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Impact of Industrial Effluents from Textile Company on Water Quality and Oreochromis Niloticus from Ilemere River, Langbasa, Ikorodu

Olatayo Ogunbanwo[*1], Sola Babalola [2] and Folajuwon Fakunmoju[3]

Department of Fisheries Technology, Lagos State Polytechnic, Ikorodu, Lagos State, Southwest Nigeria

***Corresponding Author:** Olatayo Ogunbanwo, Department of Fisheries Technology, Lagos State Polytechnic, Ikorodu, Lagos State, Southwest Nigeria*

ABSTRACT

A study was carried out on the impact of industrial effluents from textile company (Nichemtex) on water quality and Oreochromis niloticus from Ilemere River, Langbasa, Ikorodu, between July and September 2009. The water body was stratified into 3 and samples were collected. The results were analyzed in the laboratory and interpreted using ANOVA. Water quality parameters and mean (±SD) were obtained. Temperature (27.72±0.33 Oc), dissolved oxygen (3.48±0.12mg/l), salinity (0.49±0.19‰), electrical conductivity (8.25±0.25 µs/cm), pH (7.77±1.24), transparency (0.22±0.08m), biological oxygen demand (82.2±1.76mg/l), and Depth (0.11±0.01m). The sequential occurrence of heavy metals in the sampled water is as follows; F > Cu > Zn > Cr > Pb > Cd while the quantitative bio-accumulation of heavy metals in the tissue of O. niloticus is in the order of magnitude. Cr = 1.00±0.52mg/kg, Pb = 1.13±0.06mg/kg, Cd = 1.14±0.04mg/kg, Cu = 2.09±0.47mg/kg, Zn =4.19±0.27mg/kg, and Fe = 6.56±0.54mg/kg. Temperature, salinity, electrical conductivity, biological oxygen demand, dissolved oxygen and pH were significant at probability level of 5% while the means of heavy metals in water and tissue of O. niloticus were not significantly difference at p<0.05. The results indicated that the water quality characteristics from Ilemere River, Langbasa, Ikorodu, Lagos State is highly polluted.

Keywords: *Physico-chemical parameters, pollution, Heavy metals, Oreochromis niloticus, Ilemere River*

INTRODUCTION

Increase in the industrial activities and application of technology to explore natural resources have resulted in the release of various types of industrial waste materials into the environment. These wastes are complex mixtures of several classes of pollutants including hydrocarbons, pesticides, detergents, synthetic chemicals and heavy or trace metals which pollutes air, water and land (GEF/UNDP/UNEP), the composition of industrial effluents or wastes depends on the technology adopted, the raw materials and products, energy source employed and mode of waste treatment.

Effluents from textile mill, dye houses can create serious environmental hazards. These wastes inevitably contain a substantial concentration of soluble organics compounds, suspended solids, dissolved salts, and are characterized by aesthetically objectionable colors (Zorawar and Pooja, 2016). However, it is not widely realized that these effluents also contain significant amount of various heavy metals. Zinc, chromium, lead, coppers mercury, cadmium and nickel are the most prevalent. These metals originate from several sources. Zinc, copper and chromium may be present as an integral part of numerous dyes, several heavy metals are retained in the final product in term of impurities originating from intermediate compounds or catalysts employed in the synthesis (EPA 2008).

Oreochromis niloticus is one of the common fishes in Lagos waters, inhabiting both brackish and fresh water systems. They are highly prolific with high degree of parental care. Its dainty makes it to command high market price with moderate consumer preference over other fish found in Lagos water (Babalola et al., 2016). It is therefore imperative to understand the responses of Oreochromis niloticus to pollutants which are known to occur in the contaminated waters of Lagos environment and also serves as bio indicator in the monitoring of pollution status of the aquatic habitats.The harmful effects of heavy metals like other chemicals in the environment could be manifested in a number of ways in aquatic organisms such as reduction in the number of survivors, undesirable effects on metabolism or breeding efficiency and alteration of behavioral patterns, (Bhattacharya et al., 2008). The persistence of heavy metals in aquatic environment poses great danger to human consumers of sea foods that may contain accumulated metals in their tissues. Increasing public awareness on the negative effects of industrial pollutants in most countries of the world has led to the enactment of several guidelines and law which have imposed limitations on the types and quantities of waste materials that an industry can emit, it is therefore pertinent to study the toxicity of individual effluents against local species that characterize the recipient ecosystems.

