum		0.0002	
	Maximum		0.1678	
	Range		0.1675	
	Interquartile Range		0.0131	
	Skewness		4.8525	0.3925
	Kurtosis		25.9938	0.7681

DESCRIPTIVES			Statistic	Std. Error
pH_Log10	Mean		0.8413	0.0039
	95% Confidence Interval for Mean	Lower Bound	0.8333	
		Upper Bound	0.8493	
	5% Trimmed Mean		0.8407	
	Median		0.8370	
	Variance		0.0006	
	Std. Deviation		0.0237	
	Minimum		0.8048	
	Maximum		0.8899	
	Range		0.0850	
	Interquartile Range		0.0240	
	Skewness		0.7245	0.3925
	Kurtosis		-0.1691	0.7681
Resistivity_Log10	Mean		3.0709	0.0138
	95% Confidence Interval for Mean	Lower Bound	3.0429	
		Upper Bound	3.0989	
	5% Trimmed Mean		3.0685	
	Median		3.0618	
	Variance		0.0068	
	Std. Deviation		0.0827	
	Minimum		2.9380	
	Maximum		3.2463	
	Range		0.3082	
	Interquartile Range		0.1097	
	Skewness		0.4820	0.3925
	Kurtosis		-0.0512	0.7681
HPC_Log10	Mean		3.1444	0.1143
	95% Confidence Interval for Mean	Lower Bound	2.9123	
		Upper Bound	3.3764	
	5% Trimmed Mean		3.0991	
	Median		2.8573	
	Variance		0.4703	
	Std. Deviation		0.6858	
	Minimum		2.0000	
	Maximum		5.0170	
	Range		3.0170	
	Interquartile Range		0.9918	
	Skewness		0.9266	0.3925
	Kurtosis		0.8725	0.7681

DESCRIPTIVES			Statistic	Std. Error
TC_Log10	Mean		1.0604	0.1065
	95% Confidence Interval for Mean	Lower Bound	0.8442	
		Upper Bound	1.2765	
	5% Trimmed Mean		1.0460	
	Median		0.8525	
	Variance		0.4081	
	Std. Deviation		0.6389	
	Minimum		0.1584	
	Maximum		2.2212	
	Range		2.0628	
	Interquartile Range		1.0545	
	Skewness		0.5585	0.3925
	Kurtosis		-0.9388	0.7681

DESCRIPTIVES			Statistic	Std. Error
E.coli	Mean		3.1996	0.4870
	95% Confidence Interval for Mean	Lower Bound	2.2109	
		Upper Bound	4.1882	
	5% Trimmed Mean		3.0198	
	Median		1.4800	
	Variance		8.5378	
	Std. Deviation		2.9220	
	Minimum		0.3200	
	Maximum		9.6000	
	Range		9.2800	
	Interquartile Range		4.8800	
	Skewness		0.7838	0.3925
	Kurtosis		-0.8430	0.7681
FAECAL COLIFORMS	Mean		7.1740	1.7314
	95% Confidence Interval for Mean	Lower Bound	3.6591	
		Upper Bound	10.6889	
	5% Trimmed Mean		5.9468	
	Median		1.7200	
	Variance		107.9199	
	Std. Deviation		10.3885	
	Minimum		0.4800	
	Maximum		41.6000	
	Range		41.1200	
	Interquartile Range		8.2400	
	Skewness		1.8623	0.3925
	Kurtosis		2.7362	0.7681
FAECAL STREPTOCOCCI	Mean		0.9120	0.1832
	95% Confidence Interval for Mean	Lower Bound	0.5401	
		Upper Bound	1.2839	
	5% Trimmed Mean		0.7653	
	Median		0.5200	
	Variance		1.2083	
	Std. Deviation		1.0992	
	Minimum		0.0200	
	Maximum		4.8000	
	Range		4.7800	
	Interquartile Range		0.9550	
	Skewness		2.1963	0.3925
	Kurtosis		4.9640	0.7681

DESCRIPTIVES			Statistic	Std. Error
ENTEROCOCCI	Mean		1.2132	0.3602
	95% Confidence Interval for Mean	Lower Bound	0.4821	
		Upper Bound	1.9444	
	5% Trimmed Mean		0.9678	
	Median		0.3600	
	Variance		4.6695	
	Std. Deviation		2.1609	
	Minimum		-	
	Maximum		7.2000	
	Range		7.2000	
	Interquartile Range		0.7960	
	Skewness		1.8824	0.3925
	Kurtosis		1.9328	0.7681
TOTAL COLIFORMS	Mean		30.6902	8.1696
	95% Confidence Interval for Mean	Lower Bound	14.1050	
		Upper Bound	47.2754	
	5% Trimmed Mean		25.0109	
	Median		5.7600	
	Variance		2 402.7312	
	Std. Deviation		49.0177	
	Minimum		1.4400	
	Maximum		166.4000	
	Range		164.9600	
	Interquartile Range		27.1000	
	Skewness		1.7981	0.3925
	Kurtosis		1.9159	0.7681
HETEROTROPHIC BACTERIAL COUNT	Mean		1 597.9278	351.4502
	95% Confidence Interval for Mean	Lower Bound	884.4459	
		Upper Bound	2 311.4096	
	5% Trimmed Mean		1 396.0877	
	Median		660.0000	
	Variance		4 446 620.7272	
	Std. Deviation		2 108.7012	
	Minimum		62.4000	
	Maximum		6 800.0000	
	Range		6 737.6000	
	Interquartile Range		1 420.0000	
	Skewness		1.5175	0.3925
	Kurtosis		0.7935	0.7681

