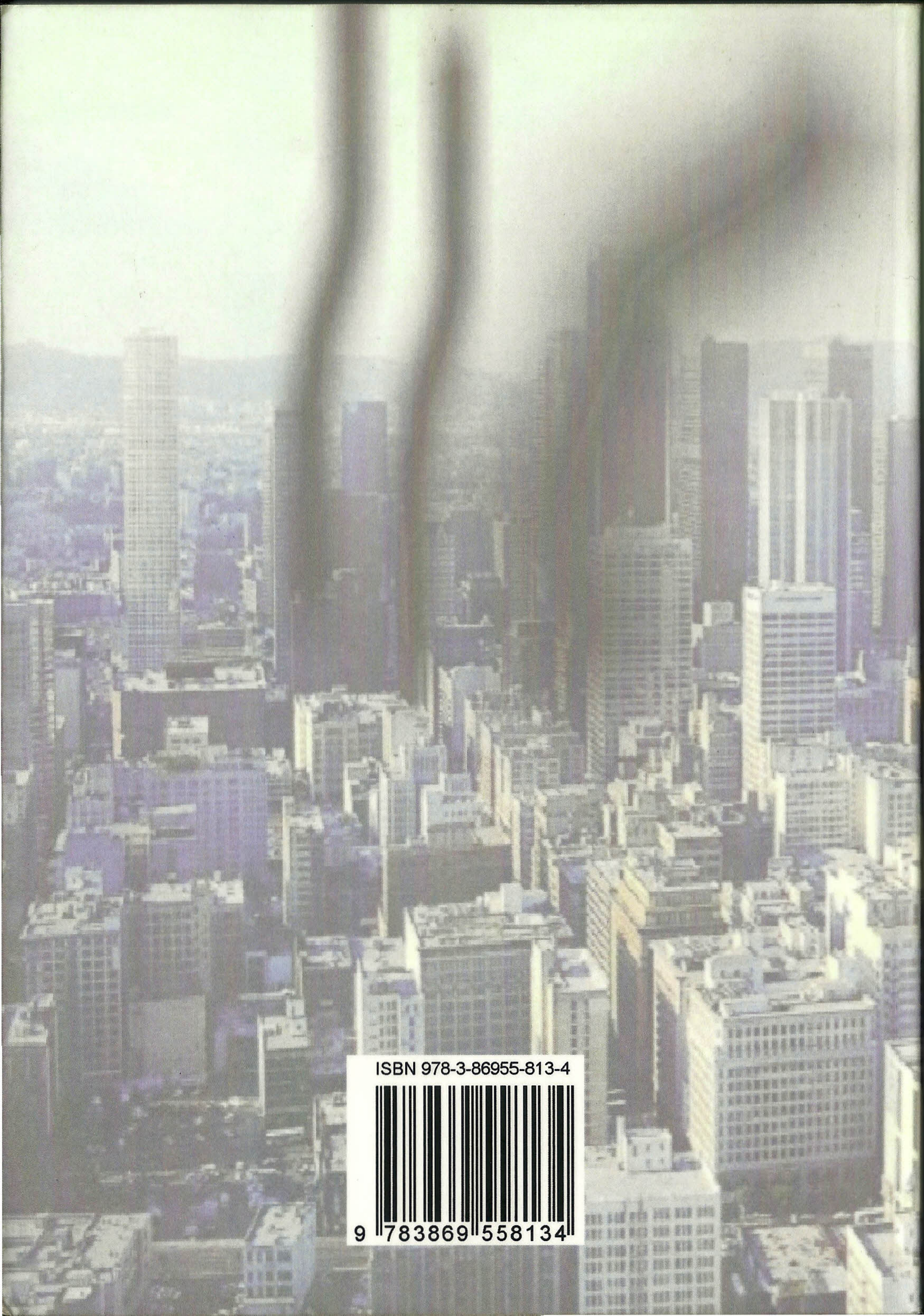

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URBAN AGRICULTURE, CITIES AND CLIMATE CHANGE

Edited by

Remi Adeyemo

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Preface

This publication is a selected refereed research papers from the Humboldt International conference (Humboldt Kolleg), Ile-Ife, 2010 which was sponsored by Alexander Humboldt Foundation, Germany. The original idea of the conference which was to discuss urban agriculture emerged from two research visits to Justus-Liebig University, Giessen, Germany.

