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Impact of Palm Oil Mill Effluent on Physico-chemical Parameters of a Southwestern River, Ekiti State, Nigeria.

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ABSRACT
The physico-chemical parameters of water and palm oil mill effluent (POME) samples of Ayanyan River was investigated between August 2009 and July 2010 to assess the impact of the POME on the water quality. The parameters tested were pH, temperature, alkalinity, total suspended solids, dissolved oxygen, biochemical oxygen demand, nitrate, phosphate, potassium, magnesium, lead, oil and grease. Standard methods of water and waste water analysis were used and compared with WHO permissible limit. The results showed that all the samples had values above the WHO standards which makes the river water unsafe to both human and aquatic life. As there is rising concern globally regarding POME as one of the sources of greenhouse gases, legislative measures are necessary to enforce laws and rules on land-use and waste regulation to control the location and management of palm oil mills, especially when cited near water bodies close to residential areas.
Keywords: Physico-chemical parameters, POME, Ayanyan River, Pollution, Remediation.

1. INTRODUCTION

Nigeria is the most populous country in Africa, with a population of about 160 million people. The country is endowed with generous resources of water bodies. The span of water bodies within the country is estimated at 900km^2. This water provides resources for fisheries, transportation, irrigation, recreation and domestic uses (Ekiye *et al.,* 2010). However, about 60 percent of the Nigeria populace both rural and some urban dwellers still source for domestic water and sometimes drinking water from ponds, streams, and shallow wells justifying the concern for increase in the level of pollutants in surface and groundwater, thus making water monitoring even more vital (Adelegan, 2004; Water Aid, 2007; Morenikeji, 2010).

Regulations put in place by the world health organization (WHO) and the federal environmental protection agency (FEPA) to protect the aquatic environment have not been so effective in Nigeria. Hence, indiscriminate dumping of refuse into water bodies and effluents from solid waste dumpsites is on the increase. These effluents range from chlorides, nitrates, oil and grease, heavy metals, e.t.c. One of the common pollutants in aquatic ecosystems in Nigeria, particularly in the south western parts of the country is the palm oil mill effluents (POME). During palm oil processing, large quantities of water is used in mills where oil is extracted from the fresh fruits of African oil palm, *Elaeis guineesis*. About 50% of the water results in palm oil mill effluent. It is estimated that for 1 ton of crude palm oil produced, 5-7.5 tonnes of water ends up as POME (Ahmad, *et al.,* 2003).

Palm oil mill effluent is the voluminous liquid waste that comes from the sterilization and clarification sections of the oil palm milling process. The raw effluent contains 90-95% water and includes residual oil, soil particles and suspended solids. Palm oil mill effluent is a highly polluting material and much research has been dedicated to means of alleviating its threat to the environment (Ho *et al.,* 1984; Perez, 1997; Chavalparit, 2006). POME is a highly polluting material due to its high BOD, low pH and colloidal nature. It was estimated that a processing plant with a capacity of 10 tons fresh fruit per hour would need a water treatment plant comparable to that required by a population of half a million inhabitants (Brezing, 1986). A more serious environmental impact of POME is that anaerobic ponds release greenhouse gases (methane and carbon dioxide) that contribute to global warming. Communities located near oil mills may also suffer from odor emissions and lack of access to good water caused by poorly managed effluent treatment systems (Chavalparit, 2006).

In Nigeria, POME are discharged directly and untreated into the nearby agricultural lands and surface waters in its raw form especially by small scale processors. Though wastes generated by these operators may be minimal because majority of the wastewater are reused and oftentimes, the receiving water bodies has the ability for self-purification. But in many cases, palm oil milling operations are on a continual basis, thus creating a lot of stress on these water bodies and breaking their capacity for self-purification. Also, large and medium scale mills produce copious volumes of POME from the processing lines which are sometimes treated before been discharged. However effective the system of oil recaptured from sludge may be, POME discharged from oil mill is objectionable and could pollute streams and rivers and surrounding lands (Hartley, 1988).