DESCRIPTIVES			Statistic	Std. Error
Log10_FC	Mean		0.6494	0.0754
	95% Confidence Interval for Mean	Lower Bound	0.4962	
		Upper Bound	0.8025	
	5% Trimmed Mean		0.6246	
	Median		0.4345	
	Variance		0.2048	
	Std. Deviation		0.4525	
	Minimum		0.1703	
	Maximum		1.6294	
	Range		1.4591	
	Interquartile Range		0.7053	
	Skewness		0.8635	0.3925
	Kurtosis		-0.6560	0.7681
Log10_FS	Mean		0.2327	0.0323
	95% Confidence Interval for Mean	Lower Bound	0.1672	
		Upper Bound	0.2982	
	5% Trimmed Mean		0.2172	
	Median		0.1817	
	Variance		0.0375	
	Std. Deviation		0.1936	
	Minimum		0.0086	
	Maximum		0.7634	
	Range		0.7548	
	Interquartile Range		0.2503	
	Skewness		1.1352	0.3925
	Kurtosis		0.9440	0.7681
Log10_ENT	Mean		0.2186	0.0491
	95% Confidence Interval for Mean	Lower Bound	0.1189	
		Upper Bound	0.3183	
	5% Trimmed Mean		0.1933	
	Median		0.1334	
	Variance		0.0868	
	Std. Deviation		0.2946	
	Minimum		-	
	Maximum		0.9138	
	Range		0.9138	
	Interquartile Range		0.2535	
	Skewness		1.5237	0.3925
	Kurtosis		0.9113	0.7681

Table VII (n): Descriptive statistics for physicochemical and microbial parameters measured at the discharge point for the NGTW between March 2012 and February 2013

DESCRIPTIVES			Statistic	Std. Error
TEMPERATURE	Mean		20.3889	0.4706
	95% Confidence Interval for Mean	Lower Bound	19.4335	
		Upper Bound	21.3443	
	5% Trimmed Mean		20.2932	
	Median		20.0000	
	Variance		7.9730	
	Std. Deviation		2.8237	
	Minimum		16.5000	
	Maximum		26.0000	
	Range		9.5000	
	Interquartile Range		5.0000	
	Skewness		0.4714	0.3925
	Kurtosis		-0.6220	0.7681
TURBIDITY	Mean		13.9822	1.5326
	95% Confidence Interval for Mean	Lower Bound	10.8708	
		Upper Bound	17.0936	
	5% Trimmed Mean		13.7740	
	Median		13.7500	
	Variance		84.5631	
	Std. Deviation		9.1958	
	Minimum		1.4000	
	Maximum		30.3000	
	Range		28.9000	
	Interquartile Range		13.2800	
	Skewness		0.5004	0.3925
	Kurtosis		-0.8072	0.7681
TOTAL DISSOLVED SOLIDS	Mean		459.2778	15.9962
	95% Confidence Interval for Mean	Lower Bound	426.8038	
		Upper Bound	491.7517	
	5% Trimmed Mean		460.4691	
	Median		464.5000	
	Variance		9 211.5778	
	Std. Deviation		95.9770	
	Minimum		275.0000	
	Maximum		623.0000	
	Range		348.0000	
	Interquartile Range		138.7500	
	Skewness		-0.1902	0.3925
	Kurtosis		-0.4885	0.7681