It is noted that increasing urbanization in West Africa sub-region is causing dwindling agricultural resources and accelerating deterioration in the quality of life for those living in urban areas. There are urgent and pressing challenges that need an equally urgent and adequate response from city dwellers and national authorities. It is vital that researchers, policy makers and other stakeholders involved in urban agriculture must be aware of the scope of existing problems and future urban development activities. The situations call for improved access of the urban inhabitants to adequate food and fiber, basic facilities and friendly environment. The conference was convened in order to broaden the scope of the research visits.

As it turned out, the conference attracted considerable interest and enthusiasm which was reflected in a large attendance. About one hundred and eighteen papers were submitted and presented during the conference out of which sixty were selected for peer review evaluation This volume contains forty-four selected research papers after subjecting them to review mechanism.

The book is a component in many disciplines; which will be useful to those who have the opportunity to read it especially if considered by agriculturalists, urban researchers, geographers, sociologists, environmentalists, health workers and policy makers.

At this point I gratefully acknowledge the financial support of the Humboldt Foundation without which this publication would not have been possible. Many thanks go to the staff of the foundation for making this publication possible.

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Contents

EFFECT OF INDUSTRIAL EFFLUENTS ON WATER QUALITY OF RIVER ATUWARA IN OTA, NIGERIA

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Abstract

The impacts of industrial wastewaters discharged into River Atuwara were estimated from the physical and chemical characteristics of the samples using standard methods. The quality of the effluent before and after dilution in the receiving water and impact on the use of the water for irrigation was studied using QUAL2K software for hydrodynamic analysis of streams and rivers. From the inputted data into the QUAL2K software, the average (and range) of the stream depth, velocity of flow and flow rates on the reaches studied were respectively 0.915 m (0.49 -2.59 m), 0.336 m/s (0.21 - 0.4 m/s) and 14.66 m^3/s (3.48 – 59.36 m^3/s). Majority of the water quality parameters exceeded the maximum concentration permissible: BOD: ≥ 31 mgL^{-1}; COD: ≥181 mgL^{-1}; Alkalinity: ≥ 138.4 mgL^{-1}; TSS: ≥ 826 mgL^{-1}; TDS: ≥ 501 mgL^{-1}; Chloride ≥ 9.95 mgL^{-1}; Nitrates ≥11.3 mgL^{-1} and Phosphates: ≥ 2.92 mgL^{-1}. High concentration of heavy metals such as Cadmium (≥0.017 ppm), Pb(≥0.29 ppm), Zn (≥0.001 ppm), Fe (≥7.04 ppm) and Mn (≥ 0.127 ppm) portends environmental hazard to riparian users. Although the water in the river could be used for irrigation to encourage urban agriculture as practiced along the river, the gross pollution of the river underscores the need for pre-treatment of the industrial effluents before discharge into the receiving water body.

INTRODUCTION

The quality and adequacy of water available to a people or nation is an essential measure of the quality of the people. Water quality is closely linked to water use and to the state of economic development. The vulnerability of surface water and ground water to degradation depends on a combination of natural landscape features, such as geology, topography and soil type and anthropogenic activities.

Water quality has been heavily impacted worldwide by industrial and agricultural chemicals (Terry, 1996). Pollution is caused by washing into surface water of sewage and fertilizers, which contain nutrients such as nitrate and phosphates which when present in excess stimulate the growth of aquatic plants and algae that consequently clog watercourses and use up dissolved oxygen as they decompose (Adenuga *et al*, 2003).

Industries discharge into the environment a variety of pollutants in their wastewater. Such pollutants include heavy metals, organic toxins, oil nutrients and solids. It is a generally accepted fact that the developed countries suffer from problems of chemical discharge into the water sources mainly groundwater while developing countries face problems of agricultural runoff in surface water sources (West, 2006).

