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Estimation of Organic Pollution of Odo Oba River (Osun State, Nigeria)

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Abstract

A study was carried out between mid June–August, 2010 to estimate the level of organic pollution of Odo Oba River in Osun and Oyo States. The parameters used to monitor the degree of pollution were Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) and Permanganate Value (PV). 14 samples were collected along the water link, 200 m away from each other from the source to where the river discharges into Asejire River. The values of DO, BOD_5, COD and PV ranges between 1.01–5.38, 04.2–24.2, 103–337 and 12–96 mg/L, respectively. The mean and standard deviation values were also (3.18±1.86), (15.35±6.59), (179±85) and (57.7±32.4) mg/L, respectively. The value of COD recorded from the analysis is greater than that of BOD_5. This suggests that the river contains a high proportion of biologically non-degradable and inert matter as a constituent of gross organic pollution. From the results of the analysis, Odo Oba River is heavily polluted. The result of the analysis places Odo Oba River water quality in class V of the Classical Prati Water Quality Index Scale.

Key words: organic pollution, Odo Oba River, water quality

INTRODUCTION

Pollution is the contamination of the Earth's environment with materials that interfere with human health, the quality of life and the natural functioning of the ecosystem. Although, some environmental pollution is as a result of natural causes such as volcanic eruptions, the major cause is manmade. Two major categories of polluting materials are biodegradable and non biodegradable pollutants. Biodegradable pollutants such as sewage rapidly decompose by natural processes. These pollutants become a problem when added to the environment faster than they can decompose. Non-biodegradable pollutants are materials that do not decompose or decompose slowly in the natural environment. Once contamination occurs, it is difficult or impossible to remove these pollutants from the environment. Non-degradable compounds such as dichlorodiphenyl-trichloromethane (DDT), dioxins, polychlorinated biphenyls (PCBs) and radioactive materials can reach dangerous levels of accumulation as they are passed up the food chain into the bodies of progressively larger animals. For example, molecules of toxic compounds may collect on the surface of aquatic plants without doing much damage to the plants. A small fish that grazes on these plants accumulate a high concentration of the toxin. Larger fish or other carnivores that eat the small fish will accumulate even greater and possibly life-threatening concentrations of the compound. This is known as bio accumulation (Ajayi and Osibanjo, 1981).

Human contamination of the Earth's surface takes many forms and has existed since humans first began to use fire for agriculture, heating and cooking. The demand for fresh water rises continuously as the world's population grows. Withdrawals of fresh water from rivers, lakes, reservoirs and other sources increases fourfold.

Of the water consumed in the world, 39 % is used for irrigation, 39 %t electric power generation, 12 % for utilities, industry and mining and 7 % is used for agricultural purposes. Sewage, industrial wastes and agricultural chemicals such as fertilizers and pesticides are the main causes of water pollution (MacDonnel, 1996). Estimates suggest that nearly 1.5 billion people lack safe drinking water and that at least million deaths per year can be attributed to water borne diseases. With over 70 % of the planet covered by water, humans have long acted as if these bodies of water could serve as limitless dumping ground for wastes. Raw sewage, garbage and oil spills have begun to overwhelm the diluting capabilities of water bodies and most waters are polluted. Beaches around the world are closed regularly, often because of high amounts of bacteria from sewage disposal and marine wildlife is beginning to suffer. Perhaps, the biggest reason for developing a worldwide effort to monitor and restrict global pollution is the fact that most forms of pollution do not respect national boundaries. The first major international conference on environmental issues was sponsored by Stockholm in 1972 and was held in the United Nations. This meeting at which the United States took a leading role, was controversial because many developing countries were fearful that a focus on environmental protection was a means for the developed world to keep the under developed world in an economically subservient position. The most important outcome of the conference was the creation of the United Nations Environmental Program (UNEP). UNEP was designed to be the environmental conscience of the United Nations and an attempt to allay fears of the developing world. It became the first United Nations Agency to be headquartered in a developing country with offices in Nairobi (Kenya). In addition to attempting to achieve scientific consensus about major environmental issues, a major focus for UNEP has been the study of ways to encourage sustainable development and increasing standards of living without destroying the environment. When UNEP was created in 1972, only 11 countries had environmental agencies. Ten years later, the number grew to 106 of which 70 were in developing countries (Beecroft, 1982).