DESCRIPTIVES			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0183	0.0164
	95% Confidence Interval for Mean	Lower Bound	-0.0151	
		Upper Bound	0.0516	
	5% Trimmed Mean		0.0164	
	Median		0.0112	
	Variance		0.0097	
	Std. Deviation		0.0986	
	Minimum		-0.3780	
	Maximum		0.4328	
	Range		0.8108	
	Interquartile Range		0.0204	
	Skewness		0.2975	0.3925
	Kurtosis		16.1922	0.7681
pH	Mean		6.9875	0.0699
	95% Confidence Interval for Mean	Lower Bound	6.8456	
		Upper Bound	7.1294	
	5% Trimmed Mean		6.9731	
	Median		6.9850	
	Variance		0.1760	
	Std. Deviation		0.4195	
	Minimum		6.3400	
	Maximum		7.8800	
	Range		1.5400	
	Interquartile Range		0.5275	
	Skewness		0.5102	0.3925
	Kurtosis		-0.1428	0.7681
DISSOLVED OXYGEN	Mean		8.0721	0.0620
	95% Confidence Interval for Mean	Lower Bound	7.9462	
		Upper Bound	8.1980	
	5% Trimmed Mean		8.0705	
	Median		8.0925	
	Variance		0.1384	
	Std. Deviation		0.3720	
	Minimum		7.4100	
	Maximum		8.8400	
	Range		1.4300	
	Interquartile Range		0.5763	
	Skewness		-0.0422	0.3925
	Kurtosis		-0.7003	0.7681

DESCRIPTIVES			Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean		4.1522	0.1814
	95% Confidence Interval for Mean	Lower Bound	3.7840	
		Upper Bound	4.5205	
	5% Trimmed Mean		4.1496	
	Median		3.9331	
	Variance		1.1846	
	Std. Deviation		1.0884	
	Minimum		2.2200	
	Maximum		6.1119	
	Range		3.8919	
	Interquartile Range		1.8514	
	Skewness		0.1307	0.3925
	Kurtosis		-0.9359	0.7681
CHEMICAL OXYGEN DEMAND	Mean		226.5093	14.1394
	95% Confidence Interval for Mean	Lower Bound	197.8048	
		Upper Bound	255.2137	
	5% Trimmed Mean		231.4918	
	Median		245.5000	
	Variance		7 197.1777	
	Std. Deviation		84.8362	
	Minimum		51.6667	
	Maximum		311.6667	
	Range		260.0000	
	Interquartile Range		150.3333	
	Skewness		-0.7841	0.3925
	Kurtosis		-0.6595	0.7681
ELECTRICAL CONDUCTIVITY	Mean		934.4722	31.7595
	95% Confidence Interval for Mean	Lower Bound	869.9971	
		Upper Bound	998.9473	
	5% Trimmed Mean		937.0432	
	Median		944.5000	
	Variance		36 311.8563	
	Std. Deviation		190.5567	
	Minimum		567.0000	
	Maximum		1 257.0000	
	Range		690.0000	
	Interquartile Range		284.7500	
	Skewness		-0.2090	0.3925
	Kurtosis		-0.4981	0.7681

DESCRIPTIVES			Statistic	Std. Error
E.coli	Mean		1.2725	0.6459
	95% Confidence Interval for Mean	Lower Bound	-0.0389	
		Upper Bound	2.5838	
	5% Trimmed Mean		0.6158	
	Median		0.0300	
	Variance		15.0209	
	Std. Deviation		3.8757	
	Minimum		-	
	Maximum		14.7200	
	Range		14.7200	
	Interquartile Range		0.2998	
	Skewness		3.1515	0.3925
	Kurtosis		8.4588	0.7681
FAECAL COLIFORMS	Mean		1.1372	0.5509
	95% Confidence Interval for Mean	Lower Bound	0.0187	
		Upper Bound	2.2557	
	5% Trimmed Mean		0.5821	
	Median		0.0060	
	Variance		10.9274	
	Std. Deviation		3.3057	
	Minimum		-	
	Maximum		12.4800	
	Range		12.4800	
	Interquartile Range		0.3182	
	Skewness		3.1175	0.3925
	Kurtosis		8.3064	0.7681
FAECAL STREPTOCOCCI	Mean		0.5645	0.2907
	95% Confidence Interval for Mean	Lower Bound	-0.0257	
		Upper Bound	1.1546	
	5% Trimmed Mean		0.2657	
	Median		-	
	Variance		3.0424	
	Std. Deviation		1.7442	
	Minimum		-	
	Maximum		6.7200	
	Range		6.7200	
	Interquartile Range		0.0200	
	Skewness		3.1415	0.3925
	Kurtosis		8.4690	0.7681

DESCRIPTIVES			Statistic	Std. Error
ENTEROCOCCI	Mean		0.6314	0.3532
	95% Confidence Interval for Mean	Lower Bound	-0.0857	
		Upper Bound	1.3484	
	5% Trimmed Mean		0.2610	
	Median		0.0000	
	Variance		4.4914	
	Std. Deviation		2.1193	
	Minimum		-	
	Maximum		8.6400	
	Range		8.6400	
	Interquartile Range		0.0125	
	Skewness		3.2186	0.3925
	Kurtosis		9.0495	0.7681
TOTAL COLIFORMS	Mean		3.5133	1.0765
	95% Confidence Interval for Mean	Lower Bound	1.3278	
		Upper Bound	5.6988	
	5% Trimmed Mean		2.6509	
	Median		0.6000	
	Variance		41.7219	
	Std. Deviation		6.4593	
	Minimum		0.0040	
	Maximum		26.2400	
	Range		26.2360	
	Interquartile Range		2.6280	
	Skewness		2.1975	0.3925
	Kurtosis		4.1001	0.7681
HETEROTROPHIC BACTERIAL COUNT	Mean		470.6917	153.1429
	95% Confidence Interval for Mean	Lower Bound	159.7950	
		Upper Bound	781.5883	
	5% Trimmed Mean		337.3031	
	Median		66.2000	
	Variance		844 299.2635	
	Std. Deviation		918.8576	
	Minimum		0.1500	
	Maximum		3 360.0000	
	Range		3 359.8500	
	Interquartile Range		660.7000	
	Skewness		2.5732	0.3925
	Kurtosis		5.8728	0.7681