Ayanyan River is the main water supply to some parts of Ado-Ekiti (especially Omisanjana areas), the capital city of Ekiti State. The river was dammed at the Ajilosun area of the town to form the Ado-Ekiti Water Reservoir, which is the major supply to the town and its environs. Although Ayanyan river is not noted for fishery activities because of its size, residents around the area do fish from it and carry out a lot of other domestic activities around it, such as farming, laundry and it's a source of water for household chores especially during dry seasons. The river also receives effluents from small scale agricultural and palm oil production activities. As a result of these activities, the river usually has a brownish coloration and a greasy surface. Though the effluents could be a source of food for the fishes, it may also contribute significantly to the pollutional load of the river and affect the quality of the river for other uses. In the light of this, this study was designed to assess the physicochemical parameters of water and palm oil mill effluent samples discharged into the Ayanyan River.

1.1 MATERIALS AND METHOD

Study Area

The study area Ayanyan River is located in Ado-Ekiti metropolis, the state capital of Ekiti State, Nigeria. Human activities around the river have led to the reduction in size of the river.

Geographically, Ayanyan is at an altitude of 433 meters above sea level and Ado – Ekiti lies within the tropical rainforest zone of southwestern Nigeria between 7^o 35’N and longitude 5^o 12’E . A stretch of grass covers the banks of the river and among these are sparsely distributed trees incuding *Parkia biglossa*, *Elaeis guineesis*, Raffia Palm, *Desmodium Sp, Andropogon Sp.* etc. Notable herbs along the banks are elephant grass (*Pennisetum purpureum*) giant star grass (*Cynodon plectostachyum*), rhodes grass (*Chloris guyanana*), siam weed (*Eupatorium odorantum*).

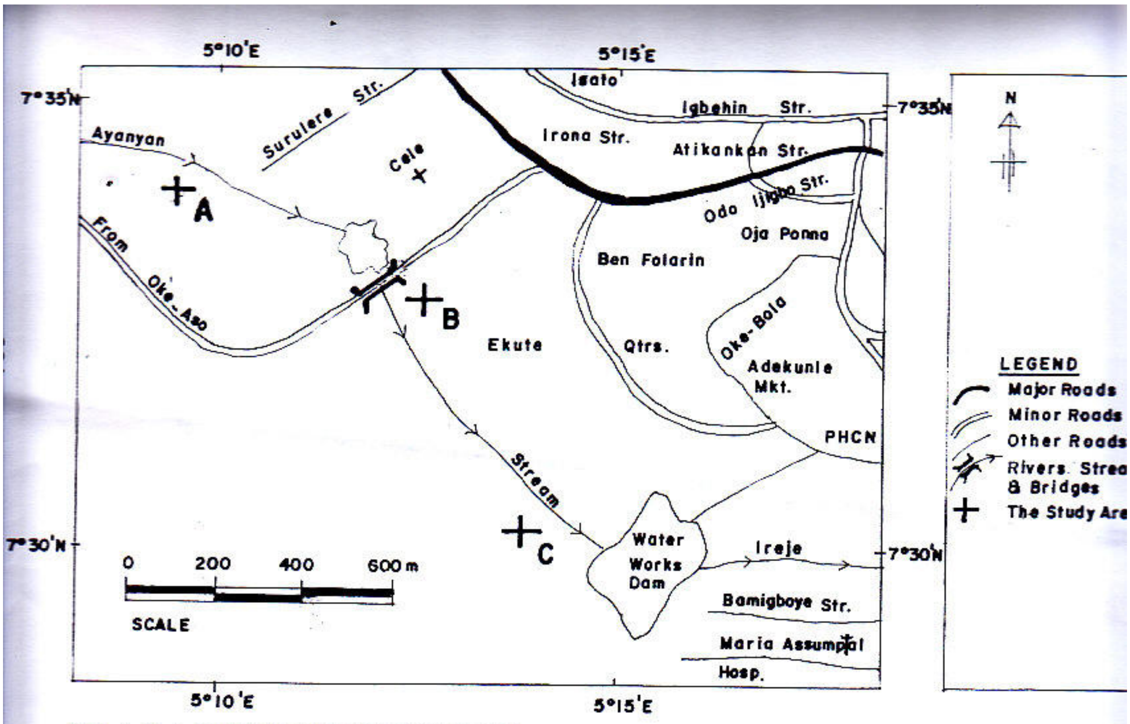

FIG. 1·2 : THE STUDY AREA WITHIN ADO-EKITI: AYANYAN STREAM.