Oyo and Osun States have developed water pollution problems on reaches of many of their rivers due to outfalls of untreated or poorly treated sewage and industrial effluents. Water pollution problems have assumed immense proportions in Osun State particularly in Iwo, were most domestic and large proportions of waste are discharged into rivers which have depleted flows (Oluwande *et al.*, 1983).

This work is aimed at studying the effect of organic pollution of Odo Oba River in Osun and Oyo States at strategic sampling locations. There is presently a scarcity of comprehensive scientific data on quality of surface waters in Nigeria, particularly, those concerning river inputs into coastal and marine environment.

For the purpose of this study, parameters such as Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) and Permanganate Value (PV) will be used to access the level of gross organic pollution. This paper is intended to estimate the effect of organic pollutants on the amount of oxygen dissolved in the river which is a good indicator of water quality (Prati *et al.*, 1971).

Description of Study Area: Figures 1 is the map of Odo Oba River showing various sampling points. Odo Oba transverses two states namely, Oyo and Osun States in Nigeria which have fairly high population densities. The main occupation of inhabitants along the entire length of the river is farming and fishing. Oba River is located on longitudes 4°E and latitudes 7°E in the south western part of Nigeria. Sampling locations (Table 1) were chosen at points before the discharge of pollution characteristics, at the point of discharge and downstream to the mouth of the river where Oba River discharges into the Asejire River in Oyo State. Locations which received significant polluting characteristics such as Ife Odan, Ajawa and Asejire were sampled below the point of the last discharge of polluting wastes and in regions were recovery of such pollutional stresses could be anticipated (Walker, 1992).

MATERIALS AND METHODS

14 water samples were collected along the water link 200 m away from each other. Sampling was carried out in the wet season staring

