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Impact of partially treated sewage effluent on the water quality of recipient Epie Creek Niger Delta, Nigeria using Malaysian Water Quality Index (WQI)

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Key Words: Malaysian Water Quality Index, Sewage, Wastewater treatment plant, Epie Creek, Fallout point, Class IV water

ABSTRACT: Impact of partially treated sewage effluent on the water quality of recipient Epie Creek in the Niger Delta area of Nigeria was investigated experimentally by analysing the physico-chemical and biological characteristics of the surface water samples collected at four (4) sampling stations: at the effluent discharge point (fall out) (SS2), 500 m upstream (SS1), 500m downstream (SS3) and 1000m (SS4) downstream respectively from the point of discharge. Sampling was carried out weekly between June 2009 and May 2010 (48 weeks). Measured parameters of the water samples and the corresponding results are: pH (5.60 – 6.80), turbidity (21.5 – 34.7 NTU), electrical conductivity (34.7 – 82.1 μS/cm), biochemical oxygen demand (BOD) (12.4 -36.7 mg/l), chemical oxygen demand (COD) (17.3 – 53.2 mg/l), total suspended solids (TSS) (17.70- 45.8 mg/l), dissolved oxygen (DO) (3.73 – 5.20 mg/l), total dissolved solids (TDS) (57.3 – 187.0 mg/l), total phosphate (0.73 – 1.73 mg/l), ammoniacal nitrogen (AN) (4.10 – 5.0 mg/l) and total fecal coliform count (TFCC) (2,120 – 20,800 cfu/ml). The water quality at each of the sampling points was also assessed using Malaysian Water Quality Index (WQI) and results show that, the water quality of Epie Creek defined at the sampling stations belongs to Class IV with values that ranged between 31.0 and 51.9. Empirically, the water quality can be described as fairly polluted. This means that the water quality across the sampling points is poor indicating that most parameters have deteriorated.

Rivers, streams, lakes, oceans and seas appear to be the most recipient of industrial and municipal wastes globally (Defew *et al*., 2004; Bryan, 1976). Industries are the major sources of pollution in all environments and depending on the type of industry, various levels of pollutants can be discharged into the environment directly or indirectly via public sewer lines and effluent/wastewater treatment facilities. Wastewater from industries includes employees' sanitary waste, process wastes, hydrotest water from pipelines and water from heating and cooling operations (Adeyinka and Rim-Rukeh, 1999).

Oxygen demanding wastes such as sewage are one of the more serious pollutants in our natural environment due to their health effect. Water polluted by sewage or effluents from sewage treatment plant is associated with heavy disease burden (Okoh, *et al*., 1997). Such ugly development could further influence the already tilted life expectancy in favour of the developed nations when compared with developing countries. Introduction of elevated levels of sewage into recipient water bodies contributes to increase oxygen demand and nutrient loading of the water bodies; promoting algal blooms. The impact of raw sewage discharge into Mazai stream in Zimbabwe is documented (Moyo, 1997). The same problem is experienced in Lake Chivero catchment where raw sewage is finding its way into Manyame, Marimba and Mukuvisi rivers, the tributaries of the lake leading to its eutrophication, increased algal growth that greatly affects aquatic invertebrate diversity (Chutter, 1972).

Wastewater from industries and sewage collected from homes and offices are released directly into streams and rivers. In a situation where treatment process is available, industrialists have adopted the use of substandard treatment methods that partially treat and in some instances, forego the effluent treatment process (Rim-Rukeh, et al., 2007). Indiscriminate discharge of industrial and municipal wastes into rivers calls for monitoring procedures aimed at protecting human health and aquatic species especially as the people rely heavily on water sources of doubtful quality in the absence of better alternatives, or due to economic and technological constraints to adequately

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treat the available water before use. Rim-Rukeh, et al., (2007) posited that scarcity of clean water and pollution of freshwater has led to a situation in which one-fifth of the urban dwellers in developing countries and three quarters of their rural dwelling population do not have access to reasonably safe water supplies.