DESCRIPTIVES			Statistic	Std. Error
Log10_EC	Mean		2.9615	0.0157
	95% Confidence Interval for Mean	Lower Bound	2.9296	
		Upper Bound	2.9935	
	5% Trimmed Mean		2.9654	
	Median		2.9756	
	Variance		0.0089	
	Std. Deviation		0.0943	
	Minimum		2.7543	
	Maximum		3.0997	
	Range		0.3453	
	Interquartile Range		0.1329	
	Skewness		-0.6770	0.3925
	Kurtosis		0.0147	0.7681
Log10_FC	Mean		0.1411	0.0516
	95% Confidence Interval for Mean	Lower Bound	0.0363	
		Upper Bound	0.2458	
	5% Trimmed Mean		0.0944	
	Median		0.0026	
	Variance		0.0959	
	Std. Deviation		0.3097	
	Minimum		-	
	Maximum		1.1297	
	Range		1.1297	
	Interquartile Range		0.1198	
	Skewness		2.7331	0.3925
	Kurtosis		6.5383	0.7681
Log10_FS	Mean		0.0878	0.0401
	95% Confidence Interval for Mean	Lower Bound	0.0064	
		Upper Bound	0.1691	
	5% Trimmed Mean		0.0489	
	Median		-	
	Variance		0.0578	
	Std. Deviation		0.2405	
	Minimum		-	
	Maximum		0.8876	
	Range		0.8876	
	Interquartile Range		0.0086	
	Skewness		2.9648	0.3925
	Kurtosis		7.5673	0.7681

DESCRIPTIVES			Statistic	Std. Error
Log10_ENT	Mean		0.0794	0.0433
	95% Confidence Interval for Mean	Lower Bound	-0.0086	
		Upper Bound	0.1674	
	5% Trimmed Mean		0.0355	
	Median		0.0000	
	Variance		0.0676	
	Std. Deviation		0.2600	
	Minimum		-	
	Maximum		0.9841	
	Range		0.9841	
	Interquartile Range		0.0054	
	Skewness		3.1572	0.3925
	Kurtosis		8.4703	0.7681
Log10_TC	Mean		0.3811	0.0724
	95% Confidence Interval for Mean	Lower Bound	0.2341	
		Upper Bound	0.5281	
	5% Trimmed Mean		0.3474	
	Median		0.2040	
	Variance		0.1887	
	Std. Deviation		0.4344	
	Minimum		0.0017	
	Maximum		1.4352	
	Range		1.4335	
	Interquartile Range		0.5239	
	Skewness		1.2621	0.3925
	Kurtosis		0.3490	0.7681
Log10_HPC	Mean		1.7415	0.1805
	95% Confidence Interval for Mean	Lower Bound	1.3751	
		Upper Bound	2.1079	
	5% Trimmed Mean		1.7357	
	Median		1.8267	
	Variance		1.1725	
	Std. Deviation		1.0828	
	Minimum		0.0607	
	Maximum		3.5265	
	Range		3.4658	
	Interquartile Range		2.1595	
	Skewness		-0.0104	0.3925
	Kurtosis		-1.1370	0.7681

DESCRIPTIVES			Statistic	Std. Error
SALINITY	Mean		0.4597	0.0163
	95% Confidence Interval for Mean	Lower Bound	0.4267	
		Upper Bound	0.4928	
	5% Trimmed Mean		0.4610	
	Median		0.4650	
	Variance		0.0095	
	Std. Deviation		0.0976	
	Minimum		0.2700	
	Maximum		0.6300	
	Range		0.3600	
	Interquartile Range		0.1475	
	Skewness		-0.2164	0.3925
	Kurtosis		-0.4370	0.7681
RESISTIVITY	Mean		1 132.7500	45.4099
	95% Confidence Interval for Mean	Lower Bound	1 040.5631	
		Upper Bound	1 224.9369	
	5% Trimmed Mean		1 113.9506	
	Median		1 085.5000	
	Variance		74 234.0214	
	Std. Deviation		272.4592	
	Minimum		795.0000	
	Maximum		1 808.0000	
	Range		1 013.0000	
	Interquartile Range		339.0000	
	Skewness		1.1553	0.3925
	Kurtosis		1.0919	0.7681
Res_Log10	Mean		3.0431	0.0162
	95% Confidence Interval for Mean	Lower Bound	3.0102	
		Upper Bound	3.0760	
	5% Trimmed Mean		3.0391	
	Median		3.0353	
	Variance		0.0095	
	Std. Deviation		0.0972	
	Minimum		2.9004	
	Maximum		3.2572	
	Range		0.3568	
	Interquartile Range		0.1359	
	Skewness		0.6335	0.3925
	Kurtosis		0.0107	0.7681