The physical and chemical characteristics of the receiving waters are important factors influencing the impacts of industrial effluents on aquatic environments. These characteristics include water hardness, temperature, acidity or alkalinity, background concentrations of nutrients and metals, and the physical nature of the receiving water body (e.g., whether it is a stream, lake, or estuary; whether it contains fresh water or salty water).

Engineers rely on the volume and (dry weather) flow of a receiving water body to assess its ability to dilute or assimilate effluent discharges and hence, the extent of impact of the discharge from a given point source (Adewumi and Ogbiye, 2009). In small watercourses, intertidal areas, or receiving waters that are subject to periodically low seasonal flows, the water volume may be insufficient to dilute the effluent to non-toxic levels (OMOE 1990). In addition, a high assimilative capacity may have little effect on the long-term impact of persistent chemicals that tend to accumulate in sediments or the tissues of aquatic organisms over long periods of time (Adelegan, 2002; Ritu and Prateek, 2004).

THE STUDY AREA: ATUWARA RIVER, ORIGIN AND COURSE IN OGUN STATE NIGERIA

The Ado-Odo/Otta Local Government Area with an area of 1,460 km² and a population of 526,565 (Nigeria Population Commission, 2006) is one of the 19 Local Government Areas and the third largest Local Government Area in Ogun State. Ota (or Otta) at 6°41′00″N 3°41′00″E / 6.68°N 3.68°E has the third largest concentration of industries in Nigeria . It has a large urban – urban drift due to its proximity to Lagos State for people looking for cheaper accommodation.

Atuwara, a major tributary to Ogun River in Ogun - Oshun River Basin, traverses several villages thereby providing the needed water and economic activities to the surrounding villages. The portion of the basin covered by this research has an estimated area of about 4,420 hectares (Fig 1).

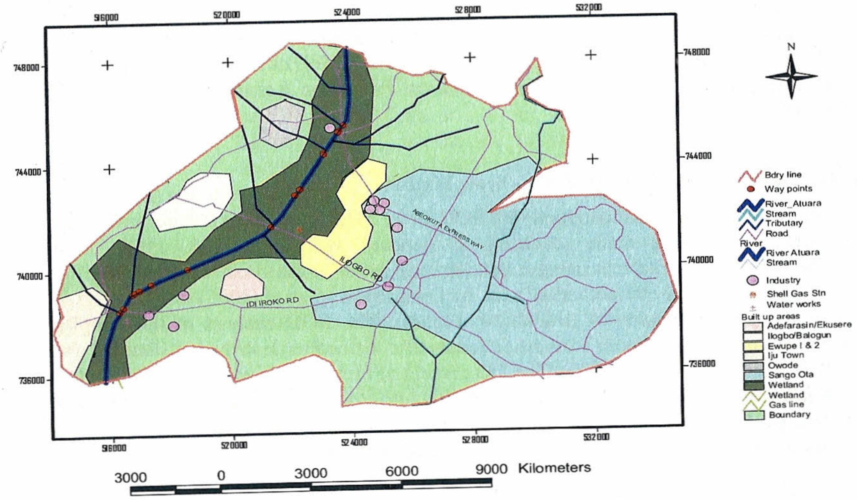

Fig 1: General Layout of Ota, Ogun State, Nigeria

A survey of Ado-Odo/Otta Municipal District lists about 100 large and small scale industries of which 35 industries and industrial units discharge their untreated or partially treated effluents directly or indirectly into the river. The impact of the industries on river Atuwara is the focus of this baseline study.

METHODOLOGY

A set of structured questionnaires were used to characterize the installed capacity, output, and capabilities and efficiencies of the treatment facility in each of 35 identified industries in Ado-Odo/Ota Industrial zone, with a sample size of at least 10 respondents from each of the selected industry. Secondary data from the Manufacturers Association of Nigeria (MAN) were also examined to extract the six sectors of effluent- producing industries studied during the course of this research (MAN, 2005).

Site Characterization Studies

In order to obtain background information and determine the extent of contamination to the water body for the pilot studies, reconnaissance survey of the study area was done. The water characteristics of the receiving water and those of the sampled industries were determined. The exact locations for sample collection on the receiving water were determined using the Garmin GPS Map 76 Global Positioning System (GPS). The effluent sample and the water sample at the respective locations were collected. The pH, Dissolved Oxygen (DO) turbidity, temperature and salinity for the water samples were determined according to standard methods (APHA, 1998).