Water quality monitoring data on fresh and marine waters arising from industrial activities are largely uncoordinated in Nigeria as very limited research on concentrations of sewage disposal in Niger Delta area especially when the river serves as receipt of industrial wastes from industrial facility. In this study, the impact of partially treated sewage on the biophysicochemical quality of the receiving Epie Creek in Yenagoa, Bayelsa state by Byanoil and gas company camp site has been evaluated. Communities located along Epie Creek, uses surface water for fishing, washing, boating, swimming, bathing and defecating and as a means of waste disposal.

***The Wastewater Treatment Process*:** Byan Oil and Gas is an oil and gas servicing company with its base camp located at approximately 300m East of Bayelsa State Commissioners quarters in Yenagoa, Southern Nigeria. The company operates a wastewater treatment facility which has a design capacity of 250m^3. The treatment facility receives domestic sewage and run-off water and treatment is based on the activated sludge system. The treated final effluent is discharged into Epie Creek.

The activated sludge process is a very widely used aerobic suspension type of liquid waste treatment system. A simplified flow diagram of the activated sludge process employed in the treatment of sewage is given in Figure 1

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After primary settling, the sewage, containing dissolved organic compounds, is introduced into an aeration tank. The aeration is provided by air injection and / or mechanical stirring. The reintroduction of most of the settled sludge from a previous run lead to rapid development of microorganisms. During the holding period in the aeration tank, vigorous development of heterotrophic microorganisms has taken place. The heterogeneous nature of the organic substrates in the sewage allows the development of diverse heterotrophic bacterial populations, including Gram-negative rods, predominantly *Escherichia, Enterobacter, Pseudomonas, Achromobacter, Flavobacterium* and *Zooglea* spp. Other bacteria include *Micrococcus, Arthrobacter,* various mycobacteria, *Spaerotilus,* and other large filamentous bacteria, and low number of filamentous fungi, yeasts, and protozoa, mainly ciliates.

The bacteria in the activated sludge tank aggregates or flocks. In the advanced stage of aeration, most of the microbial biomass becomes associated with flocs that can be removed from suspension by settling in the secondary settling tank.
Combined with primary settling, the activated sludge process tends to reduce the BOD of the effluent to 10-15 percent of that of the raw sewage.

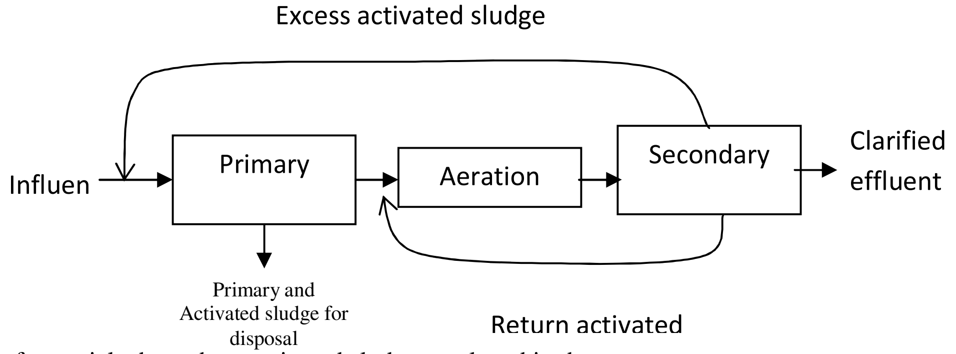

Fig. 1: The flow of materials through an activated sludge employed in the sewage treatment system.

MATERIALS AND METHODS

Study Area: The study area is the Niger Delta region of Nigeria. It is located within Latitude 5°45' – 6°35' and Longitude 4°50' – 5° 15' in the southern part of the country. Geopolitically, the Niger Delta comprised of oil producing states of; Abia, Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo, Imo, Ondo and Rivers. It covers an estimated area of about 70,000km^2 which accounts for about 8 percent of Nigeria's land mass (Okoko and Nna, 1998). The petroleum industry in Nigeria is located in the Niger Delta area. The area accounts for about 90 percent of Nigeria's gross earnings as the production and exports of oil and gas play a dominant role in her economy (Okoko and Nna, 1998).