Table VII (o): Descriptive statistics for physicochemical and microbial parameters measured upstream of the Aller River between March 2012 and February 2013

DESCRIPTIVES			Statistic	Std. Error
TEMPERATURE	Mean		18.3528	0.5571
	95% Confidence Interval for Mean	Lower Bound	17.2219	
		Upper Bound	19.4837	
	5% Trimmed Mean		18.2253	
	Median		17.0000	
	Variance		11.1717	
	Std. Deviation		3.3424	
	Minimum		13.5000	
	Maximum		25.5000	
	Range		12.0000	
	Interquartile Range		4.7500	
	Skewness		0.5804	0.3925
	Kurtosis		-0.2659	0.7681
TURBIDITY	Mean		12.3167	1.9265
	95% Confidence Interval for Mean	Lower Bound	8.4057	
		Upper Bound	16.2276	
	5% Trimmed Mean		11.2959	
	Median		8.5150	
	Variance		133.6071	
	Std. Deviation		11.5589	
	Minimum		2.4300	
	Maximum		40.8000	
	Range		38.3700	
	Interquartile Range		10.4275	
	Skewness		1.5859	0.3925
	Kurtosis		1.2920	0.7681
TOTAL DISSOLVED SOLIDS	Mean		209.3083	8.7756
	95% Confidence Interval for Mean	Lower Bound	191.4929	
		Upper Bound	227.1237	
	5% Trimmed Mean		204.8117	
	Median		201.9500	
	Variance		2 772.3951	
	Std. Deviation		52.6535	
	Minimum		152.8000	
	Maximum		348.0000	
	Range		195.2000	
	Interquartile Range		68.7250	
	Skewness		1.2828	0.3925
	Kurtosis		1.6225	0.7681

DESCRIPTIVES			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0023	0.0095
	95% Confidence Interval for Mean	Lower Bound	-0.0170	
		Upper Bound	0.0217	
	5% Trimmed Mean		0.0097	
	Median		0.0050	
	Variance		0.0033	
	Std. Deviation		0.0571	
	Minimum		-0.3204	
	Maximum		0.0544	
	Range		0.3748	
	Interquartile Range		0.0126	
	Skewness		-5.3847	0.3925
	Kurtosis		31.2800	0.7681
pH	Mean		6.9689	0.0828
	95% Confidence Interval for Mean	Lower Bound	6.8007	
		Upper Bound	7.1371	
	5% Trimmed Mean		6.9527	
	Median		7.0200	
	Variance		0.2470	
	Std. Deviation		0.4970	
	Minimum		6.2900	
	Maximum		7.9400	
	Range		1.6500	
	Interquartile Range		0.8875	
	Skewness		0.3714	0.3925
	Kurtosis		-0.8444	0.7681
DISSOLVED SOLIDS	Mean		8.0779	0.0919
	95% Confidence Interval for Mean	Lower Bound	7.8913	
		Upper Bound	8.2645	
	5% Trimmed Mean		8.0958	
	Median		7.9425	
	Variance		0.3042	
	Std. Deviation		0.5516	
	Minimum		6.8700	
	Maximum		8.8500	
	Range		1.9800	
	Interquartile Range		0.9400	
	Skewness		-0.3297	0.3925
	Kurtosis		-0.9011	0.7681

DESCRIPTIVES			Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean		6.5359	0.7439
	95% Confidence Interval for Mean	Lower Bound	5.0257	
		Upper Bound	8.0462	
	5% Trimmed Mean		6.0148	
	Median		5.3657	
	Variance		19.9243	
	Std. Deviation		4.4637	
	Minimum		1.9900	
	Maximum		20.6000	
	Range		18.6100	
	Interquartile Range		3.3600	
	Skewness		2.0178	0.3925
	Kurtosis		3.6942	0.7681
CHEMICAL OXYGEN DEMAND	Mean		216.2778	19.8063
	95% Confidence Interval for Mean	Lower Bound	176.0689	
		Upper Bound	256.4867	
	5% Trimmed Mean		221.7654	
	Median		301.5000	
	Variance		14 122.3968	
	Std. Deviation		118.8377	
	Minimum		18.0000	
	Maximum		314.0000	
	Range		296.0000	
	Interquartile Range		221.2500	
	Skewness		-0.6945	0.3925
	Kurtosis		-1.3459	0.7681
ELECTRICAL CONDUCTIVITY	Mean		433.7222	17.7583
	95% Confidence Interval for Mean	Lower Bound	397.6710	
		Upper Bound	469.7734	
	5% Trimmed Mean		424.6975	
	Median		419.5000	
	Variance		11 352.8349	
	Std. Deviation		106.5497	
	Minimum		319.0000	
	Maximum		714.0000	
	Range		395.0000	
	Interquartile Range		139.7500	
	Skewness		1.2640	0.3925
	Kurtosis		1.5697	0.7681

