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Analytical Studies on Pollution Index of River Woji in Port Harcourt, Nigeria

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Abstract: Evaluation of the physico-chemical parameters of the Woji river was conducted to investigate the extent of pollution on the river. Ten water samples were collected from the surface and subsurface layer of the river starting from the point where municipal waste is disposed directly into the river. Replicate samples were also collected at 20 m interval along the course of the river. Results of analyzed samples reveal mean values of temperature 20.0°C±03, pH 6.1-6.4±0.2, conductivity 390.1-410.8±7.3 (µS cm^{-1}), Total Suspended Solids (TSS) 21.0-23.0±0.7 mg L^{-1}, Total Dissolved Solid (TDS) 1200.0-1300.0±36.4 mg L^{-1}, Dissolved Oxygen (DO) 2.4±0.3 mg L^{-1}, Biochemical Oxygen Demand (BOD) 3.0-3.0±0.1 mg L^{-1}, Chemical Oxygen Demand (COD) 131.4-132.7±0.9 mg L^{-1}, Total acidity 3.8-4.7±0.4 mg L^{-1} and total hardness 80.1-83.0±1.5 mg L^{-1}. The values of the physcio-chemical parameters of the Woji river when compared to a reference sample are higher which could be an indication of pollution.

Key words: Biochemical oxygen demand, WHO, pollution index, Woji and municipal wastes, chemical, transporation

INTRODUCTION

Municipal wastes are wastes that are generated from town or city, abattoir, market places, homes etc. The deliberate or indeliberate disposal of these wastes into any water body may cause unprecedented effects on both the faunas and the floras. Municipal wastes just like industrial wastes are toxic substances including metals (Hg, Pb, V and Cd) which pollute water bodies. Water which is one of the basic necessities of life, finds use in all sectors which includes industries, agriculture, transportation, energy, recreation etc. Rivers are very important because it is the environment for fish, plants and animals while the banks and nearby land support creatures such as otters, kingfisher and dragonflies and variety of water-living plants (Egereonu and Dike, 2007). Rivers constitute the main inland water resources for domestic industrial and irrigation purposes and often carry large municipal sewage industrial wastewater discharges and seasonal run-off from agricultural land and coastal region (Pradhan *et al*., 2009).

Disposal of waste material into water bodies and rivers is a common occurrence in West Africa because it is inexpensive for companies and municipality but this eventually destroys the aquatic ecosystem. Pollution of aquatic environment has been defined as the direct or indirect introduction of substances or energy into the environment man which can result to deleterious effects as harm to the living resources, hazards to human health, hindrance of marine activities including fishing and impairment of quality for use of sea water (Tobonimi *et al*., 2010). It is also the introduction of substances in greater concentration than the natural concentration as a result of human activities that has a net detrimental effect on the environment. Municipal waste, city sewage and industrial discharge into water bodies are the major sources of water pollution.

Chemical analyses of the water quality indices of some Nigeria rivers reveals that water which was once an abundant natural resources is rapidly deteriorating in quality, owing to population increase and industrialization a (Akaninwor *et al*., 2007). Industrial activities, urbanization, exploration activities, refining activities in developing countries like Nigeria are some major ways through which rivers, water bodies, creeks swamps have been contaminated. These contaminated rivers had in one way or the other constituted public health hazards and socioeconomic hazards to the flora and fauna.

Woji river receives significant amount of wastes from household garbage's industrial and vehicle discharges. The main aim of this study is to assess the water quality and to delineate the pollution level of the Woji river which has been turned a dumping site for municipal waste.

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MATERIALS AND METHODS

Description of the study site: The study area, Woji river lie on longitude 6°55'7°05'E and latitude 4°57'4°48'N, (Fig. 1). It is one of the most significant rivers in Port Harcourt metropolis of Rivers State, Nigeria. The major urban settlements along the bank of the river are Rumuomasi, Rumuogba and Elelenwo. The river feels the impact of industrial activities at the coastal areas of the Port Harcourt city especially the manufacturing industries at Trans-Amadi industrial area of Port Harcourt. It also serves as a receptor for the untreated (or partially treated) industrial and municipal wastes. It receives its municipal waste primarily from the slaughter market and neighboring communities.