Previous study of the meteorology of the area (Gobo, 1998), reveals the average atmospheric temperature to be 25.50°C in the rainy season and 30.00°C in the dry season. The daily relative humidity values range from 55.50 percent in dry season to 96.00 percent in rainy season. Rainfall in the area averages 2500mm annually. The rainfall pattern shows two identifiable seasons; the rainy season (April to October) and the relatively short dry season (November to March). The area is within the humid tropical zone with defined dry (November – March) and rainy (April – October) seasons. The rainy season is brought about by the Southwest trade wind blowing across the Atlantic Ocean. The dry, dusty and often cold Northeast trade wind blowing across the Sahara desert dominates the dry season and brings a short spell of harmattan.

The ecology of the area is characterized by a vast flood plain built up by accumulation of sedimentary deposits washed down into the Niger and Benue Rivers. The area is criss-crossed with numerous rivers, streams, tributaries, creeks and creeklets. The vegetation of the area is characterized by sandy coasts, ridge barriers, brackish or saline mangrove forest; fresh water swamp forest, and tropical rain forest. The area is the largest wetland in West Africa and one of the largest mangrove forests in the world (Darafeka, 2003). The geology of the Niger Delta area is such that the area comprises a lower unit (Akata formation, Eocene 600-6000m thick), a middle parallic unit (Agbada formation, Eocene 300-4500m thick) and an upper continental sequence of (Benin formation, Miocene 200-2000m thick) (Akpokodje, 1987).

Epie Creek is a freshwater ecosystem that is located within its coordinates; 4°55'60" N and 6°16'0"E in the Niger Delta area. Epie Creek is non-tidal and fresh water in nature . The river is a major resource to Igbogene, Yenegwe, Akenfa, Agudama Epie, Akenpai, Edepie, Okutukutu, Opolo, Biogbolo, Yenizue Gene, Kpansia, Yenizue Epie, Okaka, Ekeki, Azikoro and Amarata, Onopa, Ovom, Yenagoa, Bebelibiri, Yenaka, Ikolo, Famgbe, Obogoro, Akaba, Ogu, Swali, and Agbura communities through which it traverses. Aside being a source of water for drinking and domestic purposes it is also exploited for fisheries and sand mining. Satellite imaginary of the Creek is shown in Figure 2.

Fig. 2: Satellite Imaginery showing Epie Creek in Yenegoa

Sampling procedures: Four (4) sampling stations (SS1-SS4) were established along the length of the studied part of the Epie Creek. Surface water samples were collected from the treated effluent discharge point (fall out) (SS2), 500 m upstream (SS1), 500m downstream (SS3) and 1000m (SS4) downstream respectively from the point of discharge. The pattern of sampling was devised in order to obtain a complete summation of pollutants distribution in the water body.

Sampling was carried out weekly between June 2009 and May 2010 (48 weeks). Water samples for physico-chemical parameters were collected in 1L plastic bottles while those for BOD analysis were collected in 250 ml narrow mouthed dark amber glass bottles. Water samples for fecal coliform studies were collected in sterilized bottles. All containers were pre-cleansed by washing with non-ionic detergents, rinsed with tap water, 1:1 hydrochloric acid and finally with deionized water. Prior to sampling, the bottles were rinsed three times with sample water before being filled with the sample (in order to acclimatize with the sample water environment). Sampling was carried out by dipping each sample bottle at approximately 10-20cm below the water surface by projecting the mouth of the container against the flow the direction. Preservatives were added as required in the specific test methods in order to avoid changes in chemical composition of the sample as a result of microbial degradation and inter-chemical reaction. Consequently samples for BOD analysis were kept away from sunlight and incubated at room temperature for 5 days prior to analysis. Samples were then transported in cooler boxes containing ice to the International Energy Services Laboratory, Port Harcourt within 24 hours after collection.