The samples were taken within two hours after collection to the Covenant University Chemistry Research Laboratory where they were stored in the refrigerator at a temperature of 4°C prior to analysis for preservation. The study examined the water quality scenarios that occurred between 14/10/2008 and 11/05/2009 and opted for the month of March 2009 which was the pick of the dry season and a low flow period in the River Atuwara to characterize the water body. In addition, as Atuwara River watershed receives discharges and stream flow data, water surface elevations and DO concentrations observed were compared with values of the Nigerian Standard for Drinking Water Quality (NSDWQ) by Standards Organization of Nigeria (SON, 2007) and Federal Environmental Protection Agency (FEPA) limits (FEPA, 1988, 1991 and 1992).

Laboratory Test Studies and Pilot – Scale Studies

Determination of electrical conductivity, BOD, NO_3^- PO_3^{3-}, suspended solids, dissolved solids and total solids were made according to standard methods (APHA, 1998). Electrical conductivity was carried out using a conductivity meter at the room temperature of 25 °C. The Fiske and Subbarow method as used by Ogunfowokan *et al* (2005) was adopted for the colorimetric determination of available phosphate. The BOD analysis of the samples was carried out using the Winkler's modified iodometric method as described in standard methods (APHA, 1998; Ademoroti, 1985). The DO content of each sample was determined before and after incubation. Trace metals analysis using the nitric-perchloric-hydrofluoric, acid digestion method by Carrondo, *et al* (1979) was adopted. The data were logged into the QUAL2K program to characterize the receiving stream's hydrodynamic properties.

RESULTS AND DISCUSSION

The field survey showed that the drainage area of the Atuwara River watershed is approximately 147.333 square kilometres (147x10^3 hectares) with up to 50% forested, 10% agricultural, 25% water and/or wetland, 7% residential and 8% commercial. The investigated section of Atuwara watershed covered 10.808 kilometers covering seven reaches and 17 sampling points taken in 2008 and 2009 dry and rainy seasons. The study showed that River Atuwara is actively used including its use for wetland farming that can boost urban agriculture. Most farmers are into vegetable farming along the river bank.

The results of the hydrodynamic, physical and chemical parameters of the water samples and of the physical and chemical parameters of the effluents are as shown in Tables 1 -3. The highest relative value for BOD (56 mg/l) occurred at stations STD and STG at the peak of the wet season and at the point of entry of the effluent discharged from a brewery effluent at Ewupe and a food processing effluents at Igboloye. Differences between the observed values of DO were significant and with a good fit at all the study locations. A brewery discharge at Ewupe was found to be the chief source of pollution in reach 1; it discharged 11.99 metric tonnes BOD/day, which is 58% of the total load (Table 1). Collective load of all the drains in reaches 4 and 5 were compared to the other reaches. They contributed 19% and 7.4% of the total load respectively. While the nutrients in the wastewater will boost organic farming, the other pollutants are a major concern for its use.

Table 1: Average Water Quality Input Data* for Atuwara Rivers using QUAL2K software