Sample collection and analysis: Surface water samples were collected at a depth of 4-6 cm with 1 L plastic containers that were pre-rinsed with trioxonitrate (v) acid. Nine replicate samples were also collected at different stations of 20 m interval along the course of the river from surface and bottom layers. An uncontaminated sample which served as reference sample was also collected at point where there is no waste disposal. The sample were then placed in a box containing ice packs, taken to the laboratory and kept at a temperature of about 4°C before analyses.

The samples were analyzed quantitatively in the laboratory for the following physico-chemical parameters, pH, temperature, electrical conductivity, total hardness, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and total acidity according to standard methods (Franson, 1995). Temperature, pH, Electrical Conductivity (EC) were determined using HORIBA U-10 water quality

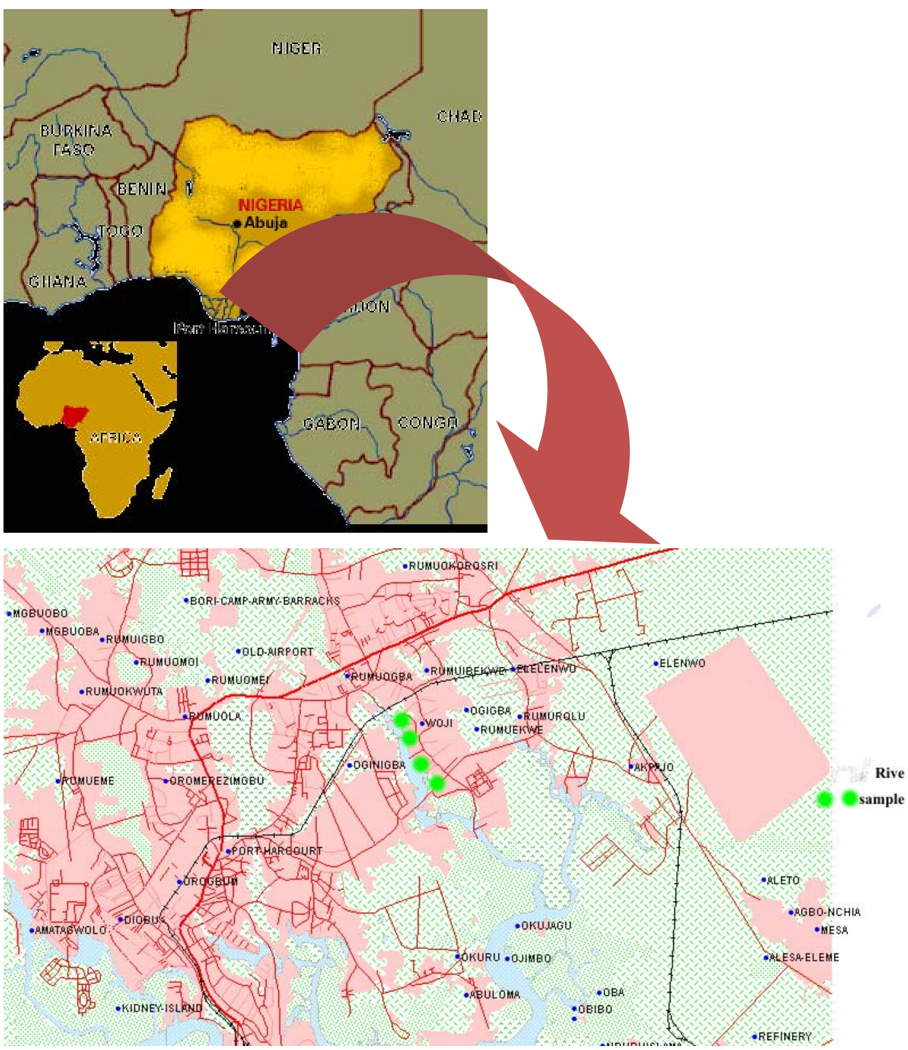

Fig. 1: Geographical representation of study area showing sample points

checker, a state of the art instrument for simultaneous multi parameter water quality analyzer. Horiba: U-10, Japan following the manufacture's recommendation. The data quality was ensured through careful standardization.