Measured Parameters and Methodology: Parameters analysed for in all samples collected were: pH, turbidity, electrical conductivity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), dissolved oxygen (DO), total dissolved solids (TDS), total phosphate, ammoniacal nitrogen (AN) and total fecal coliform count (TFCC). These parameters are good environmental impact indicators for monitoring drinking water quality (APHA, 1998 and DPR, 2002).

pH, turbidity, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS) was measured *in-situ* using a multi-parameter water quality (model 600 UPG). Note that the multi-parameter water quality monitor was properly checked and calibrated before and after use. Biochemical oxygen demand (BOD) of the water samples was determined using the Winkler Titration Method (APHA, 1998). Total suspended solids (TSS) in the water samples were determined using the weight loss method (DPR, 2002). The concentration of total phosphate was read directly from the spectrophotometer at a wavelength of 420 nm while the concentration of ammoniacal nitrogen was read directly from the colourimeter a wavelength of 340nm (DPR, 2002).For fecal coliform samples, 3 dilutions were prepared and analyzed by the membrane filtration method in triplicate (APHA, 1998).

The water quality at each of the sampling points was assessed using the Malaysian Water Quality Index (WQI) as reported (DOE, 2005). Equation 1 gives the water quality index. The index considers six parameters. The parameters which have been chosen are dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), pH value (pH), and ammonical nitrogen (AN) (Khuan *et. al,* 2002). The parameters and the weightage were assigned to each parameter.

The WQI approved by the Malaysian DOE (Equation 1) is calculated based on the above six parameters. Among them DO carries maximum weightage of 0.22 and pH carries the minimum of 0.12 in the WQI equation. The WQI equation eventually consists of the subindexes, which are calculated according to the best-fit relations given in Equations 2 - 7. The formulas used in the calculation of WQI are:

$WQI = 0.22\ SI_{DO} + 0.19\ SI_{BOD} + 0.16\ SI_{COD} + 0.16\ SI_{TSS} + 0.15\ SI_{AN} + 0.12\ SI_{pH}$ (1)

Where,
WQI = Water quality index (dimensionless unit);
SI_{DO} = Sub-index of DO;
SI_{BOD} = Sub-index of BOD;
SI_{COD} = Sub-index of COD;
SI_{AN} = Sub-index of AN;
SI_{TSS} = Sub-index of TSS;
SIpH = Sub-index of pH.
Sub-index for DO (in % saturation):
$SI_{DO} = 0$ for DO < 8 (2a)
= 100 for DO > 92 (2b)
$= -0.395 + 0.030DO^2 - 0.00020DO^3$ for 8 < DO < 92 (2c)
Sub-index for BOD:
$SI_{BOD} = 100.4 - 4.23BOD$ for BOD < 5 (3a)
= 108e-0.055BOD – 0.1BOD for BOD > 5 (3b)

Sub-index for COD:
$SI_{COD} = -1.33COD + 99.1$ for COD < 20
(4a) = 103e-0.0157COD – 0.04COD for COD > 20
(4b)
Sub-index for AN:
$SI_{AN} = 100.5 - 105AN$ for AN < 0.3
(5a) = 94e-0.573AN – 5 (AN – 2) for 0.3 < AN < 4
(5b) = 0 for AN > 4
(5c)
Sub-index for TSS:
SI_{TSS} = 97.5e-0.00676SS + 0.05SS for SS < 100
(6a) = 71e-0.0016SS – 0.015SS for 100 < SS < 1000
(6b) = 0 for SS > 1000
(6c)
Sub-index for pH:
$SIpH = 17.2 - 17.2pH + 5.02pH^2$ for pH < 5.5
(7a) $= -242 + 95.5pH - 6.67pH^2$ for 5.5 < pH < 7
(7b) $= -181 + 82.4pH - 6.05pH^2$ for 7 < pH < 8.75
(7c) = 536 – 77.0pH + 2.76pH2 for pH > 8.75
(7d)

Based on the Malaysian WQI, water quality is classified according to one of the following categories shown in the Table 1.