MATERIALS AND METHODS

Materials

Ilemere River is situated in Ikorodu, Lagos, Nigeria; its geographical coordinates are 6° 30' 0" North, 3° 35' 0" East. (Fig.1) This water body is a contingent of Lagos lagoon. The textile industry, Nichemtex is located on 145 acres in Ikorodu, on the outskirts on Lagos, commercial capital of Nigeria. The location of the factory gives easy access to Nigeria's main ports, facilitating movement of raw materials and finished goods. Nichemtex is a vertically integrated manufacturing unit with facilities including synthetic fibre and filament manufacturing, spinning, weaving, real wax printing and dyeing (estateintel.com 2017).

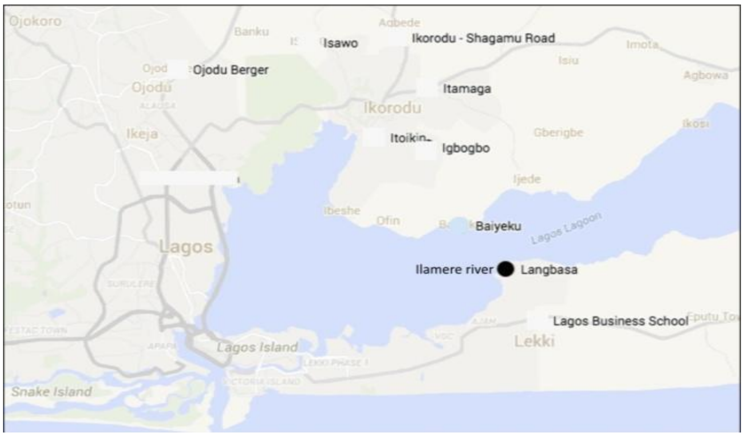

Figure1. *Geographical map of Ilemere river, Langbasa, Ikorodu. Source: estateintel.com (2017)*

Water samples were collected between 8.00 and 11.00hrs from three different sampling stations of Ilemere River, Ikorodu that stretches to about 1.5km in length and with the depth between 3 - 25 feet and stratified into 3 stratums i.e. upstream, midstream and downstream. The stations were accurately located by relying on bearing and makers on the shorelines with special attention on the contingent water body. Sterile plastic bottles of 1 liter each were used to collect water samples from each station. The time of collection was dictated by single hydrological season. Temperature, pH, Dissolved Oxygen, Salinity and Conductivity were measured in-situ in each sampling station using Ezodo digital multimeter (Model PCT-407) (Babalola and Agbebi, 2013)

Extraction of metal pollutants in water for metal pollutants was carried out using Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation, S series AA Spectrometer with Gravities furnace, UK). Water samples that were fixed with HCl were de-fixed. 25ml of water sample was measured into a conical flask of about 250ml capacity. Heat at a temperature not more than 120°C until the sample is about 5ml and allow to cool, filter using Whatman filter paper into a 50ml standard volumetric flask. Make up to mark and set the sample for AAS (calibrated) for Trace Metals reading (Babalola and Fiogbe, 2017)

Fish samples were collected at landing site from local fishermen and kept in ice pack below 40c to retain the wholesomeness of the fish for the analysis. The whole test animal samples were cleaned by rinsing with clean water to remove impurities then 5g of animal tissue is obtained and homogenized follow by digestion processes with H2O2 and HNO3 (Babalola and Fiogbe, 2016). The digested samples were filtered through Whatman filter and mark up to appropriate volume of 25cc. The determination of heavy metals in test animal was done using Atomic Absorption Spectrophotometer (AAS) model pye Unicam 969 by comparing their absorbance with those of factory prepared AAS standard solution (Babalola and Agbebi, 2013). Metal pollutants that were investigated during the period in view are: Chromium, Copper, Zinc and Iron.