The Pollution Index (PI): The pollution index of a river was computed using the multiple item of water quality as proposed by Horton (1965). Multiple item of water quality can be expressed as: Xi's and permissible levels of the respective item for the use expressed as Yij's. Then, pollution index Pij may be expressed as a function of the relative values of:

$$\frac{Xi}{Yij}$$

Where:

Xi = Value determined at analysis

Yi = WHO specification for each parameter.

$$Pij = f(X1 / Y1j), \frac{X2}{Y2j}, \frac{X3}{Y3j}, ...Xi / Yij)$$

where, i = number of the ith term of water quality. The overall pollution index can be computed using the equation:

$$Pij = \sqrt{\frac{\left(\max\left(\frac{Xi}{Yij}\right)\right)^2 + \left(\mathrm{mean}\left(\frac{Xi}{Yij}\right)\right)^2}{2}}$$

Xi/Yij shows the relative pollution contribution by single item. A value >1.0 is critical value and it indicates that the water requires treatment before it can be used for specific purpose.

Only parameters with WHO permissible limits are used in the computation. A total of 20 water samples from selected stations along the course of the river (Fig. 1) were drawn from the surface and subsurface.

RESULTS AND DISCUSSION

Results of chemical analyses reported as mean values of the surface and subsurface samples with SE calculated at 95% confidence limit are shown on Table 1 and 2. The pH values ranged from 6.10-6.50 for surface and 6.00-6.50 for subsurface with mean value of 6.36±0.70 and 6.24±0.70. The pH values are within the WHO recommend limit of 8.00 mg L^{-1} for drinking water but are a little higher than the pH of reference sample of 6.00. There is a range of pH which some organism can live. Aquatic biota are sensitive to extreme pH. This is because they find it extremely difficult to live in a salinity which they are not adapted to (Manaham, 2005). Continual increase in pH kills organism or plant adapted to it and this suggests that the increasing pH of water is associated with increasing nitrogenous species in water (Pradhan *et al*., 2009).

Table 1: Physico-chemical properties of surface samples of Woji river

Samp.	Temp.	pH	EC	TDS	TSS	DO	BOD	COD	Acidity	T/Hard
1	20.00	6.50	410.60	1200.00	21.00	2.40	3.00	131.40	4.00	80.10
2	20.00	6.40	390.10	1230.00	23.00	2.40	3.50	131.40	3.70	83.00
3	19.50	6.40	400.20	1300.00	22.00	2.40	3.50	132.70	3.80	83.00
4	20.00	6.20	400.10	1250.00	22.00	2.30	3.70	132.00	4.70	80.00
5	20.50	6.40	400.80	1240.00	21.50	2.35	3.50	132.00	4.00	80.20
6	20.00	6.30	400.20	1230.00	22.00	2.40	3.60	133.00	3.80	80.30
7	20.00	6.10	400.80	1230.00	23.00	2.40	3.50	130.00	4.00	80.20
8	20.00	6.50	400.30	1200.00	23.00	2.30	3.40	131.00	4.20	80.20
9	20.50	6.40	400.40	1200.00	21.00	2.35	3.00	132.00	4.30	80.10
10	20.00	6.40	400.40	1230.00	22.00	2.30	3.40	132.00	4.20	80.20
Mean	20.05	6.36	400.39	1231.00	22.00	2.36	3.41	131.14	4.07	80.73
REFR	20.00	6.00	240.00	850.00	12.00	2.20	2.80	32.40	3.80	70.10

