



Physico-Chemical Analysis of Power Plant Effluent Discharge on Ekemazu Stream in Delta State, Nigeria

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Abstract

Physicochemical analysis of Ekemazu stream in Delta State, Nigeria was carried out to assess the water quality between September 2014 and June 2015. Physicochemical parameters were analyzed according to standard methods for examination of water and wastewater. The turbidity of all the samples analysed across the seasons showed that the value was highest at the effluent discharge point at the peak of the flood season and least in the upstream at the setting – in of raining season in the following range: upstream; 12 ± 1 NTU to 25 ± 0 NTU, effluent discharge point; 121 ± 0 NTU to 423 ± 39 NTU, domestic activities point; 85 ± 2 NTU to 373 ± 40 NTU and in the downstream; 70 ± 0 NTU to 341 ± 44 NTU. All other parameters analyzed followed similar trend (highest in the effluent discharge point) either during the peak of flood season or peak of raining season and least in the upstream sample at other seasons. The statistical analysis of the difference in the physicochemical parameters of the upstream samples and the values obtained in effluent discharge point, domestic activities point and the downstream were all significant ($P < 0.05$). This research clearly showed that some physicochemical parameters of the stream are higher than the WHO acceptable limit. This is due to the release of heavily polluted effluent into the stream, seasonal variations as well as some human activities in the water body resulting to high pollution of the stream. metal pollution in the air, without experiencing damage to the leaf stomata fruit

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Introduction

Water is one of the most fundamental elements which make man and the entire ecosystem exist on this planet earth (Akatah *et al.*, 2018). Water is a vital component of the development of an area and as such, human settlement is to a large extent dependent on the availability of reliable sources of water preferably in close proximity to the settled localities (Edet *et al.*, 2012). The availability of drinking water is an indispensable feature for preventing epidemic diseases and improving the quality of life (Daniel *et al.*, 2012). Water also plays very important role in many industries such as power plant, food and cosmetics industries, as well as Pharmaceutical industries, hence, its quality is very crucial (Ogbonna, 2010). However, these industries and some human activities heighten surface water's exposure to various kinds of pollution with deleterious chemicals and pathogenic microorganisms (Prerana and Vijay, 2013). As such, most rural villages in developing countries have poor access to safe clean water supply. Chemicals which cause stream

pollution from industries are ammonia, phosphate, hydrocarbon compounds, herbicides and pesticides (Suha, 2013).

Polluted water bodies pose a very great health risk to people using such water for drinking, bathing, irrigation of crops which are eaten raw, fishing and recreational activities (Decker & Simmons, 2013). The components and characteristics of polluted water bodies are dependent on the source(s) of its pollutants (Osibanjo *et al.*, 2010). The industrial sector is responsible for the release of hazardous substances/wastes resulting in pollution of the receiving water bodies with hazardous components (Govindaraju *et al.*, 2011). Water bodies polluted by effluent from combined cycle power plant contain compounds such as ammonia, phosphate, dissolved solids, free Chlorine, Phosphate, and Chlorides (Mishra, 2010).

A study by Osibanjo *et al.*, (2010) on the impact of the industries on surface water quality of River Ona and River Alaro in Oluyole Industrial Estate, Ibadan Nigeria showed that the concentrations of nitrate in the polluted rivers ranged between 3.00 and 8.55 mg/l, chloride ranged between 7.48 and 11.78 mg/l, total phosphorus ranged between 2.14 and 3.57 mg/l, total solids ranged between 260 and 520 mg/l and oil grease ranged between 381.20 and 430.80 mg/l.

Another study by Andargachew, (2013) on the effects of Dashen brewery wastewater treatment effluent on the bacteriological and physicochemical quality of Shinta River in Gondar, North West Ethiopia show that the pH varied between 6.6 and 7.9, Total suspended solids fluctuated between 6 and 42 mg/L, the total dissolved solids between 73 and 201 mg/l and the biochemical oxygen demand (BOD) ranged between 3.8 and 23.0 mg/l. Govindaraju *et al.*, (2011) on their study of waters around Kudan Kulam nuclear power plant showed that the maximum values of pH was 8.25, temperature was 29°C, salinity was 32.4 ppt, dissolved oxygen (DO) was 5.9 ppt, chloride was 1.7 mg/l, phosphate was 59.98 mg/l, calcium was 3300 mg/l, nitrate was 0.79 mg/l and nitrite was 7.03 mg/l.

The normal value (acceptable limit) of nitrate is 50 mg/l and free chlorine is 5 mg/l (WHO, 2011). While conductivity, total dissolved solids and pH is 1000 μ S/cm, 500 mg/l and 6.5 to 8.5 respectively (Daniel *et al.*, 2012). Govindaraju *et al.*, (2011) on their study of waters around Kudan Kulam nuclear power plant showed that the maximum values of pH was 8.25, temperature was 29°C, salinity was 32.4 ppt, dissolved oxygen (DO) was 5.9 ppt, chloride was 1.7 mg/l, phosphate was 59.98 mg/l, calcium was 3300 mg/l, nitrate was 0.79 mg/l and nitrite was 7.03 mg/l. The normal value (acceptable limit) of nitrate is 50 mg/l and free chlorine is 5 mg/l (WHO, 2011). While conductivity, total dissolved solids and pH is 1000 μ S/cm, 500 mg/l and 6.5 to 8.5 respectively (APHA, 2005). However, toxicological effects of ammonia are observed at exposures above 200 mg/kg body weight and chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water. The components of polluted water bodies have significant effects to both the aquatic and human lives. Some of the components contain nutrients that support the growth of some harmful microorganisms which are threat and sometimes fatal to human lives (Guecker *et al.*, 2000).