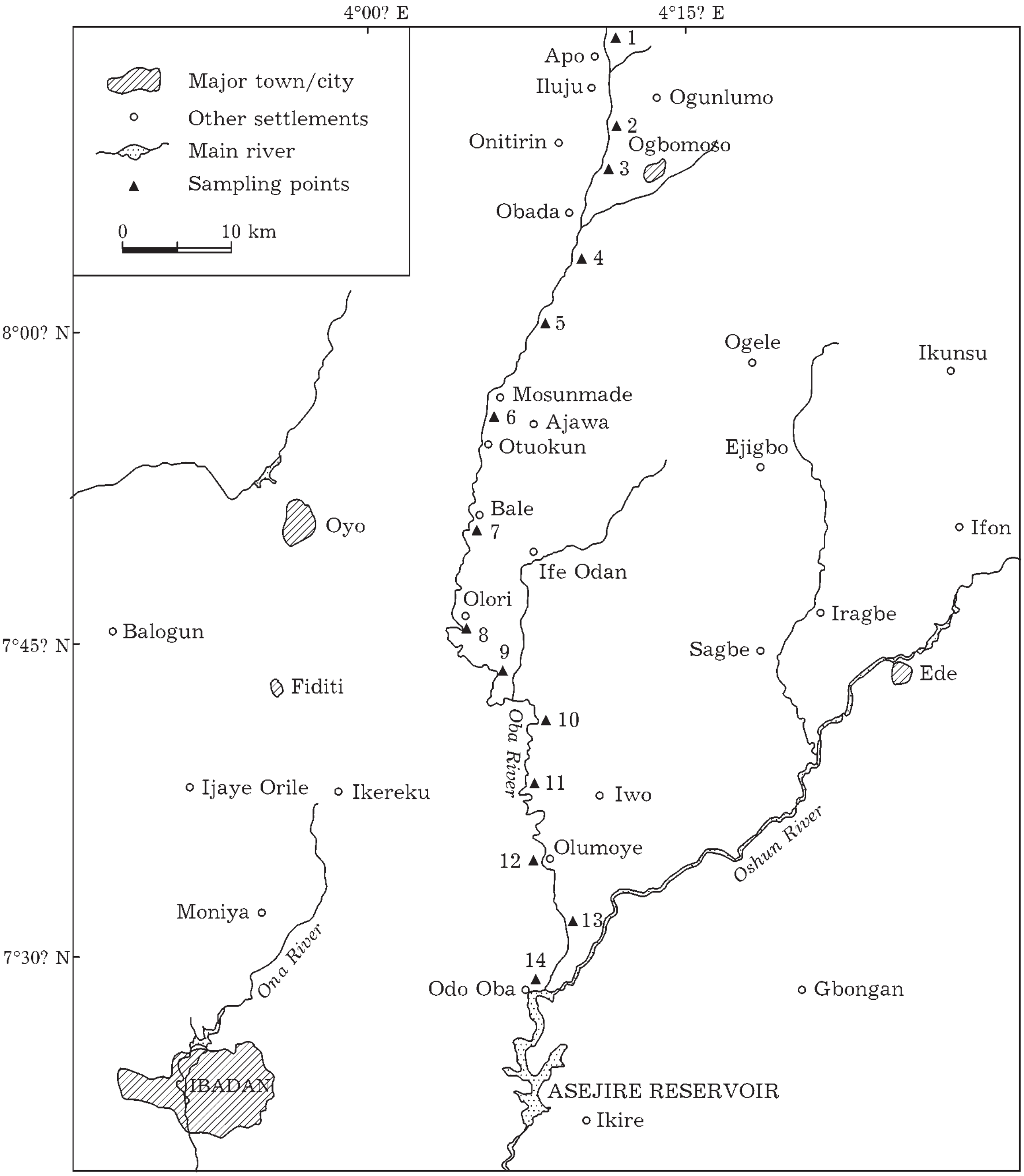

Fig. 1. Map of Odo Oba River showing sampling points.

from mid June–August, 2010 at locations upstream and downstream of major pollution sources and waste water inflow of the river.

Duplicate samples were collected at each sampling point in chemically cleaned close-fitting 250 mL glass stopper BOD bottles labelled A for DO and BOD_5 determinations. Samples labelled B were collected in plastic containers for COD and PV determinations. The samples collected from 14 points along the river link were labelled S1–S14, with water sample describing sample condition and area of polluting characteristics. All samples labelled A for DO and BOD_5 determinations were preserved to remove interferences caused by nitrates in biologically treated waste water and incubated

TABLE 1

List of sampling locations

Sample No.	Sampling location code	Description of area
1	S1	Apo
2	S2	Ogbomoso (Lautech Road)
3	S3	Ogbomoso (Township)
4	S4	Obada
5	S5	Obada
6	S6	Ajawa
7	S7	Bale
8	S8	Olori (Ife Odan Road)
9	S9	Olori
10	S10	Olori (Iwo road)
11	S11	Odori
12	S12	Olumoye
13	S13	Olumoye (Point of discharge of Odo Oba River into Asejire River)
14	S14	Asejire (Confluence of Odo Obaand Asejire River)

BOD_5 samples. The samples were preserved by fixing with 1 mL of manganous sulphate solution and 1 mL of alkaline iodide azide solution well below the surface of sample to displace 2 mL of sample. The sample bottles were corked immediately to prevent inclusion of air. All samples were preserved immediately in ice packed containers at 4 °C before analysis. Preservation was done to ensure that no significant change in composition occurred prior to analysis. The analysis carried out on the sample were DO, BOD_5, COD and PV. The analyses were carried out in accordance with standard methods for the determination of water and waste water. The results of the analyses were expressed in mg/L (APHA-AWWA-WPCF, 1995).