Mean±SE at the rate of 95 confidence level. REFR = Values of Reference samples. Temp (°C), EC (µS cm^{-1}), every other parameter is in (mg L^{-1}). All computations were done using Microsoft excel software

Table 2: Physico-chemical properties of sub-surface samples of Woji river

Samp no.	Temp.	pH	EC	TDS	TSS	DO	BOD	COD	Acidity	T/Hard
1	20.00	6.50	410.50	1200.0	20.00	2.30	3.00	131.20	4.00	80.00
2	20.00	6.30	393.20	1220.0	22.00	2.40	3.40	131.20	3.60	82.00
3	19.50	6.30	400.00	1300.0	21.00	2.20	3.40	132.00	3.80	82.00
4	20.00	6.30	400.00	1290.0	21.00	2.30	3.50	132.00	4.60	80.00
5	20.50	6.20	400.40	1250.0	20.50	2.30	3.40	131.00	4.00	80.20
6	19.50	6.20	400.00	1220.0	22.00	2.30	3.40	132.00	3.70	80.20
7	19.50	6.00	400.50	1230.0	23.00	2.40	3.40	130.00	4.00	80.10
8	20.00	6.40	400.20	1200.0	23.00	2.20	3.40	130.00	4.10	80.10
9	20.00	6.20	400.00	1200.0	20.00	2.30	3.00	131.00	4.30	80.00
10	20.00	6.00	400.20	1220.0	20.00	2.20	3.20	131.00	4.10	80.10
Mean	19.90	6.24	400.50	1233.0	21.20	2.29	3.31	131.14	4.02	80.47

Mean±SE at the rate of 95 confidence level. REFR = Values of Reference samples. Temp (°C), EC (µS cm^{-1}), every other parameter is in (mg L^{-1}). All computations were done using Microsoft excel software

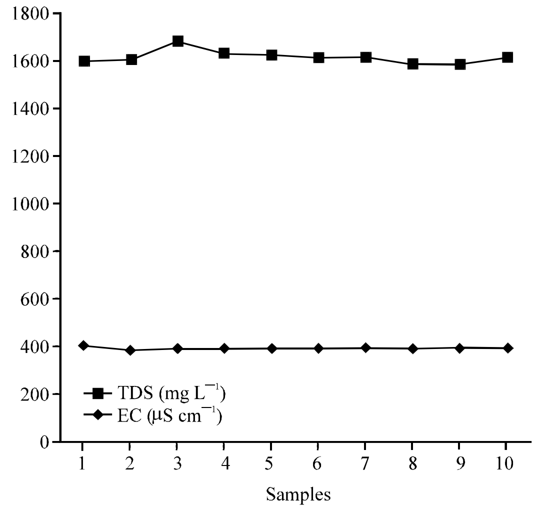

Fig. 2: Graph showing the relationship between EC and TDS

Electrical Conductivity (EC) and Total Dissolved Solids (TDS) values ranged from 390.10-410.80 μS cm^{-1}, 1200.00-1230.00 mg L^{-1} and 393.30-410.50 μS cm^{-1}, 1200.00-1290.00 mg L^{-1} for surface and subsurface samples, respectively. These values are far higher than the values obtained where there is no waste dump which has values of 240.00 μS cm^{-1} and 850.00 mg L^{-1}. The EC shows positive correlation with BOD (0.59) and TH (0.33), the correlation between TH and EC shows that the river contains some metals like magnesium and calcium which contribute to conductivity of water. The water body under investigation cannot be classified as fresh since, its values exceeds (0-100 mg L^{-1}) (Carroll, 1962). TDS is an important indicator of the usefulness of water for various applications (Tobonimi *et al.*, 2010). TDS level >1000 mg L^{-1} makes any water body unpalatable and cannot be used for certain purposes (WHO, 2004). This is the case of Woji river with TDS level >1000 mg L^{-1}. Egereonu and Dike (2007) found a linear relationship between the electrical conductivity and total dissolved solids (Fig. 2). Conductivity is related to both the total concentration of ionized substances in water and the temperature which it is measured. It can affect aquatic life if it is high. High TDS could cause excessive scaling of water pipes, heaters, boilers and household appliances (WHO, 2004).