DESCRIPTIVES			Statistic	Std. Error
SALINITY	Mean		0.2081	0.0088
	95% Confidenc	Lower Bound	0.1901	
		Upper Bound	0.2260	
	5% Trimmed Mean		0.2036	
	Median		0.2050	
	Variance		0.0028	
	Std. Deviation		0.0531	
	Minimum		0.1500	
	Maximum		0.3500	
	Range		0.2000	
	Interquartile Range		0.0675	
	Skewness		1.2288	0.3925
	Kurtosis		1.5122	0.7681
RESISTIVITY	Mean		2 418.6389	84.1269
	95% Confidenc	Lower Bound	2 247.8522	
		Upper Bound	2 589.4256	
	5% Trimmed Mean		2 436.1358	
	Median		2 390.0000	
	Variance		254 784.1802	
	Std. Deviation		504.7615	
	Minimum		1 411.0000	
	Maximum		3 110.0000	
	Range		1 699.0000	
	Interquartile Range		849.2500	
	Skewness		-0.2417	0.3925
	Kurtosis		-0.6603	0.7681
Turb_Log10	Mean		0.9368	0.0603
	95% Confidenc	Lower Bound	0.8143	
		Upper Bound	1.0593	
	5% Trimmed Mean		0.9302	
	Median		0.9299	
	Variance		0.1311	
	Std. Deviation		0.3620	
	Minimum		0.3856	
	Maximum		1.6107	
	Range		1.2251	
	Interquartile Range		0.5527	
	Skewness		0.3729	0.3925
	Kurtosis		-0.5583	0.7681

DESCRIPTIVES			Statistic	Std. Error
TDS_Log10	Mean		2.3089	0.0168
	95% Confidence Interval for Mean	Lower Bound	2.2749	
		Upper Bound	2.3429	
	5% Trimmed Mean		2.3030	
	Median		2.3052	
	Variance		0.0101	
	Std. Deviation		0.1005	
	Minimum		2.1841	
	Maximum		2.5416	
	Range		0.3575	
	Interquartile Range		0.1537	
	Skewness		0.7000	0.3925
	Kurtosis		0.1827	0.7681
BOD_Log10	Mean		0.7444	0.0394
	95% Confidence Interval for Mean	Lower Bound	0.6644	
		Upper Bound	0.8245	
	5% Trimmed Mean		0.7343	
	Median		0.7296	
	Variance		0.0559	
	Std. Deviation		0.2365	
	Minimum		0.2989	
	Maximum		1.3139	
	Range		1.0150	
	Interquartile Range		0.2810	
	Skewness		0.7869	0.3925
	Kurtosis		0.4651	0.7681
EC_Log10	Mean		2.6258	0.0164
	95% Confidence Interval for Mean	Lower Bound	2.5925	
		Upper Bound	2.6591	
	5% Trimmed Mean		2.6201	
	Median		2.6226	
	Variance		0.0097	
	Std. Deviation		0.0984	
	Minimum		2.5038	
	Maximum		2.8537	
	Range		0.3499	
	Interquartile Range		0.1506	
	Skewness		0.6944	0.3925
	Kurtosis		0.1712	0.7681

DESCRIPTIVES			Statistic	Std. Error
SAL_Log10	Mean		0.0817	0.0031
	95% Confidence Interval for Mean	Lower Bound	0.0754	
		Upper Bound	0.0880	
	5% Trimmed Mean		0.0802	
	Median		0.0810	
	Variance		0.0003	
	Std. Deviation		0.0186	
	Minimum		0.0607	
	Maximum		0.1303	
	Range		0.0696	
	Interquartile Range		0.0245	
	Skewness		1.1130	0.3925
	Kurtosis		1.1932	0.7681
TSS_R_Log10	Mean		0.0197	0.0035
	95% Confidence Interval for Mean	Lower Bound	0.0126	
		Upper Bound	0.0268	
	5% Trimmed Mean		0.0171	
	Median		0.0191	
	Variance		0.0004	
	Std. Deviation		0.0210	
	Minimum		-0.0019	
	Maximum		0.1368	
	Range		0.1388	
	Interquartile Range		0.0053	
	Skewness		5.1809	0.3925
	Kurtosis		29.8106	0.7681