		Trace Organic Pollutants							Inorganic Water Pollutants						Heavy Metals				
SAMPLE CODE	Relative Distance To STA-Atuara Upstream (km)	BOD_5	pH	Cond. (mS/cm-l)	DO	T.Hard.	Temp °C	T.Alkal.	TSS	TDS	COD	PO_4^-	Cl^-	NO_3.i	Cad.	Pb.	Zn.	Fe.	Mn.
FEPA STD.		30	6.5-8.5	**1000**	**4**	150	**20-33**		**30**	**500**	**80**	5	250	50	0.003	**0.01**	3	**0.3**	0.2
STA	0.00	21	6.7	7.3	7.03	6.2	26.6	47.6	14.5	136	73.8	1.17	4.04	3.6	0.006	0.29	<0.001	1.17	<0.002
STB	0.19	18	6.9	18.3	7.79	7.34	26.9	50.4	16.1	170	154	2.76	6	8.5	0.008	0.25	<0.001	1.46	<0.002
STC	0.24	23	6.85	4.1	7.24	7.62	26.8	49.2	17.6	161	121	1.55	5.57	8.5	0.005	0.24	<0.001	1.24	<0.002
STD	1.21	31	6.55	4.7	7.33	7.67	27.2	50.8	31.6	374	117	1.28	5.15	7.1	0.009	0.19	<0.001	7.03	<0.002
STE	1.26	19	6.5	48.1	2.18	7.2	33.8	55.2	32.8	410	91	0.81	7.43	6.5	0.006	0.23	<0.001	7.04	<0.002
STF	2.78	6	6.9	40.1	7.88	7.51	26.9	52.4	20.8	501	56	0.6	9.19	2.6	0.01	0.25	<0.001	1.47	<0.002
STG	2.83	30	6.85	2	6.66	7.78	26.9	63	19.8	128	65	2.49	5.51	4.4	0.009	0.29	<0.001	1.32	<0.002
STH	3.08	10	6.85	4.7	4.99	2.36	27	62	37.6	104	71	0.9	4.66	3.6	0.008	0.2	<0.001	1.56	<0.002
STJ	4.67	12	6.85	0.33	7.3	7.54	26.9	48	20.4	308	53	2.33	5.27	0.04	0.006	0.18	<0.001	1.54	<0.002
STK	7.94	9	6.95	2.01	7.78	8.89	26.9	61.2	56.4	256	181	0.32	6.31	2.4	0.017	0.13	<0.001	1.81	<0.002
STL	8.36	13	6.65	0.17	1.03	3.78	27.1	138.4	59	323	92	2.92	3.68	11.3	0.011	0.2	<0.001	6.36	0.038
STM	9.28	6	6.95	6.9	6.51	6.19	27	70.8	72.6	193	116	2.49	4.66	1.8	0.016	0.28	<0.001	1.77	0.037
STN	9.71	11	6.65	36.1	2.61	15.42	27.1	110.8	69	189	76	1.52	9.26	2.5	0.011	0.24	<0.001	2.37	0.071
STP	9.88	12	6.55	0.9	0.85	13.53	27	113.2	82	211	102	1.37	9.95	4.8	0.01	0.26	<0.001	3.48	0.127
STQ	9.88	10	6.7	25.5	4.2	12.2	27.1	112.6	89.8	242	51	1.08	7.73	3.7	0.004	0.01	<0.001	1.85	0.12
STR	10.71	17	6.85	1.8	5.32	11.75	27.1	111.2	826	204	42	2.18	6.25	5.2	<0.002	0.01	<0.001	1.365	0.041
STS	10.81	15	6.95	2.95	5.46	10.41	26.9	58.8	39.2	102	58	2.11	7.84	4.2	<0.002	0.01	<0.001	1.33	0.041

*Units in mg/l except when otherwise stated in the table.

The water quality of the river sections from Ewupe to Adefarasin before the main tributary was found to correspond to Class E as explained in Table 2 suggesting that the water could not be used for purposes of drinking, fisheries, bathing and swimming but only for irrigation, industrial cooling and controlled waste disposal. Due to the huge pollution load from both the Distillery firm and Sewage discharges even from desludging vehicles, the DO concentration dropped down again to the anoxic state.

The BOD concentration of the stream at the headwater peaked at 32 mg/l in the month of May 2009 and was least in February 2009 at 10 mg/l. Subsequent loading at Igboloye from Distillery firm drain resulted in an increase in BOD level to about 56 mg/l (Table 3). At the downstream of the Brewery discharge, Combined (Nigeria –German, Fermex Mayer Nigeria Plc) and other pharmaceutical drains culminated to the lowest BOD level found to be 3 mg/l at Ewupe downstream. BOD levels increased several folds from 12 mg/l to 56 mg/l whereas DO decreased to zero from 8.40 mg/l in the river (Table 3, Figs 2-3).