Statistical Analysis

To evaluate concentrations of different metal pollutants between the fish and water within the stations, one-way ANOVA and Duncan multiple tests were used. A probability level of 0.05 or less was considered significant.

RESULTS

All the water quality parameters taken from Ilemere River are reported in Table 1.The Temperature was taken in-situ and the highest value of Temperature (28.10OC) was recorded in September while the lowest value (27.50OC) was recorded in July. The means and standard deviation of all the temperature taken during the period in view was 27.72± 0.33 OC. There is significant different in the means (±SD) of Temperature at 5% level of probability

Table I: Physico-chemical characteristics during hydrological period from Ilemere river, Langbasa, Ikorodu

Month	Temp (°c)	D.O (mg/l)	pH	Salinity (‰)	E.Cond. (µs/cm)	BOD (mg/l)	Transparency (m)	Depth (m)
July	27.50	3.39	9.18	0.30	8.01	84.0	0.30	0.10
August	27.55	3.43	7.31	0.50	8.23	82.0	0.15	0.11
September	28.10	3.61	6.83	0.67	8.50	80.5	0.20	0.12
Total	83.15	10.43	23.32	1.47	24.74	246.5	0.65	0.33
Mean (±SD)	27.72 ± 0.33	3.48 ±0.12	7.77 ±1.24	0.49 ±0.19	8.25 ±0.25	82.2 ±1.76	0.22 ±0.08	0.11 ±0.01
	Threshold Limit							
LASEPA (2006)	26	4	6.0	0.5-35	70	50	0.5	1.5

Dissolved Oxygen from the study site was also recorded with lowest value in September (3.39mg/l) and the highest value in July (3.61mg/l). The average means during the study period was 3.48±0.12mg/l. The values of dissolved oxygen were also taken in-situ and are significant at 5% level of probability.

During the study period, the pH of freshwater brackish of Ilemere River ranged between 9.13 and 6.83. The elevated value is during the pick of rainy season (July). The difference in pH values during the sampling periods is significant at 5% level of probability. The mean standard deviation for the values taken during the study period is 7.77±1.24.

The Salinity of the freshwater brackish was taken in-situ using hand held digital meter. Least value was recorded in July (0.30%o) while the highest value was recorded in September (0.67%o). There is significant different at 5% level of probability. The total mean value during the sampling period was 0.49±0.19%o.

The seasonal Electrical Conductivity from freshwater brackish of Ilemere River ranged between 8.01 and 8.50 (µs/cm) with mean standard deviation of 8.25±0.25 µs/cm and July had the lowest value while September had the highest value. There is significant difference in the means (±SD) of electrical conductivity at 5 % level of probability.

The trend of seasonal variation in Biological Oxygen Demand from the study site was recorded as shown in Table 1 above. The seasonal value ranged between 80.5 and 84.0 (mg/l). July had the highest value while September d the lowest value and the mean standard deviation for the 3 months sampling period was 82.2±1.76mg/l. There is significant difference in the mean (±SD) of biological oxygen demand at 5 % level of probability.

The Transparency of the water from the study site was measured using Secchi Disk graduated in meters and the least value was recorded in September (0.20m) while the highest was reported in July (0.30m). The mean standard deviation of the values collected for the 3 months sampling period is 0.22±0.08m. There is significant difference in the mean (±SD) of turbidity at 5 % level of probability.

The seasonal mean depth of 0.11±0.01 (m) in freshwater brackish of Ilemere from 3 sampling stations during rainy season was reported as shown in Table 1 above. The mean depth is not significantly different at 5% probability. However, the depth is determined by the topography of the river floor.