Table VII (p): Descriptive statistics for physicochemical and microbial parameters measured downstream of the Aller River between March 2012 and February 2013

DESCRIPTIVES			Statistic	Std. Error
TEMPERATURE	Mean		18.3917	0.6767
	95% Confidence Interval for Mean	Lower Bound	17.0179	
		Upper Bound	19.7655	
	5% Trimmed Mean		18.3364	
	Median		19.0000	
	Variance		16.4859	
	Std. Deviation		4.0603	
	Minimum		12.0000	
	Maximum		26.0000	
	Range		14.0000	
	Interquartile Range		7.3750	
	Skewness		0.0248	0.3925
	Kurtosis		-0.9161	0.7681
TURBIDITY	Mean		13.2922	1.0679
	95% Confidence Interval for Mean	Lower Bound	11.1242	
		Upper Bound	15.4603	
	5% Trimmed Mean		12.9216	
	Median		14.0500	
	Variance		41.0581	
	Std. Deviation		6.4077	
	Minimum		5.1000	
	Maximum		28.2000	
	Range		23.1000	
	Interquartile Range		9.9250	
	Skewness		0.6875	0.3925
	Kurtosis		0.3123	0.7681
TOTAL DISSOLVED SOLIDS	Mean		322.2500	10.8126
	95% Confidence Interval for Mean	Lower Bound	300.2993	
		Upper Bound	344.2007	
	5% Trimmed Mean		318.9691	
	Median		309.0000	
	Variance		4 208.8214	
	Std. Deviation		64.8754	
	Minimum		241.0000	
	Maximum		463.0000	
	Range		222.0000	
	Interquartile Range		101.0000	
	Skewness		0.7067	0.3925
	Kurtosis		-0.2599	0.7681

DESCRIPTIVES			Statistic	Std. Error
TOTAL SUSPENDED SOLIDS	Mean		0.0200	0.0596
	95% Confidence Interval for Mean	Lower Bound	-0.1010	
		Upper Bound	0.1411	
	5% Trimmed Mean		0.0181	
	Median		0.0134	
	Variance		0.1280	
	Std. Deviation		0.3577	
	Minimum		-1.4828	
	Maximum		1.5040	
	Range		2.9868	
	Interquartile Range		0.0164	
	Skewness		-0.0824	0.3925
	Kurtosis		17.3299	0.7681
pH	Mean		7.1486	0.0763
	95% Confidence Interval for Mean	Lower Bound	6.9938	
		Upper Bound	7.3034	
	5% Trimmed Mean		7.1336	
	Median		7.0900	
	Variance		0.2094	
	Std. Deviation		0.4576	
	Minimum		6.4700	
	Maximum		8.0800	
	Range		1.6100	
	Interquartile Range		0.6050	
	Skewness		0.6216	0.3925
	Kurtosis		-0.2867	0.7681
DISSOLVED OXYGEN	Mean		8.1919	0.0779
	95% Confidence Interval for Mean	Lower Bound	8.0337	
		Upper Bound	8.3502	
	5% Trimmed Mean		8.2085	
	Median		8.4125	
	Variance		0.2187	
	Std. Deviation		0.4676	
	Minimum		7.2300	
	Maximum		8.8500	
	Range		1.6200	
	Interquartile Range		0.8538	
	Skewness		-0.4389	0.3925
	Kurtosis		-1.2429	0.7681