Table 1: Classes in Malaysian Water Quality Index (DOE, 2005)

Parameter	Class				
	I	II	III	IV	V
An	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	>2.7
Bod	<1	3	3 -6	6 - 12	>12
Cod	<10	10-25	25-50	50-100	>100
Do	>7	5 - 7	3-5	1-3	<1
Ph	>7	6 - 7	5-6	<5	<5
Tss	<2.5	25 - 50	50 - 150	30 - 50	>300
Wqi	>92.7	76.5 – 92.7	51.9 – 76.5	31 – 51.9	<31.0

Generally, based on Malaysian WQI water quality is classified as follows:
WQI Quality of water
91-100 Excellent
71-90 Good
51-70 Medium or average
26-50 Fair
0-25 Poor

RESULTS AND DISCUSSION

Results indicating the physico-chemical and biological characteristics of the surface water quality of Epie Creek at the different sampling points along the studied portion of the water body are presented in Table 2.

Table 2: Mean Values of Measured Parameters in Epie Creek

Parameters	Sampling Stations				
	SS1 (500m upstream)	SS2 (Fall out)	SS 3 (500m downstream from fallout point)	SS 4 (1000m downstream from fallout point)	FMENV Regulatory for drinking water (1995)
pH	6.77 ± 0.11	5.6± 0.12	6.55± 0.11	6.80 ± 0.12	6.5 – 8.5
Turbidity(NTU)	21.5± 0.06	34.7 ± 0.03	31.5 ± 0.05	28.3 ± 0.07	5.0
Electrical Conductivity (µS/cm)	34.7 ± 0.17	82.1 ± 0.13	67.4 ± 0.11	63.8± 0.14	-
DO (mg/l)	5.2 ± 0.03	3.73± 0.03	4.45 ± 0.06	4.71± 0.04	>7.5
COD (mg/l)	17.3 ± 0.12	53.2± 0.11	41.9± 0.17	35.3±0.15	-
BOD (mg/l)	12.4 ± 0.06	36.7± 0.03	30.0 ± 0.07	22.5 ± 0.05	-
TDS (mg/l)	57.3 ± 1.41	187 ± 1.20	106.8± 1.37	94.6± 1.31	2000
TSS (mg/l)	17.70± 0.06	31.6± 0.03	38.7 ± 0.07	45.8± 0.04	50
Total Phosphate (mg/l)	0.73 ± 0.03	1.73±0.03	1.20± 0.02	1.17±0.04	-
Ammonical nitrogen (mg/l)	4.10±0.03	5.10 ± 0.02	4.77± 0.04	4.26 ± 0.03	-
Total Feacal coliforms (cfu/ml)	2,120 ±0.73	20,800 ± 4.70	16,650 ± 3.70	10,200± 3.20	Nil
Water Quality Index (WQI)	32.19	48.28	40.61	37.25	

From the results (Table 2), the surface water quality at the sampled locations is slightly acidic with pH ranging between 5.60 and 6.80. The acidic pH at these points (SS1, SS2, SS3 and SS4) may have resulted from humic acid (HA) formed from decaying organic matter which is consistent with the report of the Niger Delta swamp environment (Rim-Rukeh et al., 2006 and RPI, 1995). However at point SS2 (the fallout) the water quality was more acidic than points SS1, SS3 and SS4 and this may have resulted from substances discharged from the wastewater from the sewage treatment plant. Water bodies receiving untreated or partially treated sewage have been reported to be highly acidic, sometimes with pH as low as 2.6 (Vijay et al., 2010). This acidic pH range appears to be unsuitable for the survival of freshwater fish and bottom dwelling invertebrates (Arimoro, 2007) and also below values recommended for good quality water (WHO, 1984). pH affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefers a range of 6.5-8.0 (KWW, 2001). pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and available for uptake by aquatic plants and animals.