Ekemazu stream located precisely in Independent Power Plant camp in Okpai Oluchi, Ndokwa East local government area of Delta state in this research serves as the major source of water for domestic purposes, fishing and recreational activities for the residents in the area is heavily polluted by the Independent Power Plant located along the course of the stream with compounds of ammonia, phosphate, sodium hypochlorite, hydrazine, and dissolved salts from their water and steam treatment processes. The stream is also polluted

with domestic wastes from the power plant residential lodge and from the local community residents, living near the stream.

Water for different purposes has its own requirements of composition and purity hence each body of water has to be analysed regularly in order to monitor its quality and ascertain if it is safe to use for domestic and/or industrial purposes (Mishra, 2010). It is on these backgrounds that this research is being carried out. The aim of this study was to analyse the physicochemical parameters of the stream during the different seasons of the year.

Materials and Methods

Period of Study

This research was conducted between the months of September, 2014 and June, 2015. The choice of the months of the year is to examine the effect of the peak of the flood season, setting in of the dry season, peak of the dry season, and the raining season on the bacteriological and physicochemical properties of the stream

Study Area

The study area was a section of Ekemazu stream located in Independent Power Plant Camp near Okpai Oluchi, Delta State Nigeria. The Ekemazu stream is the source of water for domestic purposes, for the residents as well as fishing. It receives effluent from Independent Power Plant which contains compounds of ammonia, phosphate, sodium hypochlorite, hydrazine, and dissolved salts from the water and steam treatment process. The polluted water body also contains domestic wastes from the power plant residential lodge and from the local community residents, living near the stream.

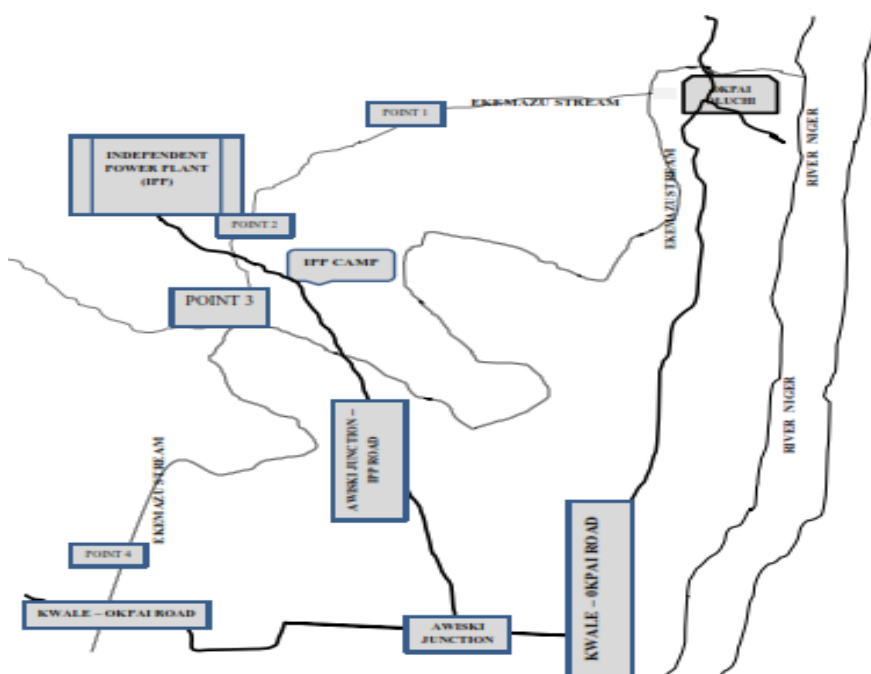


Figure1. Map showing the various sampling point

Sample collection, transportation and storage

The water samples were collected from four sampling points along the stream in duplicates with sterile containers and designated with numbers 1 to 4. A retort stand clamp mounted on a stick was used to hold the neck of the sampling container tight and the cover of the container aseptically removed with the mouth of the bottle faced upstream. Then, the neck was dipped downwards about 30cm below the water surface till the container was completely filled and the cover carefully replaced (Decker and Simmon, 2013).

The samples were collected once in each month of the study period.

Sampling point 1: Upstream (before effluent discharge and human activities point).

Sampling point 2: Midstream A (Effluent discharge point).

Sampling point 3: Midstream B (About 1500metres from effluent discharge point): Bathing and domestic activities point.

Sampling point 4: Downstream (about 1000metres away from sampling point 3).

The samples were transported to the laboratory in ice bag to keep the samples cold and to avoid multiplication of the microorganisms during the period (Kasich *et al.*, 2013).

Analysis of physico-chemical parameters

The physico-chemical parameters analysed are conductivity, total dissolved solids (TDS), temperature, total suspended solids (TSS), turbidity, hydrogen ion concentration (pH), total iron, free chlorine, total hardness, phosphate, nitrate, ammonia and chloride and biochemical oxygen demand (BOD).