TABLE 2

Result showing organic pollution of Odo Oba River in Oyo and Osun States

Sample No.	Sample location code	T, °C	DO, mg O_2/L	PV, mg O_2/L	COD, mg O_2/L	BOD_5, mg O_2/L
1	S1	24	4.93	24	119	06.4
2	S2	25	5.02	12	103	04.2
3	S3	30	1.92	83	205	19.6
4	S4	25	5.38	37	118	20.3
5	S5	28	2.45	72	312	09.6
6	S6	22	3.89	16	106	09.3
7	S7	27	3.02	24	103	13.1
8	S8	27	2.86	48	125	12.4
9	S9	28	2.73	85	107	14.3
10	S10	30	1.17	92	302	22.3
11	S11	31	1.01	96	337	24.2
12	S12	27	2.86	84	154	21.0
13	S13	28	1.87	72	202	18.1
14	S14	32	2.06	63	208	20.2

RESULTS AND DISCUSSION

The results of organic pollution of Odo Oba River are presented in Table 2 and summarised in Table 4.

Odo Oba River in Osun and Oyo States were analysed for DO. The range mean and standard deviation values of DO in Odo Oba River were 1.01–5.38 mg O_2/L and (3.18±1.86) mg O_2/L, respectively, at an average temperature of 28 °C. From literature, in fresh water systems, dissolved oxygen is 14.6 mg O_2/L at 0 °C and approximately 9.1, 8.3 and 7 mg O_2/L at 20, 25 and 35 °C, respectively, at 1 atm (Walker, 1992). The value of dissolved oxygen in Odo Oba River is relatively low. The river cannot sustain aquatic life as few fishes were found in the river as a result of low dissolved oxygen. Although some locations recorded low temperatures and hence higher dissolved oxygen, fish kills were not experienced in such locations. These sampling points were S1, S2, S4 and S6. This can also be attributed to the fact that the solubility of gases in water increases at lower temperatures. Locations S4 and S5 were sampled in sparsely populated areas; hence these areas experienced lower inputs of pollutants from municipal and industrial waste and higher dissolved oxygen. Higher dissolved oxygen values were due to lower microbial activity by decomposers which use oxygen as they degrade biological waste. Areas which experienced input of organic waste from populated areas recorded lower values of dissolved oxygen. Such locations include locations S3 S8 S9 S10, S11, S12, S13, and S14. Locations S3 S8, S9, S10 and S11 had polluting characteristics ranging from sewage, domestic and market waste. Polluting input of S11, S12 and S13 were due to market waste from Odori Market. Locations S13 recorded polluting characteristics from tributary Oshun River. Location S14 recorded low values of dissolved oxygen due to high load of industrial effluents from Nigerian Breweries. These locations recorded low dissolved oxygen because in such locations along the river bank, local disturbing influences could not be avoided. From the results of dissolved oxygen in Table 2, it can also be deduced that dissolved oxygen minimum were due to night time respiration and elevated temperatures during the day.

The range, mean and standard deviation values of BOD_5 of Ogunpa River are 0.42–24.2 mg O_2/L and (15.35±6.59) mg O_2/L, respectively. From the results of Table 2, sampling locations S3, S8, S9, S10, S11, S12 S13 and S14 reflected high BOD_5 values. Polluting characteristics of these locations were from non point source pollution of market domestic and industrial waste. BOD_5 is an important parameter for the determination of water quality and organic loading of domestic and industrial waste water. It also provides an indirect means of evaluating the amount of organic matter that needs to be oxidized by microbial action. A natural water body is generally regarded as polluted if its BOD exceeds 5 mg O_2/L (Ian, 2001). Hence the unexceptionally high BOD_5 value recorded by these locations in the analysis of Odo Oba River illustrated that high amount of organic matter needs to be oxidized by microbial action. Odo Oba River can be regarded as polluted because the BOD_5 values recorded exceeds 5 mg O_2/L. Sampling locations S1, S2, S4, and S5 reflected lower BOD_5 values as compared with BOD_5 values of other locations. This indicated that the organic loading at these points were low due to turbulent flow of water along such area. These areas also reflected less domestic, municipal and industrial polluting characteristics.