From the inputted data into the QUAL2K software in Table 4 the average (and range) of the stream depth, velocity of flow and flow rates on the reaches studied were respectively 0.915 m (0.49 -2.59 m), 0.336 m/s (0.21 -0.4 m/s) and 14.66 m^3/s (3.48 – 59.36 m^3/s). Somewhere the main tributaries discharged into the river; this research found these discharges to be the main source of replenishment to buffering the capacity of River Atuwara. The low velocity of flow encourages sedimentation of solids and may encourage development of benthic culture that further lowers the DO concentration.

This aeration recovery capacity is encouraging for the river's use for urban agriculture and wetland farming. However the high concentrations of toxic substances and possibly pathogens from sewage discharged into the stream will put farm workers at risk of infection with water-borne diseases. Where the produce is vegetable or fruits, there is further risk of food borne infection. Therefore, it is very essential that the industrial effluents be treated before discharge into River Atuwara.

Given the areas traversed by the river and its traditional use, there is the need for the Monitoring agencies to enforce the treatment of effluents to make the water useable. The public health aspect of the water use is also important consideration, where the heavy metals are concerned. Since the metals can bioaccumulate in tissues of plants and aquatic life, there is the need for pre-treatment to meet effluent discharge standard set by FEPA and other regulatory bodies.

Table 2: The surface water quality classification by DO and BOD

Characteristic	Class				
	A	B	C	D	E
DO (mg /l)	>6	>5	>4	>4	<4
BOD (mg /l)	<2	<3	<4	<6	>6

Source: CPCB (Central Pollution Control Board of India, 1980 -81)

Legend:

A: Drinking watercourses without conventional treatment but after disinfection
B: Bathing Swimming and Recreation
C: Drinking water source after conventional treatment
D: Propagation of wild life, fisheries etc.
E: Irrigation, industrial cooling and controlled waste disposal

Table 3: Summary of Statistical analysis of the Data of Atuwara River in Table 1

S/NO	PARAMETERS	MEAN	STANDARD DEVIATION	RANGE
1	BOD_5	15.50	7.71	6 to 31
2	pH	6.76	0.15	6.5 to 6.95
3	Conductivity	12.69	15.94	0.17 to 48.1
4	DO	5.42	2.49	0.85 to 7.88
5	Total hardness	8.31	3.41	2.36 to 15.42
6	Temperature	27.39	1.71	26.6 to 33.8
7	Total alkalinity	74.80	30.82	47.6 to 138.4
8	TSS	91.62	197.48	14.45 to 826
9	TDS	244.38	111.47	104 to 501
10	COD	91.36	38.87	42 to 181
11	Phosphate	1.61	0.81	0.32 to 2.92
12	Chloride	6.29	1.91	3.68 to 9.95
13	Nitrates	4.78	2.94	0.04 to 11.3
14	Cadmium	0.009	0.004	0.004 to 0.017
15	Lead	0.203	0.09	0.01 to 0.29
16	Zinc	0.00	0.00	0 to 0
17	Iron	2.68	2.13	1.17 to 7.04
18	Manganese	0.027	0.04	0.037 to 0.127

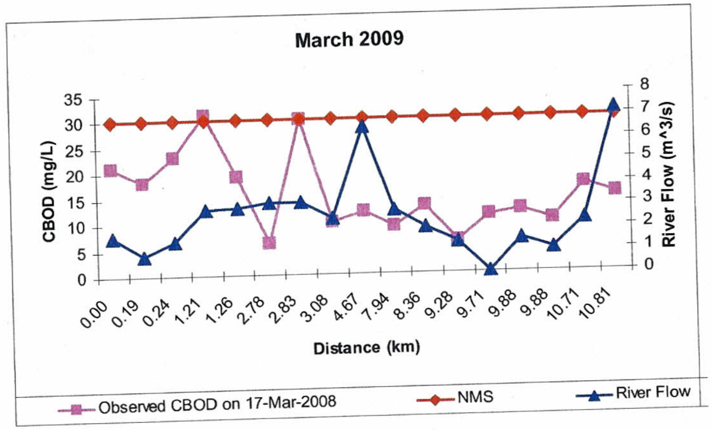

Fig 2: The plot of critical river flow versus CBOD for River Atuwara in March 2009