Source: Ministry of Lands Urban & Regional Planning, State Secretariat, Ado-Ekiti, Ekiti State, Nigeria.

1.1.1. Sampling for Determination of Physicochemical Parameters of Water and POME.

Three sampling stations (coded A, B and C) were selected along the length of the river. Bimonthly sampling was carried out from August, 2009 to March, 2010. On each occasion, water and POME samples were collected between 6:00 am and 8:00 am. The laboratory procedures were carried out using the water and effluents analysis method of Ademoroti (1996) at the Institute for Agricultural Research and Training (IART), Ibadan, Nigeria. The parameters determined were temperature, hydrogen ion concentration (pH) alkalinity, TSS, dissolved oxygen (DO_2), BOD, COD, nutrients including nitrate and phosphate, and metals including potassium, magnesium, and lead. The oil and grease content of both water and POME samples were also determined.

1.2. RESULTS

The means of physicochemical parameters of water and POME samples of Ayanyan River are presented in Tables 1 and 2. A neutral pH was recorded during the rainy season months of August – October and the lowest (6.0) was recorded during the dry season months. The water samples were generally slightly acidic with a mean value of 6.6 ± 0.46 while the POME samples were acidic with a mean value of 3.85 ± 0.21.The pH values for both the water samples and POME were within the WHO recommended limits for drinking water. The

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temperature of water samples ranged between 26.0^0C – 30.0^0C with a mean of 28.8^0C ± 0.65 during the period of study, while that of the POME samples ranged from 21.0^0C to 35.0^0C with a mean value of 35.1 ± 0.57. Temperature of the water samples were within the WHO standard while that of POME samples was found to exceed the WHO recommended limits of 30-32. Alkalinity values of the water samples ranged from 140.0 – 160.0 mg$CaCO_3$/L with a mean of 152 ± 6.84mg$CaCO_3$/L. The highest value of 160.0 mg$CaCO_3$/L was recorded during the rainy season month of September. For the POME samples, alkalinity ranged from 128.0-275.0mg/$CaCO_3$/L, having a mean value of 175.0 ± 8.40 mg$CaCO_3$/L. Total suspended solids of the water samples had a mean of 16.06 ± 1.61mg/L and ranged between 11.0 – 19.0mg/L.

Table 1: Means of Physicochemical Parameters of water samples of Ayanyan River

Physicochemical Parameters	Mean±Std	Range	WHO Standard	NESREA 2011
pH	6.6 ±0.46	6.00 – 8.8	6.5 – 8.5	6.5-8.5
Temp (^0C)	28.8 ± 0.65	26.0 – 30.0	30 – 32	-
Alkalinity (mg$CaCO_3$)/L	152.08 ± 6.84	140.0 - 160.0	-	-
TSS (mg/L)	16.06 ± 1.61	11.00 – 19.00	5	0.25
DO_2 (mgO_2/L)	10.64 ± 0.74	8.00 – 12.45	4	6
BOD (mg/L)	18.50 ± 2.43	14.50 – 25.05	3.00	-
COD (mg/L)	40.40± 1.77	35.00 – 45.00	-	≤10
NO_3 (mg/L)	60.30 ± 2.36	49.00 – 71.50	10.00	9.10
PO_4 (mg/L)	45.60 ± 1.58	28.50 – 54.80	3.50	5.00
K (mg/L)	82.50 ± 10.08	43.80– 123.20	-	-
Mg (mg/L)	78.00 ± 7.96	42.60– 125.70	0.50	0.50
Pb (mg/L)	0.35 ± 0.21	0.02 -2.29	0.50	-
OLG (mg/L)	0.56 ± 0.07	0.01 -1.18	-	-