Conductivity, Total Dissolved Solids (TDS) and Temperature

The conductivity and total dissolved solids (TDS), are closely related and they were determined using conductivity meter, EC71, product of HACH LANGE company, Loveland USA. The meter was first calibrated with standard solutions (Potassium Chloride) of 147 $\mu\text{s}/\text{cm}$ and 1413 $\mu\text{s}/\text{cm}$. The conductivity value was determined by dipping the electrode into the sample and waited for a few minutes to stabilize, then the reading taken and recorded in $\mu\text{s}/\text{cm}$. The total dissolved solids (TDS) were determined by selecting the TDS option from the menu bottom and the value recorded in mg/l. The temperature was measured using the electronically in-built thermistor in the conductivity meter. The value was displayed on the meter and recorded in degree Celsius.

Total Suspended Solids (TSS)

The total suspended solids (TSS) were analysed using spectrophotometer DR 5000 by HACH LANGE Company, Loveland, USA. The stored Program number for TSS concentration analysis 630 was selected and the wavelength 810 nm automatically selected. Then the sample was well shaken and about 10ml added into a sample cell. 10ml of demineralised water was added into a second sample cell and used as the blank. The blank was inserted into the cell holder to obtain the zero concentration, then, the prepared sample was also inserted into the cell holder to obtain the total suspended solids concentration in mg/L.

Turbidity

The turbidity was determined with turbidimeter, 2100 N, product of HACH LANGE, Loveland, USA. The instrument was first calibrated with the manufacturer's standard solutions, formazin (Hexamethylene Tetramine). The sample was well shaken and about 50

ml added into a sample cell and inserted into the cell holder of the meter, then waited for stability. The turbidity values were recorded in Nephelometry Turbidity Unit (NTU).

Hydrogen ion concentration (pH)

The hydrogen ion concentration (pH) was determined using sension1 pH meter, product of HACH LANGE, Loveland, USA. The meter was first calibrated with buffer solutions; 4, 7 and 10. The pH values of the samples were obtained by dipping the electrode into the sample, waited for stability and the value recorded.

Total iron

The total iron concentration was analysed using ammonium thioglycolate and thioglycolic acid reagent in DR 5000 spectrophotometer manufactured by HACH LANGE Company, Loveland, USA. The stored Program number for total iron concentration analysis 260 was selected and the wavelength 562 nm automatically selected. 2 ml of the sample was added into a clean 25-mL sample cell and demineralised water was used to fill the cell to 25-ml mark to obtain 12.5 dilution factors. Then, the prepared sample was inserted into the cell holder of the meter and the zero concentration obtained. The reagent was added into the sample, allowed to react for five minutes and the concentration in mg/l obtained was multiplied by the dilution factor in order to obtain the concentration of the original (undiluted) sample.

Free chlorine

The concentration of the free chlorine in the sample was analysed using the N, N-diethyl-p-phenylenediamine (DPD) free chlorine reagent in a DR 5000 spectro-photometer product of HACH LANGE Company Loveland, USA. The stored Program number for free chlorine concentration analysis 80 was selected and the wavelength 530 nm automatically selected. 10ml of the sample was added into a sample cell and the zero concentration obtained from the spectrophotometer. The contents of the DPD free chlorine reagent was then added into the sample and the concentration in mg/l obtained from the spectrophotometer. The contents of the DPD free chlorine reagent was then added into the sample and the concentration in mg/L obtained from the spectrophotometer within 20 seconds.

Total hardness

The total hardness was analysed using the calcium and magnesium indicator (propionic acid), alkali solution for calcium and magnesium test (sodium hydroxide and Nitrilotriethanol), ethylenediamine tetra acetate (EDTA), and ethylene glycol tetra acetic acid (EGTA) in DR 5000 spectrophotometer product of HACH LANGE company Loveland USA. The stored Program number for magnesium hardness concentration analysis 225 was selected and the wavelength 522 nm automatically selected. 100 ml of sample was measured into 250 ml clean conical flask and 1 ml each of the indicator and the alkali solution were added into the sample and properly swirled to mix. Then 25 ml each of the prepared solution was measure into three 25-mL sample cells. A drop of EDTA was added into the first sample solution and used as blank for magnesium hardness while a drop of EGTA was added into the second sample solution and used to obtain the concentration of the magnesium hardness in mg/l. This second sample was as well used as blank for calcium hardness. The stored Program number for calcium hardness concentration analysis 220 was

selected and the wavelength 522 nm automatically selected. Then, the concentration of calcium hardness was obtained from the third sample solution in mg/L.

Phosphate

The phosphate concentration was determined using ascorbic acid, potassium pyrosulfate and sodium molybdate reagents in DR 5000 spectrophotometer product of HACH LANGE, Loveland USA. The stored Program number for phosphate concentration analysis, 490 was selected and the wavelength 880 nm automatically selected. 10ml of sample was added into a sample cell and the zero concentration obtained from the spectrophotometer. Then the content of the phosphate reagent was added into the sample and allowed to react for two minutes and the concentration in mg/L was recorded.

Nitrate

The concentration of the Nitrate was analysed using Nitrate reagents (Magnesium sulphate, potassium sulphate and sulfanilic acid compounds) in DR 5000 spectrophotometer by HACH LANGE Company Loveland USA. The stored Program number for nitrate concentration analysis, 351 was selected and the wavelength 507 nm automatically selected. 10ml of the sample was added into a sample cell and the zero concentration obtained from the spectrophotometer. Then, the content of the Nitrate reagent was added into the sample and shaken for one minute and allowed to stand for another two minutes for complete reaction. The concentration of the Nitrate was then obtained from the spectrophotometer and recorded in mg/l.