The results of seasonal concentrations of heavy metals in water from Ilemere River, Ikorodu during the sampling period between July and September 2009 were recorded. Each heavy metal identified was present in measurable amount and the threshold limits are discussed based on the international regulatory limit and

Standard (USEPA, 1986) . The sequential occurrence of heavy metals in the sampled water is as follows; F > Cu > Zn > Cr > Pb > Cd. At 5% probability, there is no significant difference in the means of heavy metal concentrations in the water in different months but there is significant difference in the means of different heavy metal species during the study periods. The trend of occurrence is shown in Table 2.

Table 2: Metal pollutants concentrations (mg/l) in water from ilemere river, Langbasa, Ikorodu

Month	Cr (mg/l)	Cu (mg/l)	Zn (mg/l)	Fe (mg/l)	Pb (mg/l)	Cd (mg/l)
July	12.77	127.76	77.42	320.69	10.330	10.300
August	17.86	133.02	118.67	308.89	10.320	10.180
September	15.49	165.15	117.84	349.67	10.500	10.300
Total	46.12	425.93	313.93	979.25	31.15	30.78
Mean (±SD)	15.4 ±2.55	142.0 ±20.24	104.6 ±23.58	326.0 ±20.98	10.4 ±0.10	10.3 ±0.07
Permissible Level (USEPA, 1986)	1.0	1.0	1.0	1.0	0.05	0.01

Table 3 shows the mean values of heavy metals in the tissues of Oreochromis niloticus from freshwater brackish of Langbasa in July, August, and September. There is no significant difference in the means of heavy metal concentrations in the tissues at different months but there is significant difference in the means of different heavy metal species during the study periods, all at 5% probability. The quantitative bio-accumulation of heavy metals in the tissue of O. niloticus is stated in the order of magnitude, from lowest to highest. Cr = 1.00±0.52mg/kg, Pb = 1.13±0.06mg/kg, Cd = 1.14±0.04mg/kg, Cu = 2.09±0.47mg/kg, Zn =4.19±0.27mg/kg, and Fe = 6.56±0.54mg/kg.

Table 3: Metal pollutants concentrations (mg/kg) in tissue of *Oreochromis niloticus* from ilemere river.

Month	Cr (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Cd (mg/kg)
July	0.48	1.58	3.98	6.02	1.09	1.10
August	1.01	2.20	4.10	6.56	1.11	1.15
September	1.51	2.50	4.50	7.10	1.20	1.18
Total	3.0	6.28	12.58	19.68	3.40	3.43
Mean (±SD)	1.00 ±0.52	2.09 ±0.47	4.19 ±0.27	6.56 ±0.54	1.13 ±0.06	1.14 ±0.04
Permissible Level WHO/FAO(mg/day)	50	3.0	60.0	43.0	0.214	0.1

Discussion

Industrialization in the face of economic growth has progressively introduced some pollutants into the environment especially water bodies that have become the receptacle of such pollutants. Temperature serves as the major driving force in determining the solubility and concentrations of other essential water quality parameters in the aquatic environment. Hence, the values of other investigated parameters can probably be influenced by temperature range in the study site as indicated in Table 1 (Babalola and Fiogbe, 2017). The difference in the mean value of temperature during the study period from Ilemere River, Langnasa is significant at 5% level of significance, this level of significance could be as a result of the hot waste water from steam boiler during the process of conversion of natural cotton into dyed and printed fabric in the NICHEMTEX textile industry that are released into the Ilemere river. Steam from water boiler plays a vital role in textile industry; it is the vaporized state of water that contains heat energy which is transferred into the aquatic environment. The mean standard deviation of the Temperature from the study site is above standard regulatory limit of LASEPA (LASEPA, 2006).

Dissolved oxygen assists in regulating metabolic processes in plant and animal community and also as an indicator of pollution in aquatic ecosystem (Babalola and Fiogbe, 2016). Inverse relationship between dissolved oxygen and temperature subsisted in the study site. The decreased dissolved oxygen could be traceable to release of hot waste water from the industry. Dissolved oxygen varied depending on temperature, the solubility of oxygen decreases as temperature increases (Wetzel, 2001). Also, the effect of oxidation-reduction on residual chemical compounds in the wastewater from the industry could also be responsible for the low concentrations of dissolved oxygen. This agreed with the findings of Boyd and Lichtkoppler (1979) as cited by Babalola and Fiogbe (2017). The reported means (±SD) of dissolved oxygen is below regulatory standard (LASEPA, 2006).