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye. The measurement of turbidity is a key test of water quality. Turbidity is an optical property relating to light adsorption and scattering in water. It is an important parameter because it affects the penetration of sunlight into the water body. The turbidity of the water body across all sampling points ranged between 21.5 and 34.7 Nephelometric Turbidity Units (NTU) which is above regulatory limits of 5mg/l (FMENV, 1995). This relatively high turbidity accounts for non visibility of river bed from the surface. This may also affect the transmission of light rays of the sun and hence have effect on the bottom dwelling phytoplankton. The higher turbidity values are to the presence of human activities such as washing of clothes and runoff especially during the rainy season.

Electrical conductivity refers to the specific electrical conductance of water i.e. the ability of water to pass electric current. The conductivity of water in µS/cm is roughly proportional to the concentration of dissolved solids (mostly inorganic salts) it contains. Thus conductivity is important in ecology and environmental management as an indicator of the total dissolved inorganic salts and other solids in water. Electrical conductivity of the surface water samples ranged between 34.7 and 82.1µS/cm. The low values of electrical conductivity may be attributed to the freshwater nature of the water body as have been similarly reported (Puyate and Rim-Rukeh, 2008).

A good level of dissolved oxygen is essential for aquatic life. It is an important parameter in water quality assessment. The concentration of DO vary daily and seasonally and depends on the species of phytoplankton present, light penetration, nutrient availability, temperature, salinity, water movement, partial pressure of atmospheric oxygen in contact with the water, thickness of the surface film and the bio-depletion rates (Emerson and Abell, 2001). The DO levels of the surface water body ranged between 3.73 to 5.20mg/l. DO value for fresh water depends upon the temperature, and its value varies from 14.62 mg/l at 0°C to 7.63 mg/l at 30°C (at normal atmospheric pressure). DO levels below 5.0mg/l, aquatic life is put under stress and could result in large fish kills if sustained for a few hours (Emerson and Abell, 2001).

The water body in the study area provides a poor condition for the survival for aquatic life (US Dept., of Interior, 1968).

The observed DO levels at sampling point 2 (fallout) (3.73 mg/l) may have resulted from the biodegradation of organic waste in the sewage effluent. DO in water is usually depleted, if organic matters undergoing biological degradation are present such as has been observed at point the fallout point.

Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water. TDS is directly related to electrical conductivity of water as;
TDS (mg/L) = EC (**µS/**cm at 25°C) x 0.6 8.0
TDS level in the surface water samples ranged between 57.3 mg/l and 187.0 mg/l. As a rough estimation, freshwater may be considered to have TDS of 1500mg/l; brackish water, 5000mg/l and saline water, above 5000mg/l and sea water TDS values lie between 30,000 and 34,000 mg/l. The recommended maximum value for surface water bodies is 2000mg/l (DPR, 2002)
.
Total suspended solids (TSS) consists of an inorganic fraction (silts, clays, etc) and an organic fraction (algae, zooplankton, bacteria, and detritus) that are carried along by water as it runs off the land and these contribute to the turbidity or cloudiness of a water body (KWW, 2001). Suspended solids can clog fish gills, resulting in either fish death or reduction in growth rate. They also reduce light penetration, thereby reducing the ability of algae to produce food and oxygen. A positive effect of the presence of suspended solids in water is that toxic chemicals such as pesticides and metals tend to adsorb to them or become complexes with them thereby making the toxics less available for absorption by living organisms. In a study in which TSS was increased to 80mg/l, the macro invertebrate population was decreased by 60% (KWW, 2001). TSS level in the surface water samples was between 17.70mg/l and 45.8mg/l. The obtained levels of TSS may have resulted from presence of silt and other suspended materials observed in the water body.