Ammonia

The ammonia concentration was determined using mineral stabilizer (Sodium tartrate and Sodium citrate), polyvinyl alcohol, and Nessler reagent in a DR 5000 spectrophotometer product of HACH LANGE Company, Loveland, USA. The stored Program number for ammonia concentration analysis 380 was selected and the wavelength 425 nm automatically selected. 25 ml of the sample was added into a 25-mL mixing graduated cylinder (prepared sample). 25 ml of deionised water was added into another 25-mL mixing graduated cylinder (the blank). Three drops of mineral stabilizer (Sodium tartrate and Sodium citrate) was added into each cylinder, stoppered and inverted several times to mix. Also three drops of polyvinyl alcohol was added to each of the cylinder stoppered and inverted several times to mix. Then 1 ml of Nessler reagent (potassium tetraiodomercurate (II)) was added into each cylinder, stoppered and inverted several times to mix. They were allowed to react for one minute and each solution poured into sample cell. The blank was placed into the cell holder of the spectrophotometer and the light shield closed to obtain the zero concentration. The prepared sample was also placed into the cell holder, the light shield closed and the concentration in mg/L obtained and recorded.

Chloride

The chloride concentration was determined using mercuric thiocyanate and ferric ion solution in a DR 5000 spectrophotometer, product of HACH LANGE Company, Loveland, USA. The stored program number for chloride concentration analysis 70 was selected and the wavelength 455 nm automatically selected. A sample cell was filled with 25 ml of the sample and another cell with 25 ml of deionised water (the blank) 2.0 ml of mercuric thiocyanate was added into the each of the sample cells and swirled to mix. Also 1.0 ml of

ferric ion solution was added into each of the cells and swirled to mix. They were allowed to react for two minutes. The blank was placed into the cell holder and the light shield closed. After the two minutes reactions the zero concentration was obtained and the prepared sample was also placed into the cell holder, the light shield closed and the concentrations in mg/L obtained and recorded.

Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand (BOD) was determined using BOD nutrient buffer solution (Calcium Chloride, Magnesium sulphate, Potassium Phosphate, Sodium Phosphate and Ferric Chloride compounds) in dissolved Oxygen meter, HQ40d, product of HACH LANGE Loveland USA. The meter was calibrated with Oxygen Saturated water contained in a BOD bottle.

The sample dilution water was prepared by adding BOD nutrient buffer solution into distilled and sterilized water contained in a sterile jug which was previously stored overnight in an incubator at 20°C for it to be saturated with oxygen and well Shaken to dissolve the slurry. A serological pipette was used to add 20 ml, 40 ml, 60 ml and 100 ml of each of the samples into 300-mL BOD bottles and labelled appropriately. The dilution water was added into each of the samples to the neck of the BOD bottles. Another 300 ml BOD bottle was also filled to the neck with dilution water only to serve as the control. The initial dissolved oxygen reading of the samples and the control were measured using the dissolved oxygen meter and recorded as D_1 . Enough dilution water was added into each of the bottles to the lip, capped and kept in an incubator at 20°C in the dark for five days. When the five days incubation was completed, the dissolved oxygen content in mg/l (dissolved oxygen remaining) in each bottle were determined and recorded as D_2 .

The following formula was used to calculate the biochemical oxygen demand after five days (BOD_5).

$$BOD_5 = \frac{D_1 - D_2}{\rho}$$

Where:

- D_1 = Dissolved oxygen of the diluted sample immediately after preparation.
- D_2 = Dissolved oxygen of the diluted sample after five days incubation at 20°C
- ρ = decimal volumetric fraction of the sample used which is calculated as $\frac{\text{Volume of sample used}}{300 \text{ ml}}$

Statistical analysis

Independent sample t test was used to find the difference between the physicochemical parameters of the upstream samples and the values obtained in the effluent discharge point, domestic activities point and the downstream samples in all the seasons using SPSS 21.0.

Results

Vegetation and Industry Conditions of Industrial Areal Physicochemical parameters

The temperature of the stream in all the samples analysed across the seasons varied between 26.7 ± 0.3 °C at the peak of dry season in upstream sample and 38.9 ± 0.3 °C during the peak of raining season in effluent discharge point sample (Table1 - 5). The conductivity of the stream in all the samples analysed across the seasons varied between 65.0 ± 0 μ S/cm in upstream sample at the setting in of dry season and 370 ± 2 μ S/cm in effluent discharge point sample during the peak of raining season (Table1 - 5). The total dissolved solids of the stream in all the samples analysed across the seasons varied between 32 ± 0 mg/l in upstream sample at the setting in of dry season and 185 ± 1 mg/l in effluent discharge point sample during the peak of raining season (Table1 - 5). The total suspended solids of the stream in all the samples analysed across the seasons varied between 11 ± 1 mg/l in upstream sample during the setting in of the raining season and 392 ± 30 mg/l in effluent discharge point during the peak of raining season (Table1 - 5).

The turbidity of the stream in all the samples analysed across the seasons varied between 12 ± 1 NTU in upstream sample at the setting in of the raining season and 423 ± 39 NTU in effluent discharge point during the peak of raining season (Table 1 - 5). The pH of the stream in all the samples analysed across the seasons varied between 6.5 ± 0 in upstream sample at the setting in of the raining season and 8.9 ± 1 in effluent discharge point during the peak of raining season (Table 1 - 5).