Table 2: Means of Physicochemical Parameters of POME samples of Ayanyan River Compared with WHO and NESREA Standards

Physicochemical Parameters	Mean±Std	Range	WHO Standard	NESREA 2011
pH	3.85 ±0.21	3.5 – 4.5	6.5 – 8.5	6.5-8.5
Temp (^0C)	35.1 ± 0.57	21.0 – 35.0	30 – 32	-
Alkalinity (mg$CaCO_3$)/L	175.0 ± 8.40	128.0 - 275.0	-	-
TSS (mg/L)	35.00 ± 4.10	29.00 – 42.00	5	0.25
DO_2 (mgO_2/L)	14.50 ± 0.07	3.00 – 15.25	4.00	6.00
BOD (mg/L)	30.83 ± 1.63	25.00 – 35.52	3.00	-
COD (mg/L)	41.80± 0.87	33.70 – 55.00	-	≤10
NO_3 (mg/L)	95.50 ± 5.36	56.00– 126.50	10.00	9.10
PO_4 (mg/L)	69.00 ± 4.51	53.00 – 84.80	3.50	5.00
K (mg/L)	98.50 ± 10.12	35.80– 125.20	-	-
Mg (mg/L)	58.00 ± 2.83	32.60 – 98.00	0.50	0.50
Pb (mg/L)	0.27 ± 0.10	0.00 - 0.56	0.05	-
OLG (mg/L)	2.84 ± 0.26	1.10 – 4.35	-	-

The highest value was recorded during the rainy season between August – October. TSS values for the POME samples ranged from 29.0 – 42.0mg/L, with a mean value of 35.00 ± 4.10mg/L. Both the water samples and POME had mean values greater than the WHO recommended limits of ≤ 5mg/L. Dissolved oxygen content of the water samples had a mean value of 10.64 ± 0.74 mgO_2/L and ranged from 8.00 – 12.45 mgO_2/L, while that of the POME samples ranged from 3.00 – 15.25 mgO_2/L and had a mean value of 14.5± 0.07 mgO_2/L. Both samples were observed to have mean values higher than the WHO recommended standards for drinking water. The biochemical oxygen demand of water samples had a mean value of 30.83 ± 1.63mg/L and ranged between 25.00 – 35.52mg/L during the period of study. Mean values of BOD for the POME samples were lesser than observed for water samples (18.50 ± 2.43mg/L). However, both recorded values greater than the WHO recommended standard. The chemical oxygen demand of POME samples were also observed to be higher than that of water samples, having a mean value of 41.80± 0.87mg/L with a range of 33.70mg/L to 55.00mg/L. While for the water samples, COD had a mean value of 40.40± 1.77mg/L and ranged between 35.00 – 45.00mg/L.

For the nutrients, both the nitrate and phosphate contents of the POME samples had values greater than that observed in the water samples. Nitrate ranged from 49.00 – 71.50mg/L with a mean value of 60.30 ± 2.36mg/L in the water samples, while in the POME samples, it ranged from 56.00 mg/L to 126.50mg/L with a mean of 95.50 ± 5.36mg/L. Both the water and POME samples had mean values that were above the recommended standard of ≥ 10mg/L. Phosphate in the water samples ranged between 28.50mg/L and 54.80mg/L with a mean of 45.60 ± 1.58 mg/L. While for the POME sample, phosphate had a mean value of 69.00 ± 4.51mg/L and ranged from 53.00mg/L – 84.80mg/L. Only the POME samples recorded a higher value (84.80mg/L) than the WHO standard of ≤ 75mg/L during the beginning of the dry in November.

Potassium had a higher mean value in the POME samples (98.5 ± 10.12mg/L) than what was observed for the water samples (82.50 ± 10.08mg/L). Magnesium and lead were however higher in the water samples than in POME samples (See Tables 1& 2). Oil & grease recorded a higher value in the POME sample (2.84) and a much lower value (0.56) in the water samples.