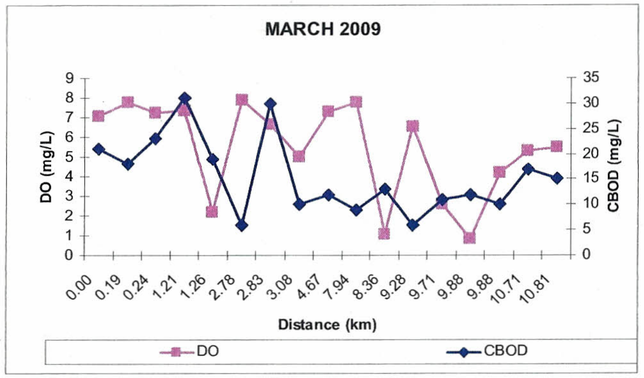

Fig 3: The CBOD Prediction model for River Atuwara based on the critical data in March 2009

The statistical analyses of the data in Table 3 showed that majority of the parameters are within the safety level. However the hydrogeometric characteristics of river Atuwara showed excellent recovery capacity because of the dilution power of river Atuwara which receives discharge from Afara meje stream and other tributaries (Table 4).

Table 4: Hydro – Geometric Parameters of the Receiving Atuwara River in March 2009

Way Point Station	Station Description	Width (m)	Depth(m)			Temperature (^{o}C)		Velocity (m/ s)	Flow (m^3/s)
			Left	Mid Stream	Right	Air	Water		
STA	Water Corporation	13.80	2.59	1.37	1.34	29.1	26.6	0.29	59.36
STB	200 m- Downstream	8.00	1.13	1.25	0.55	30.3	26.9	0.29	14.10
STC	50 m- Downstream	6.90	0.55	0.82	0.64	29.2	26.8	0.22	6.93
STD	IDL Discharge	8.70	0.55	0.82	1.01	29.8	27.2	0.21	11.23
STE	IDL Raw Effluent	-	-	-	-	-	-		
STF	50 m IDL Upstream	5.70	0.64	0.70	0.95	29.1	26.9	0.30	6.94
STG	50 m M & B Down Stream	4.78	0.92	1.40	0.95	29.2	26.9	0.38	9.91
STH	M&B Effluent	6.50	0.88	1.71	0.76	29.4	27.0	0.38	14.05
STJ	100 m M & B Upstream	13.40	0.76	1.04	1.56	29.3	26.9	0.43	28.97
STK	250 m Downstream to Ewupe	8.10	0.64	1.25	0.58	29.4	26.9	0.37	11.06
STL	Ewupe Effluent	8.00	0.65	1.59	1.04	29.8	27.1	0.36	16.82
STM	50 m Upstream of Ewupe	8.30	0.64	1.68	0.73	29.6	27.0	0.37	15.55
STN	Sona Effluent Discharge	8.80	0.58	1.40	0.55	29.7	27.1	0.4	12.47
STP	50 m Sona Upstream	9.50	0.49	1.13	0.54	29.7	27.0	0.33	10.42
STQ	50 m Downstream to Abattoir	6.00	0.65	0.82	0.56	29.8	27.1	0.35	6.30
STR	Abattoir Discharge	4.10	0.58	0.65	0.55	29.8	27.1	0.36	3.48
STS	250 m Upstream of Abattoir	9.20	0.49	0.64	0.55	29.6	26.9	0.34	7.03

The pH ranged from 5.95 to 8.8. Temperatures were in the range between 25.5 and 32.6^{o}C which was within the national limit (SON, 2007). The TDS, TSS, TS, Cl, COD, were specifically very high. The pH, in most samples from IDL indicated that they are slightly acidic (values range from 5.2 – 6.7) despite the dilution effect of the river.

CONCLUSION

The QUAL2K model used in this project showed that there was effective dilution of River Atuwara for its use as a receiving stream. The river can also support urban agriculture through its use for irrigation of wetlands along its course. Downstream riparian users of the River must be adequately protected from exposure to both pathogenic and other toxic chemicals in the stream. There is also need to enforce corporate social responsibility by the industries located along the river through provision of safe water supply possibly through groundwater source. Government must ensure that existing Environmental Control Laws and Regulations are respected by industries in the study area in the overall interest of the people living along and within the watershed studied.

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