The total iron concentration of the stream in all the samples analysed across the seasons varied between 7.2 ± 0.2 mg/l in upstream sample at the peak of dry season and 38.7 ± 0.1 mg/l in effluent discharge point at the setting in of raining season (Table 1 - 5). The free chlorine concentration of the stream in all the samples analysed across the seasons varied between 0.00 ± 0 mg/l in the upstream sample throughout the whole seasons and 0.035 ± 0.005 mg/l in effluent discharge point at the peak of the flood season (Table 1 - 5). The total hardness of the stream in all the samples analysed across the seasons varied between 2.35 ± 0.05 mg/l in upstream sample at the peak of the flood season and 5.6 ± 0.2 mg/l in effluent discharge point at the setting-in of the raining season (Table 1 - 5).

The phosphate concentration of the stream in all the samples across the seasons varied between 0.005 ± 0.005 mg/l in upstream sample at the setting in of the raining season and 0.57 ± 0.03 mg/l in effluent discharge point also at the setting in of the raining season (Table1 - 5). The nitrate concentration of the stream in all the samples across the seasons varied between 0.89 ± 0.04 mg/l in upstream sample at the peak of dry season and 7.57 ± 0.26 mg/l in effluent discharge point at the peak of the flood season (Table 1 - 5). The ammonia concentration of the stream in all the samples across the seasons varied between 0.00 ± 0 mg/l in upstream in all the seasons and 0.35 ± 0.03 mg/l in effluent discharge point at the setting-in of raining season (Table 1 - 5). The chloride concentration of the stream in all the samples across the seasons varied between 0.14 ± 0 mg/l in upstream at the setting-in of dry season (Table 4) and 0.42 ± 0.06 mg/l in effluent discharge point at the peak of flood season (Table 1 - 5). The BOD₅ concentration of the stream in all the samples across the seasons varied between 1.2 ± 0.1 mg/l in upstream at the peak of the dry season (Table 3) and 9.5 ± 0.3 mg/l in effluent discharge point at the peak of flood season (Table 1 - 5).

The statistical analysis of the difference between the physicochemical parameters of the upstream samples and the values obtained in effluent discharge point, domestic activities point and the downstream using independent sample t – test showed that the results were all significant ($P < 0.05$) at the peak of flood season and the setting – in of dry

season and very highly significant ($P<0.05$) at the peak of the dry season and the setting – in of raining season. At the peak of the raining season, the difference with the effluent discharge point was very highly significant and highly significant ($P<0.05$) with the domestic activities point and the downstream.

Table 1: Physico-chemical parameters from the different sampling points during the peak of flood season.

Parameters	Unit	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Temperature	°C	28.6 ± 0.1	34.4 ± 0.1	32.1 ± 0.1	30.4 ± 0.1	NA
Conductivity	µs/cm	67.5 ± 0.5	204 ± 3	168 ± 3	159 ± 1	1000
Total dissolved solids	mg/l	33.5 ± 0.5	102 ± 1	84 ± 1	79.5 ± 0.5	500
Total suspended solids	mg/l	22.5 ± 0.5	115 ± 2	80 ± 2	66 ± 2	0
Turbidity	NTU	25.0 ± 1.0	122 ± 4	85 ± 2	70 ± 3	0
pH	.....	6.7 ± 0.1	7.9 ± 0.1	7.7 ± 0.1	7.5 ± 0.1	6.5 – 8.5
Total iron	mg/l	9.1 ± 0.7	24.6 ± 1.8	19.4 ± 0.8	18.2 ± 0.4	NA
Free chlorine	mg/l	0.00 ± 0	0.035 ± 0.005	0.01 ± 0	0.00 ± 0	5
Total hardness	mg/l	2.35 ± 0.05	4.9 ± 0.2	3.5 ± 0.7	2.9 ± 0.7	NA
Phosphate	mg/l	0.11 ± 0.01	0.36 ± 0.02	0.28 ± 0.03	0.23 ± 0.02	NA
Nitrate	mg/l	1.2 ± 0.02	7.57 ± 0.26	7.07 ± 0.15	6.82 ± 0.02	50
Ammonia	mg/l	0.01 ± 0	0.32 ± 0.01	0.23 ± 0.01	0.13 ± 0.01	NA
Chloride	mg/l	0.145 ± 0.005	0.42 ± 0.06	0.32 ± 0.04	0.24 ± 0.04	NA
BODs	mg/l	2.7 ± 0.1	9.5 ± 0.3	8.7 ± 0.3	8.3 ± 0.1	NA

Results are given as mean ± standard deviation

Key: Peak of flood season = September and October

Table 2: Physico-chemical parameters from the different sampling points during the setting – in of dry season.