Biochemical oxygen demand (BOD) is the amount of oxygen required by microorganisms to stabilize decomposable organic matter at a particular time and temperature. BOD test is widely used to determine the pollutional strength of domestic and industrial wastes in terms of the oxygen that they require to deliver end products as CO_2 and H_2O. Most pristine rivers will have a 5-day BOD below 1 mg/l. Moderately polluted rivers may have a BOD value in the range of 2 to 8 mg/l. Municipal sewage that is efficiently treated by a three stage process would have a value of about 20 mg/l. Untreated sewage varies, but averages around 600 mg/l in Europe and as low as 200 mg/l in the United State, or where there is severe groundwater or surface water infiltration (APHA, 1998). BOD level in the surface water samples was between 12.4 mg/l and 36.7 mg/l. Using the BOD values as standard for evaluating the water body, the water quality may be described as heavily polluted.

COD is the amount of (dissolved) oxygen required to oxidize and stabilize (organic and inorganic content of) the sample solution. It is used to measure the content of oxidizable organic as well as inorganic matter of the given sample of waters. Chemical oxygen demand is related to biochemical oxygen demand (BOD), another standard test for assaying the oxygen-demanding strength of waste waters. The COD of a waste is higher than the BOD because more compounds are chemically oxidized in a short interval of time. It had the advantage of getting completed in 3 hours compared to 5 days of the BOD test. It is possible to correlate BOD and COD. BOD_5/COD ratio is called Biodegradability Index and varies from 0.4 to 0.8 for domestic wastewaters. If BOD/COD is > 0.6 then the waste is fairly biodegradable and can be effectively treated biologically. If BOD/COD ratio is between 0.3 and 0.6, then seeding is required to treat it biologically. If BOD/COD is < 0.3 then it cannot be treated biologically. COD level in the surface water samples were between 17.3 mg/l and 53.2mg/l. Using the BOD/COD values as standard for evaluating the water bodies, they may be classified as highly biodegradable. The obtained COD level in the water body especially at point of fallout is low compared with 30,000 mg/l that is reported for starch processing companies (Cereda and Matos, 1996).

The nutrient content of water is an indication of the degree of sustainability of the system of primary production. At very high concentration of nutrients such as total phosphate and ammonical nitrogen, eutrophication in river bodies may be possible. The ranges of total phosphate and ammonical nitrogen in the study river body ranged between 0.73 – 1.73 mg/l and 4.10 – 5.10 mg/l respectively
.
Total fecal coliform count (TCC) in the water body across the sampling points ranged between 2,120 and 20,800 (cfu/ml). However, at point of fallout TCC was highest with 20,800cfu/ml indicating a point source of contamination which invariably is the sewage treatment plant.

Results of the assessment of the water quality of the streams at the sampling points using the water quality index as reported (DOE, 2005) are presented in Table 3 and illustrated graphically in Figure 3

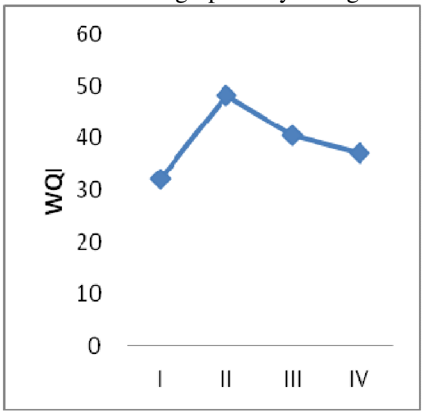

Fig. 3: Water quality index at the sampling points of the studied Epie Creek

Using the water quality index, the water quality of Epie Creek defined at the sampling stations belongs to Class IV with values that ranged between 31.0 and 51.9. Empirically, the water quality can be described as fairly polluted. This means that the water quality across the sampling points is poor indicating that most parameters have deteriorated.

Conclusion: The environmental impact of partially treated sewage into Epie Creek in Bayelsa State southern Nigeria has been experimentally studied. This is sequel to the fact that most of the water bodies in the study area serve the purpose for drinking and other domestic activities.

Results of the assessment of the water quality of the water body at the sampling points indicate that the water quality is poor (fairly polluted). Sewage treatment related water pollution problems have been observed. From the study, there is high risk of water contamination from fecal coliforms on a specific scale and other water quality monitoring parameters on a broad scale. However, site-specific effects can be significant especially at point the point of fallout.

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