DESCRIPTIVES			Statistic	Std. Error
BIOLOGICAL OXYGEN DEMAND	Mean		5.2889	0.3139
	95% Confidence Interval for Mean	Lower Bound	4.6516	
		Upper Bound	5.9262	
	5% Trimmed Mean		5.2489	
	Median		4.8881	
	Variance		3.5473	
	Std. Deviation		1.8834	
	Minimum		1.8450	
	Maximum		9.4700	
	Range		7.6250	
	Interquartile Range		2.6886	
	Skewness		0.3474	0.3925
	Kurtosis		-0.6782	0.7681
CHEMICAL OXYGEN DEMAND	Mean		190.9444	17.0995
	95% Confidence Interval for Mean	Lower Bound	156.2306	
		Upper Bound	225.6583	
	5% Trimmed Mean		192.9239	
	Median		212.8333	
	Variance		10 526.1746	
	Std. Deviation		102.5971	
	Minimum		32.3333	
	Maximum		313.3333	
	Range		281.0000	
	Interquartile Range		207.5000	
	Skewness		-0.2762	0.3925
	Kurtosis		-1.5019	0.7681
ELECTRICAL CONDUCTIVITY'	Mean		661.3056	21.6431
	95% Confidence Interval for Mean	Lower Bound	617.3678	
		Upper Bound	705.2433	
	5% Trimmed Mean		654.9444	
	Median		634.0000	
	Variance		16 863.1897	
	Std. Deviation		129.8583	
	Minimum		497.0000	
	Maximum		941.0000	
	Range		444.0000	
	Interquartile Range		200.7500	
	Skewness		0.6916	0.3925
	Kurtosis		-0.2891	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
E.coli	Mean		20.1161	6.9944
	95% Confidence Interval for Mean	Lower Bound	5.9168	
		Upper Bound	34.3154	
	5% Trimmed Mean		14.4895	
	Median		0.1000	
	Variance		1 761.1579	
	Std. Deviation		41.9662	
	Minimum		-	
	Maximum		147.2000	
	Range		147.2000	
	Interquartile Range		12.5575	
	Skewness		2.1458	0.3925
	Kurtosis		3.3680	0.7681
FC	Mean		10.2620	2.1319
	95% Confidence Interval for Mean	Lower Bound	5.9340	
		Upper Bound	14.5900	
	5% Trimmed Mean		9.5220	
	Median		0.6300	
	Variance		163.6210	
	Std. Deviation		12.7914	
	Minimum		-	
	Maximum		35.3200	
	Range		35.3200	
	Interquartile Range		22.8755	
	Skewness		0.7038	0.3925
	Kurtosis		-1.2070	0.7681
FS	Mean		2.0136	0.5056
	95% Confidence Interval for Mean	Lower Bound	0.9872	
		Upper Bound	3.0400	
	5% Trimmed Mean		1.7475	
	Median		0.1400	
	Variance		9.2021	
	Std. Deviation		3.0335	
	Minimum		-	
	Maximum		9.6000	
	Range		9.6000	
	Interquartile Range		3.1600	
	Skewness		1.2839	0.3925
	Kurtosis		0.1480	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
ENT	Mean		2.4924	0.6400
	95% Confidence Interval for Mean	Lower Bound	1.1932	
		Upper Bound	3.7917	
	5% Trimmed Mean		2.0652	
	Median		0.1080	
	Variance		14.7447	
	Std. Deviation		3.8399	
	Minimum		-	
	Maximum		13.6000	
	Range		13.6000	
	Interquartile Range		4.4800	
	Skewness		1.5054	0.3925
	Kurtosis		1.2656	0.7681
TC	Mean		54.4035	14.2772
	95% Confidence Interval for Mean	Lower Bound	25.4193	
		Upper Bound	83.3878	
	5% Trimmed Mean		44.7242	
	Median		1.5600	
	Variance		7 338.1711	
	Std. Deviation		85.6631	
	Minimum		0.0112	
	Maximum		294.4000	
	Range		294.3888	
	Interquartile Range		96.1960	
	Skewness		1.6176	0.3925
	Kurtosis		1.6980	0.7681
HPC	Mean		1 743.8056	356.5494
	95% Confidence Interval for Mean	Lower Bound	1 019.9718	
		Upper Bound	2 467.6394	
	5% Trimmed Mean		1 527.1914	
	Median		620.0000	
	Variance		4 576 589.4754	
	Std. Deviation		2 139.2965	
	Minimum		-	
	Maximum		7 600.0000	
	Range		7 600.0000	
	Interquartile Range		2 767.5000	
	Skewness		1.3566	0.3925
	Kurtosis		1.1475	0.7681

DESCRIPTIVES				
			Statistic	Std. Error
Log10_ECOLI	Mean		0.5627	0.1284
	95% Confidence Interval for Mean	Lower Bound	0.3019	
		Upper Bound	0.8235	
	5% Trimmed Mean		0.5056	
	Median		0.0407	
	Variance		0.5940	
	Std. Deviation		0.7707	
	Minimum		-	
	Maximum		2.1708	
	Range		2.1708	
	Interquartile Range		1.0939	
	Skewness		1.0943	0.3925
	Kurtosis		-0.3002	0.7681
Log10_FS	Mean		0.2966	0.0635
	95% Confidence Interval for Mean	Lower Bound	0.1676	
		Upper Bound	0.4256	
	5% Trimmed Mean		0.2746	
	Median		0.0552	
	Variance		0.1454	
	Std. Deviation		0.3813	
	Minimum		-	
	Maximum		1.0253	
	Range		1.0253	
	Interquartile Range		0.6190	
	Skewness		0.8427	0.3925
	Kurtosis		-1.0428	0.7681
Log10_ENT	Mean		0.3277	0.0692
	95% Confidence Interval for Mean	Lower Bound	0.1873	
		Upper Bound	0.4682	
	5% Trimmed Mean		0.3011	
	Median		0.0441	
	Variance		0.1723	
	Std. Deviation		0.4151	
	Minimum		-	
	Maximum		1.1644	
	Range		1.1644	
	Interquartile Range		0.7364	
	Skewness		0.8170	0.3925
	Kurtosis		-1.0199	0.7681