Parameters	Unit	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Temperature	°C	28.0 ± 0	34.8 ± 0	33.2 ± 0	31.0 ± 0	NA
Conductivity	µs/cm	65.0 ± 0	215 ± 0	178 ± 0	166 ± 0	1000
Total dissolved solids	mg/l	32.0 ± 0	108 ± 0	89 ± 0	83 ± 0	500
Total suspended solids	mg/l	23.0 ± 0	115 ± 0	82 ± 0	66 ± 0	0
Turbidity	NTU	25.0 ± 0	121 ± 0	88 ± 0	70 ± 0	0
pH	.....	6.7 ± 0	8.0 ± 0	7.7 ± 0	7.6 ± 0	6.5 – 8.5
Total iron	mg/l	7.8 ± 0	24.5 ± 0	22.6 ± 0	18.2 ± 0	NA
Free chlorine	mg/l	0.00 ± 0	0.03 ± 0	0.01 ± 0	0.01 ± 0	5
Total hardness	mg/l	2.5 ± 0	5.1 ± 0	3.2 ± 0	2.8 ± 0	NA
Phosphate	mg/l	0.20 ± 0	0.43 ± 0	0.32 ± 0	0.24 ± 0	NA
Nitrate	mg/l	1.1 ± 0	4.51 ± 0	4.04 ± 0	3.31 ± 0	50
Ammonia	mg/l	0.0 ± 0	0.29 ± 0	0.17 ± 0	0.11 ± 0	NA
Chloride	mg/l	0.14 ± 0	0.27 ± 0	0.20 ± 0	0.18 ± 0	NA
BOD ₅	mg/l	2.3 ± 0	8.5 ± 0	7.7 ± 0	7.3 ± 0	NA

Results are given as mean ± standard deviation

Key: Setting - in of dry season = November

Table 3: Physico-chemical parameters from the different sampling points during the peak of dry season.

Parameters	Unit	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Temperature	°C	26.7 ± 0.3	34.9 ± 1.9	33.9 ± 2	32.5 ± 0.5	NA
Conductivity	µs/cm	65.3 ± 1.9	277 ± 16	241 ± 48	215 ± 41	1000
Total dissolved solids	mg/l	32.7 ± 0.9	138 ± 29	121 ± 24	107 ± 21	500
Total suspended solids	mg/l	12.7 ± 4.1	208 ± 67	185 ± 77	172 ± 77	0
Turbidity	NTU	14.7 ± 4.1	223 ± 72	194 ± 79	180 ± 78	0
pH	.....	6.6 ± 0.1	8.4 ± 0.4	8.3 ± 0.5	8.0 ± 0.4	6.5 – 8.5
Total iron	mg/l	7.2 ± 0.2	30.6 ± 4.8	29 ± 4.8	26.7 ± 5.1	NA
Free chlorine	mg/l	0.00 ± 0	0.02 ± 0.05	0.01 ± 0	0.01 ± 0	5
Total hardness	mg/l	3.0 ± 0.2	5.5 ± 0.2	3.5 ± 0.2	3.2 ± 0.1	NA
Phosphate	mg/l	0.08 ± 0.05	0.53 ± 0.07	0.40 ± 0.06	0.31 ± 0.04	NA
Nitrate	mg/l	0.89 ± 0.04	1.9 ± 0.3	1.4 ± 0.3	1.1 ± 0.2	50
Ammonia	mg/l	0.00 ± 0	0.30 ± 0.05	0.22 ± 0.03	0.17 ± 0.04	NA
Chloride	mg/l	0.145 ± 0.005	0.29 ± 0.04	0.23 ± 0.06	0.20 ± 0.07	NA
BOD ₅	mg/l	1.2 ± 0.1	4.6 ± 0.9	5.6 ± 0.5	4.6 ± 0.4	NA

Results are given as mean ± standard deviation

KEY: Peak of dry season = December to February

Table 4: Physico-chemical parameters from the different sampling points during the setting – in of raining season.

Parameters	Unit	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Temperature	°C	27.2 ± 0.4	37.4 ± 0.2	36.2 ± 0.1	34.2 ± 0.2	NA
Conductivity	µs/cm	68.5 ± 0.5	358 ± 6	315 ± 13	293 ± 9	1000
Total dissolved solids	mg/l	34.5 ± 0.5	179 ± 3	157.5 ± 6.5	146.5 ± 4.5	500
Total suspended solids	mg/l	11.0 ± 1.0	293 ± 9	279 ± 7	268 ± 4	0
Turbidity	NTU	12.0 ± 1.0	309 ± 13	293 ± 9	277 ± 4	0
pH	.....	6.5 ± 0	8.9 ± 0.1	8.7 ± 0	8.5 ± 0.1	6.5 – 8.5
Total iron	mg/l	7.3 ± 0	38.7 ± 0.1	36.1 ± 0.1	34.1 ± 0.1	NA
Free chlorine	mg/l	0.00 ± 0	0.03 ± 0	0.02 ± 0	0.01 ± 0	5
Total hardness	mg/l	2.95 ± 0.005	5.6 ± 0.2	5.1 ± 0.1	4.4 ± 0	NA
Phosphate	mg/l	0.005 ± 0.005	0.57 ± 0.03	0.47 ± 0.05	0.41 ± 0.03	NA
Nitrate	mg/l	0.9 ± 0.03	3.0 ± 0.2	2.4 ± 0.2	2.1 ± 0.1	50
Ammonia	mg/l	0.00 ± 0	0.35 ± 0.03	0.28 ± 0.01	0.25 ± 0.03	NA
Chloride	mg/l	0.145 ± 0.005	0.37 ± 0.01	0.32 ± 0.01	0.31 ± 0.01	NA
BODs	mg/l	1.55 ± 0.15	3.9 ± 0.1	5.8 ± 0	5.5 ± 0.1	NA

Results are given as mean ± standard deviation

KEY: Setting - in of raining season = March and April

Table 5: Physico-chemical parameters from the different sampling points during the peak of raining season.