Dissolve Oxygen (DO) and Biochemical Oxygen Demand (BOD) for surface and subsurface samples ranged from 2.30-2.40, 3.00-3.70 for surface and 2.20-2.40, 3.0-3.50 mg L^{-1} for subsurface, respectively. There was a slight variation of DO and BOD for research and reference samples (Table 3), though the mean value of BOD is less than WHO permissible limit of 4.00 mg L^{-1}, it exceed the value of the reference samples. There was a negative correlation between BOD and DO (-0.11). The DO values measured were also within the WHO permissible limit of 4.00 mg L^{-1}. Dissolved oxygen in water can be depleted as is it used in the oxidation of organic matter thereby reducing its magnitude in water. DO also may be consumed by the bioxidation of nitrogenous materials in water (Manaham, 2005). The reason for the drop in dissolve oxygen is not unconnected with pollution.

Table 3: Computation of the pollution index of Woji river

Parameters	Mean (Xi)	WHO permissible limit	Xi/Yij
Temp	20.05	28.00	0.72
pH	6.36	8.50	0.75
EC	400.39	1400.00	0.29
TDS	1231.00	1000.00	1.23
TSS	22.00	100.00	0.21
DO	2.36	10.00	0.24
BOD	3.41	4.00	0.85
Acidity	4.07	20.00	0.20
T/hard.	80.73	100.00	0.81

Mean (Xi/Yij) = 0.589, Pij = 0.964. All computations were done using Microsoft excel software

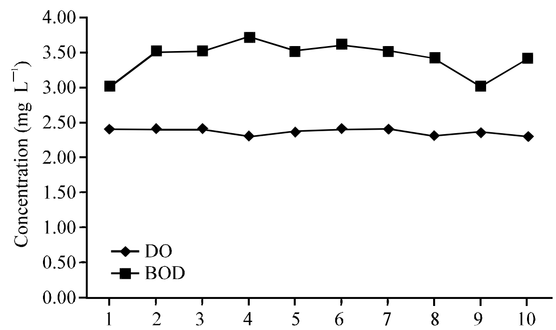

Fig. 3: Graph showing the relationship between DO and BOD for river samples

The value of Chemical Oxygen Demand (COD) ranged from 130.00-133.00 mg L^{-1} for surface and 130.00-132.00 mg L^{-1} for subsurface. There is a positive correlation between COD with BOD (0.15) and TH (0.19). Both the COD and BOD are design to measure the oxygen requirements by oxidation of organic matters in the water samples. The strength of sewage is mainly dependent on the level of BOD, TSS and COD in the sewage (Magi *et al.*, 2005). There is usually a positive correlation between BOD and COD and negative with DO (Fig. 3) and (Table 4).

The value of total acidity of the water samples ranged from 3.70-4.30 mg L^{-1} for surface and 93.60-4.30 mg L^{-1} for subsurface, respectively. The mean value of acidity is higher than that of the reference sample of 3.80 mg L^{-1}. Carbon (iv) oxide is the source of acidity in water body and is usually produced in water through biological oxidation of organic matter particularly in polluted waters (Sawyer *et al.*, 2003).