1.3. DISCUSSION

Physicochemical parameters such as those evaluated in this study have been known to have effect on water quality and the general well-being of the aquatic ecosystems (Maybeck, *et al*., 1989; Aderinola, *et al.,* 2009; Adewuyi and Opasina, 2010; Adeyemi, 2011 and Adeogun *et al.,* 2012). The pH of water samples was alkaline throughout the period of sampling. This indicates that the water can support adequate fish production as recommended by Boyd (1979) and as well be a source of good drinking water after treatment. However, the pH of the POME samples was generally more acidic. This observation was in agreement with that of other previous researchers such as Ideriah *et al.* (2007); Awotoye *et al.* (2011); Ibrahim *et al.* (2012); and Akinsorotan, (2013) to mention a few. This implies that the acidity of the POME if not treated before being discharged will affect that of the water and if discharge continues unabated, the productivity of such receiving river may be reduced. pH has profound effect on water quality by affecting solubility, alkalinity and hardness of the water. Aquatic organisms are also affected by pH because most of their metabolic activities are pH dependent (Chen and Lin, 1995; Aiyesanmi and Ipinmoroti, 1997 and Wang *et al.,* 2002).

Dissolved oxygen was lower in the water samples than in POME. This may be as a result of high level of nutrients and total solid content of the POME. DO gives an indication of the degree of freshness of a river and it's very important for the survival of aquatic organisms. The DO content of the water sample which ranges between 8.5 -12.5mg/L could sustain aquatic lives. The BOD content of both the water and POME samples were high indicating that they contain high amount of polluting organic matter. The COD was equally high in both the water and POME samples. High COD indicates recalcitrance of chemicals that have escaped biodegradation. These chemicals may be persistence in nature and may cause severe environmental problems like bioaccumulation (Kanu and Ochi, 2011). The high COD recorded in this study may also be attributed to the observed high total suspended solids. The high levels of BOD and COD recorded for the POME samples had been observed to result in rapid consumption of DO in the water leading to a phenomenon known as oxygen sag (Akinsorotan, 2013).

The level of nutrients, nitrate and phosphate in both the water and POME samples were fairly high. Nitrates in both samples exceeded the 10mg/L value for good drinking water as specified by NESREA and WHO. Phosphate also had values far above the NESREA and WHO standards of 3.50-5.00mg/L in both water and POME samples. The metals assayed in this study equally recorded higher values above the recommended standards for good drinking water. This indicates high pollution arising from the palm oil milling operations and may have been further enhanced from other sources including land-use around the river, local runoffs from nearby surface soils, interactions between the water and sediments from dead plants and animal remains at the bottom of rivers (Adeyemo, *et al.* 2008), laundry activities of surrounding residents and runoff of house hold effluents into the river (Fakayode, 2008).

1.4. CONCLUSION AND RECOMMENDATIONS

The physicochemical parameters of water and POME samples of Ayanyan River, Ado-Ekiti, Nigeria, was assessed to determine the impact of the palm oil mill effluent originating from a local oil mill plant located close to the river. The results showed that all the samples had values above the recommended standards of NESREA and WHO, thus making the river water unsafe to both human and aquatic life. There is the need for continuous regulation and quality control monitoring to prevent and control pollution in order to safeguard human health and to facilitate Nigerian attainment of millinieum development goal (MDG) and sanitation. Also, utilization of the entire waste biomass including the empty fruit bunch (EFB) and POME for power generation and other uses should be encouraged, as done in Malaysia and other developed countries. Use of the waste biomass as feedstock in the production of renewable energy, cellulosic ethanol, biogas, bio-hydrogen and bio-plastic could also increase the feasibility of the industry. These will also most importantly reduce the carbon dioxide emissions into the environment. Climate change studies, especially in relation to water quality and ecology, are at fairly early stage in Nigeria. It is therefore pertinent to develop and fully implement strategies aimed at understanding the processes and mechanisms controlling water quality and ecology of Nigerian rivers, and also understand how these may combine and interact to sustain our potable water supplies and conserve the river systems.

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