Parameters	Unit	Upstream	Effluent discharge point	Domestic activities point	Downstream	WHO/FEPA set limit
Temperature	°C	27.9 ± 0.1	38.9 ± 0.3	35.4 ± 2.0	33.0 ± 2.8	NA
Conductivity	µs/cm	67.0 ± 0	370 ± 2	342 ± 16	314 ± 12	1000
Total dissolved solids	mg/l	34.0 ± 0	185 ± 1	171 ± 8	157 ± 6	500
Total suspended solids	mg/l	14.5 ± 0.5	392 ± 30	348 ± 40	322 ± 49	0
Turbidity	NTU	16.5 ± 0.5	423 ± 39	373 ± 40	341 ± 44	0
pH	.....	6.6 ± 0	8.9 ± 0.1	8.6 ± 0.1	8.4 ± 0.1	6.5 – 8.5
Total iron	mg/l	7.85 ± 0.34	35.7 ± 3.9	31.5 ± 4.9	28.5 ± 6.1	NA
Free chlorine	mg/l	0.00 ± 0	0.02 ± 0	0.01 ± 0	0.01 ± 0	5
Total hardness	mg/l	2.75 ± 0.05	4.9 ± 0.1	4.4 ± 0.1	4.1 ± 0.1	NA
Phosphate	mg/l	0.01 ± 0	0.49 ± 0.2	0.41 ± 0.01	0.39 ± 0.02	NA
Nitrate	mg/l	0.99 ± 0.01	4.1 ± 0.7	3.4 ± 0.6	2.7 ± 0.3	50
Ammonia	mg/l	0.00 ± 0	0.26 ± 0.02	0.21 ± 0.01	0.15 ± 0.03	NA
Chloride	mg/l	0.145 ± 0.005	0.40 ± 0.20	0.34 ± 0.1	0.31 ± 0.01	NA
BODs	mg/l	1.95 ± 0.15	5.0 ± 0.8	6.5 ± 0.4	5.9 ± 0.1	NA

Results are given as mean ± standard deviation

Key: Peak of raining season = May and June

Discussion

The physico-chemical quality of Ekemazu stream in Delta state, Nigeria was investigated in order to determine the impact of effluent discharge and seasonal variations on the stream. The results of the physicochemical parameters of the stream showed that the temperature was in the range of 26.8 to 39.2°C. This is a good temperature range for the growth of mesophilic micro-organisms (Ogbonna, 2010). This result is similar to that of Prerana and Vijay (2013) on their study of physicochemical study of Kanhan river water receiving fly ash disposal wastewater of Khaperkheda thermal power station of India who recorded 24.2 to 35.3°C in their research. The value was highest in effluent discharge point, followed by domestic activities point, then the downstream point. Upstream sample was the lowest. The high temperature results mostly from release of effluent with high temperature into the water body (Akatah et al., 2018).

The conductivity and total dissolved solids of 64 to 372 $\mu\text{s}/\text{cm}$ and 32 to 186 mg/l recorded during the period of this research is within WHO, (2011) limit of 1000 $\mu\text{s}/\text{cm}$ and 500 mg/l respectively. This is contrary to the research of Prerana and Vijay, (2013) who recorded conductivity of 380 to 2330 $\mu\text{s}/\text{cm}$ and total dissolved solids of 225 to 1362 mg/l. In this research, although the conductivity and the total dissolved solids are within WHO acceptable limit the effluent discharge greatly influenced these two parameters because of high content of dissolved solids in the effluent (Buecker, 2014). The results of the total suspended solids and turbidity of 8 – 422 mg/l and 10 – 462 NTU respectively are out of WHO (2011) acceptable limit of 0 mg/l and 0 NTU. The results of the total suspended solids is similar to that of Andargachew and Sahile, (2013) on their study of the effects of Dashen brewery wastewater treatment effluent on the bacteriological and physicochemical quality of Shinta River in Gondar, North West Ethiopia at the upstream sample of 6 mg/l, but higher than their record after discharge point which they recorded as 42 mg/l. Suspended solids of effluent polluted water body can serve as attachment for microbes (Daniel *et al.*, 2012). It can also settle and deposit sand and grit into aquatic systems resulting in interruption of natural ecosystem and aquatic lives (Kasich *et al.*, 2013).

The results of the pH were acidic in the upstream sample but alkaline in other samples (6.4 – 9.0). The result in this research is above WHO acceptable limit of 6.5 – 8.5. The acidic nature of the upstream sample could be attributed to forest fire, bacteria action on soil, lightning, (Mishra, 2010). The alkalinity nature of the effluent discharge point, domestic activities point and the downstream samples could be attributed to the components of the effluent continuously released from the Independent Power Plant such as ammonia, phosphate, sodium hypochlorite etc. which have high pH value (Guecker, 2000). The iron content of 7.0 to 39.8 mg/l is high. High iron content serves as good nutrient and ecological nurture for microbes (Govindaraju *et al.*, 2011). This research showed that the iron concentration was highest in effluent discharge point. This can be attributed to release of effluent with high iron content resulting from water purification process in the power plant (Suha, 2013).

The results of other parameters such as the free chlorine, total hardness, phosphate, nitrate, ammonia, chloride and biochemical oxygen demand (BOD) are within WHO acceptable range. However, the effluent release from the independent power plant greatly influenced the effluent discharge points, domestic activities point and the downstream. Their concentrations in the stream do not pose any serious effect to human consumption, except the biochemical oxygen demand (Kasich *et al.*, 2013; Ashraf *et al.*, 2010). Presence of ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution. It can compromise disinfection efficiency, result in nitrite formation in distribution systems, cause the failure of filters for the removal of manganese and cause taste and odour problems (WHO, 2011). There was observed fluctuation in the physicochemical parameters analysed during the research period. Apart from human activities in the stream and effluent discharge by the Independent Power Plant, seasonal variation also influenced the water quality. This observation is similar to that of Ogonna, (2010)..