Table 4: Correlation matrix between physico-chemical properties of Woji river samples

	TEMP	pH	EC	TDS	TSS	DO	BOD	COD	Acidity	T/H
TEMP	1.00	-	-	-	-	-	-	-	-	-
pH	0.06	1.00	-	-	-	-	-	-	-	-
EC	-0.17	0.18	1.00	-	-	-	-	-	-	-
TDS	-0.59	-0.28	-0.24	1.00	-	-	-	-	-	-
TSS	-0.40	-0.32	-0.61	0.12	1.00	-	-	-	-	-
DO	-0.26	-0.11	0.01	-0.02	-0.02	1.00	-	-	-	-
BOD	-0.34	-0.55	0.59	0.59	0.59	-0.11	1.00	-	-	-
COD	-0.10	0.25	-0.49	-0.49	-0.49	0.00	0.15	1.00	-	-
Acidity	0.29	-0.21	-0.22	-0.22	-0.22	-0.80	-0.01	-0.08	1.00	-
T/H	-0.56	0.17	0.33	0.33	0.33	0.48	0.22	0.19	-0.62	1.00

The value of total hardness of water ranged from 80.00-82.00 mg L^{-1} for surface and subsurface with a mean of 80.73 mg L^{-1}. The mean is higher than the value of reference sample of 70.10 mg L^{-1} but slightly lower than the WHO limit of 100 mg L^{-1}. Surface water with hardness above 200 mg L^{-1} may cause scale deposition in treatment works, pipe distribution systems and tanks within buildings; it can also result in excessive soap consumption and subsequent scum formation (WHO, 2004).

CONCLUSION

The environment and natural resources is been impacted greatly by human activities. The level of degradation varies from one geographical location to another. It was observed that the value of Pij = 0.964 is very close the critical level. This shows that the pollution level of Woji river is on the rising and if left unchecked will affect the use of the fresh water for agriculture, source of drinking water, irrigation and transportation to mention but a few. This study shows that some of the physico- chemical properties of water under study were altered and need monitoring to avoid getting to an alarming level. It is therefore, recommended that the appropriate environmental agencies should stop the use of the water body and it’s environ as a dumping site for waste and other environmental hazards. It is also important to achieve comprehensive assessment of anthropogenic impact on water resource.

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REFERENCES

Akaninwor, J.O., E.O. Anosike and O. Egwim, 2007. Effect of Indomie industrial effleunt discharge on microbial properties of new Calabar River. Sci. Res. Essay, 2: 1-5.

Carroll, D., 1962. Rainwater as a chemical agent of geological processes: A review. U.S. Geological Survey Water-Supply Paper No. 1535-G, pp: 18.

Egereonu, U. and R. Dike, 2007. Evaluation of the pollution levels of Orashi Rivers and Oguta Lake waters. J. Chem. Soc. Niger., 32: 159-166.

Franson, M.A., 1995. Standard Methods for the Examination of Water and Wastewater. 14th Edn., APHA-AWA-WPCF, New York, USA., pp: 150-252.

Horton, R.K., 1965. An index number system for rating water quality. J. Water Pollut. Control Fed., 37: 300-305.

Magi, E., C. Righetti, M. Dicarro, M.S. Sanguinetti and M. Ferri, 2005. Study of the water quality close to urban sewers in Eastern Ligurian coast by means of bioluminescence test and conventional analyses. Chem. Ecol., 21: 47-60.

Manaham, S.E., 2005. Environmental Chemistry. 8th Edn., CRC Press, Boca Raton, FL., USA., ISBN: 9781566706339, pp: 179.

Pradhan, U.K., P.V. Shirodkar and B.K. Sahu, 2009. Physico chemical characteristics of the coastal water off Devi estuary, Orissa and evaluation of its seasonal changes using chemo-metric technology. Curr. Sci., 96: 1203-1209.

Sawyer, C.N., P.L. McCarty and G.F. Parkin, 2003. Chemistry for Environmental Engineering and Science. 5th Edn., McGraw Hill Book Co., New York, USA., ISBN: 9780072480665, pp: 45-50.

Tobonimi, J.K.I., A. Omubo and O.S. Herbert, 2010. Assessment of water quality along Amadi creek in Port Harcourt, Nigeria. Sci. Afr., 9: 153-165.

WHO, 2004. Guidelines for Drinking-Water Quality. Vol. 1, World Health Organization, Geneva, Switzerland, pp: 210-220.