The elevated pH value reported from Ilemere River, Langbasa may perhaps be derived from mineral acids in the discharged wastewater from the textile industry into the study area.

Wastewater from the textile processing industry is considered to be of high pH values which give excessive pH measurement of the aquatic environment due to the presence of pH controller such as Soda Ash, Acid, Caustic, and Neutracid RBT (Nonvolatile) in the wastewater (Khan, 2008). The highly alkaline wastewater that is emptied into aquatic environment will raise the pH beyond the threshold for aquatic life and could subsequently destroy the plant and animal community that are in it (Babalola and Fiogbe, 2017).

One of the main ecological features influencing the spatial distribution of organisms in aquatic environment is salinity variation (Wurts, 1992). The salinity values reported in this study is assumed to come from the salts used in dyeing in the textile industry such as common and Glauber salts and from some inorganic compounds. Salt has a tremendous high empathy for water and it is necessary in the textile industry for the fascination of dye into fabrics during the dyeing process in textile. Also, the use of salt leads to maximum breaking down of dye molecules during dyeing process in textiles and majorly, as an electrolyte for migration, adsorption and fixation of the dyestuff to the cellulose material (Khan, 2008).

A corresponding relationship exists between electrical conductivity concentration and salinity concentration in the sampled water. There is a positive correlation between salinity and conductivity of Ilemere water and significant at 5% level. The electrical conductivity reported in the Ilemere River is due to the presence of salts in the discharged wastewater from the textile industry into the river. Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. Salts solution produce an anion and a cation. These ions make up the source of conductivity in water (Perlman, 2013)

Biological oxygen demand (BOD) concentration in the aquatic environment is generally used as a pollution indicator (Hynes, 1974). The correlation between biological oxygen demand and dissolved oxygen from Ilemere River is positive and significant at 5% level. The mean (±SD) of BOD is above the regulatory standard limit. The high titer value of microbes in the sampled water that transmute the dissolved oxygen in the ecosystem could be responsible for high biological oxygen demand. The high titer value could be due to high concentrations of organic matters from raw materials and some species of chemical elements in the discharged wastewater from textile industry into the river. Also, reduction-oxidation (REDOX) potentials of some chemical compounds in the sampled water may also be one of the factors responsible for high BOD (*Himanshu and Vashi*, 2015).

Transparency measures the extent of light penetration to the depth of the water body. The penetration of light guarantees the primary productivity in the aquatic ecosystem. This primary productivity provides the trophic index of the ecosystem (gvsu.edu, 2018). The mean (±SD) during the study period is low which indicates low transparency. The low transparency is from the residual dye used in the processing of raw cotton into fabric that is present in the discharged wastewater from the industry into the river. The low transparency is an indication of high turbidity. Depth plays vital roles in determining the values of other essential physicochemical parameters. There are correlations between depth, dissolved oxygen, temperature and transparency/turbidity (Babalola and Agbebi, 2013). The depth falls below standard limit due to sludge deposit from the textile industry.

The results of trace metal analyses from Ilemere River water showed that the heavy metal concentrations in the water samples are higher than the Lagos State Environmental Protection Agency (LASEPA) safe limits. The mean (±SD) concentration values of heavy metals from Ilemere River are in sequence, from higher concentration to lower concentration. F= (326.0±20.98 mg/l), Cu= (142.0±20.24 mg/l), Zn= (104.6±23.58 mg/l), Cr = (15.4±2.55 mg/l), Pb = (10.4±0.10 mg/l), Cd = (10.3±0.07 mg/l). The sources and the concentrations of heavy metal in the river of Ilemere during the study periods are perceived to be from the large areas sampled (Babalola and Fiogbe, 2017), the textural nature of the river sediments (Barron, 1995) and point-source discharge of wastewater that contain chemical compounds from dye materials from textile industry into the river (Muluken , 2014). These effluents discharge certainly contain a considerable concentration of soluble organic compounds, suspended solids, and dissolved industrial salts which are categorized by visually obnoxious colours and odours. These commercial dyes and supplementary textile chemicals are established source of chemical pollutants that can cause cancer in human through food chain and web (Muluken , 2014 & Babalola and Fiogbe, 2017).