Conclusions

This research clearly showed that some physicochemical quality of Ekemazu stream in Okpai-Oluchi, Delta state Nigeria is higher than the WHO acceptable limit. This is due to release of heavily polluted effluent by the Independent Power Plant into the stream as well

as some human activities in the water body. The value of the total suspended solids, turbidity, iron, and biochemical oxygen demand (BOD) can be used to classify Ekemazu stream as a polluted water body and as such unfit for any human or domestic use/consumption in accordance to World Health Organisation water use guidelines standard. This is a gross violation of effluent discharge permit limits employed by the power plant. It is therefore recommended that the independent power plant should unlike their present method of only primary treatment of their wastewater, adequately treat their effluent to tertiary stage of waste treatment before discharging into the stream. It is also required that the environmental monitoring body, Federal Environmental Protection Agency, FEPA, regularly inspect and certify the company's effluent before their release into the water body in order to ascertain compliance by the company. This can be employed through enacting of rules and regulations that can guide against improper sanitary and hygiene practice, education of the masses on the implications of polluted water body and the need to live a healthy life.

References

- Akatak H.A; Omonigho S.E; Ibrahim A.G; Seyinde D.O. (2018). Physico-chemical and microbiological analyses of Ikpoba river water, Benin City, Edo State, Nigeria. *International Research Journal of Biological Sciences* 7(5): 1-5. ISSN 2278-3202.
- Andargachew, B. and Sahile, S. (2013). Effects of Dashen Brewery wastewater treatment effluent on the bacteriological and physicochemical quality of Shinta River in Gondar, North West Ethiopia: *World environment* 3(1): 29-36
- APHA, (2005). *Standard methods for the examination of water and wastewater*. American Public Health Association, Washington DC 21pp
- Ashraf, M.A., Maah, M.J., Yusoff, I. and Mehmood, K. (2010). Effects of polluted water irrigation on Environment and Health of people in Jamber District Kasur, Pakistan. *International Journal of Basic and Applied Science* 10(3): 37-57
- Daniel, M.H., Montebolo, A., Bernades, M.C., Ometto, J.P., Decamargo, P.B., Krusche, A.V., Ballester, M.V., Victoria, R.L. and Martinelli, L.A. (2012). Effects of Urban sewage on dissolved oxygen, organic and Inorganic carbon and electrical conductivity of small streams along a gradient of urbanization in the Piracicaba river basin. *Water Air and soil Pollution* 136: 189-206
- Decker, C. and Simmons, K. (2013): *Surface water Sampling*, 4th ed. U.S. Environmental Protection Agency, Science and Ecosystem Support Division, Athens, Georgia 22pp
- Duncan, D., Harvey, F. and Walker, M. (2007). *Environmental Protection Authority Guidelines: Regulatory monitoring and testing water and wastewater sampling*, Environmental Protection Authority, South Australia 58pp
- Edet, E.J., Etim, E.E. and Titus, O.M. (2012). Bacteriological and Physicochemical analysis of streams water in Nduetong Oku community, Uyo, Akwa Ibom State Nigeria. *International Journal of Modern Chemistry* 3(1): 65-73
- Govindaraju, M., Kumar, P., Selvaraj, M. and Rajina, C. (2011). Study on physicochemical parameters along the coastal waters around Kudan Kulam Nuclear power plant: *International Journal of Oceans and Oceanography* 5(1): 75-83
- Guecker, B., Brauns, M., Pusch, M.T. (2000). Effects of wastewater treatment plant discharge on ecosystem structure and function of lowland streams. *Journal of the North American Benthological Society* 25: 313-329
- Kasich, J.R., Taylor, M., and Nally, S.J. (2013): *Surface water Field Sampling Manual for Water Column Chemistry, bacteria and flows*. 3rd ed. Environmental protection Agency Ohio USA 41pp

- Mishra, A. (2010). Assessment of Water quality using principal component analysis: A case study of river Ganges. *Soviet Journal of water Chemistry and Technology* **32**(4): 227-234
- Ogbonna, D.N. (2010). Seasonal dynamics of microbial population and physicochemical characteristics of a water body receiving industrial pollutants in Port-Harcourt, Nigeria. *Agriculture and Biology Journal of Nigeria* **1**(6): 1333-1339
- Osibanjo, O., Adegbenro, P.D., and Adewole, M.G. (2010). Impact of industries on surface water quality of River Ona and River Alaro in Oluyole industrial estate, Ibadan Nigeria: *African Journal of Biotechnology* **10**(4):696 - 702
- Owa, F.N. (2014). Water pollution. Sources, effects control and Management. *International letters of Natural Sciences* **8**(2014):1-6
- Prerana, T. and Vijay, C.N. (2013). Physicochemical study of Kanhan River water receiving fly ash disposal wastewater of Khaperkheda thermal power station of India: *International Research Journal of Environment Sciences* **2**(9): 10-15
- Suha, A.I. (2013). Studying wastewater parameters of thermal power station: *Australian Journal of Basic and Applied Sciences* **7**(8): 565 – 570
- WHO, (2011): *Guidelines for drinking water quality*, 4th ed. World Health Organisation, Geneva 541pp.