The occurrence of heavy metals in the aquatic ecosystem can have a positive or negative effect on the wellbeing of the organisms depending on the heavy metals concentrations and their tolerance limits. Some heavy metals such as Zn, Cu, and Fe are essential for organisms vigor and they play a key roles in some metabolic activities in aquatic organisms such essential elements only become lethal when their concentration surpass the trace amounts required for normal metabolism (Law and Singh, 1991).

Heavy metals concentration in the tissue of Oreochromis niloticus caught from Ilemere River as illustrated in Table 3 shows that their concentrations exceed that of Lagos State Environmental Protection Agency (LASEPA) permissible limits. In concentrations, it follows the trend; Cr=1.00±0.52mg/kg, Pb = 1.13±0.06mg/kg, Cd = 1.14±0.04mg/kg, Cu = 2.09±0.47mg/kg, Zn =4.19±0.27mg/kg, and Fe = 6.56±0.54mg/kg. These heavy metals through the natural process of bio magnification of little quantities of heavy metals via various food chains and web becomes elevated in concentrations to levels which can be proved to be toxic to both human and the aquatic organisms (Ackefor et al., 1979). The source of these heavy metals in the tissue of Oreochromis niloticus is from surrounding water and river sediments that serves as cistern for textile effluents discharge from Nichemtex Textile industry into the Ilemere River, Langbasa, Ikorodu.

Heavy metals are stable and persistent elements in the environmental. When the concentration exceeds threshold limit, it becomes pollutants in the aquatic ecosystem. However, some essential heavy metals such as Cu, Zn and Fe which are required for metabolic activity in organisms lies in the threshold limit between their essentiality and toxicity. Other heavy metals such as Cd, Pb and Cr which are non-essential may show high level of toxicity at low levels under certain environmental circumstances (Perzada, 1990).

The effect of non-essential heavy metals such as cadmium, Chromium and Lead (Pb) are considered to be toxic heavy metal with records of causing cancer and kidney failure in human through accidental ingestion. It also prompts cell damage and death by snooping with calcium regulation in metabolic activities. Cadmium has been found to play a vital role in endocrine disorderly activities with serious health implications (Forstner and Wittmann, 1983). Aside from human health disruptions, it has also been found to be toxic to fish and other organisms in the aquatic environment causing physiological challenges (Perzada, 1990). In the same vein Pb has been considered to be potentially harmful and toxic to most forms of life. It has been found to be responsible for a quite a number of health issues in humans such as cancer and chromic neurological disorders especially in foetus, children and adults (USEPA, 1986).

Conclusion And Recommendation

The qualitative and quantitative studies of effluents discharge into Ilemere River, Lagbansa were grossly higher than the set limits by the Lagos State Environmental Protection Agency (LASEPA) and some other relevant international regulatory bodies. The metal concentrations in water and fish from Ilemere River in Langbasa were higher than the maximum acceptable concentration stipulated by (LASEPA) which are indications of pollution from point sources in and around Langbasa and from diffuse sources such as run-off. However, the results also indicate that the maximum acceptable concentration (MAC) or safe limits were exceeded due to the continuous activity and discharges from Nichemtex Textile Industry. Since the maximum acceptable concentrations of metal detected both in the water samples and in the fish tissues were above the safe limits, therefore the water from Ilemere River cannot be used for domestic and recreational purposes and also the fishes caught from the river water are not fit for human consumption. It is therefore recommended that the Lagos State Environmental Protection Agency should stop the activities of Nichemtex Textile Industry until the industry confirm to standard practice of treating the industrial effluents.

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