The range, mean and standard deviation values of COD in Odo Oba River water are were summarised in Table 3 as 103–337 mg O_2/L and (179±85) mg O_2/L, respectively. From the results of Table 2, it can be deduced that the concentration of COD increased along the water way from the upper stream to the mouth of the river (Ajayi and Adelaye, 1977). The concentration values of COD recorded in Odo Oba River is higher than other parameters *i.e.* DO, BOD_5 and PV values. This implied that

TABLE 3

Summary of result of organic pollution of Odo Oba River showing DO, BOD_5, COD and PV values, mg O_2/L

Pollution parameters	Mean + S. D.	Range
DO	3.18±1.86	1.01–5.38
BOD_5	15.35±6.59	4.2–24.2
COD	179±85	103–337
PV	57.7±32.4	12–96

TABLE 4

Water Quality Classification (Prati *et al.,* 1971)

Class	BOD, ppm
I	0−1.5
II	1.6−3.0
III	3.0−6.0
IV	6.0−12.0
V	<12.0

TABLE 5

Simplified Water Quality Classification (Prati *et al.*, 1971)

Class	BOD indices
I	0−1
II	1−2
III	2−4
IV	4−8
V	>8

polluting characteristics of Odo Oba River is much more due to biologically inert matter rather than biologically oxidizable matter. This also suggests that the water contains polluting characteristics which are not readily biodegradable (Cuningham and Cunningham, 2004). The high COD values were due to polluting input from domestic matter which contains biologically inert matter and market waste.

The range, mean and standard deviation values of PV in Odo Oba River water were 12−96 mg O_2/L and (57.7± 32.4) mg O_2/L, respectively as summarised in Table 3. From the results of Table 2, it can be deduced that the concentration of PV increased along the water way from the upper stream. Downstream the value was erratic due to point and non-point sources of pollution. High PV values estimate a high mg/L of O_2 consumed from a permanganate solution. This indicates that high amounts of oxygen were consumed from the river. These organisms that cause pollution degrade organic and inorganic matter in the river water. The strength of pollution of the river is high as reflected by the high PV values. Such locations recorded disturbing local influences which brought in polluting characteristics from sewage, domestic and market waste from point and non point sources along the river bank.

In general, the COD values are greater than the corresponding BOD_5 values. As summarised in Table 3, the range values of BOD_5 and COD were 4.2−24.2 and 103−337 mg O_2/L, respectively. The mean values were (15.35±6.59) and (179±85) mg O_2/L, respectively. BOD_5 and COD are directly comparable and are used side by side to allow for differentiation between biologically oxidizable matter and biologically inert matter. A higher value of COD suggests that the samples contain large amounts of organic substances that are inert and not readily biodegradable. This is because BOD will be zero for non-biodegradable compounds. The values of BOD_5 are greater than zero in all samples analysed. This means that the organic pollutants in Odo Oba River are biodegradable to some extent. For biodegradable compounds, the value for BOD_5 will tend to approach COD as the test period increases. The reason for relatively low BOD_5 values as compared to COD is due to the 5 days BOD_5 incubation period. However, ultimate BOD_5 will be less than COD since a proportion of the compound biodegraded is not oxidised but used for cell growth. In rare cases, when a highly biodegradable compound is poorly oxidised in the COD test (*e.g.* benzene), BOD_5 may be greater than COD. This does not apply in this study because all the COD values are greater than the BOD_5 values (Zhu *et al.*, 1989). Comparison of BOD_5 with COD assesses whether the compound is readily biodegradable. However, lower BOD_5 may merely mean that the test microbes need longer than the test period to begin breaking the compound down and therefore ultimate BOD_5 or other biodegradation test is generally more reliable (Winkler, 1885).

BOD values have been selected as the basis of reference because of its simplicity of application. Concentrations of polluting characteristics increase approximately from class I to class V in geometrical progression as seen below (Prati *et al.*, 1971).

Class I = Excellent
Class II = Acceptable
Class III = Slightly Polluted
Class IV = Polluted
Class V = Heavily Polluted

As a further simplification and to obtain dimensionless indices, the values of BOD (ppm) were divided by 1.5 ppm to obtain the transformed new

TABLE 6

Classification of location quality (Prati *et al.*, 1971)

Sample No.	Sample location code	BOD_5	Corresponding Prati scale
1	S1	6.4	IV
2	S2	4.2	IV
3	S3	19.6	V
4	S4	20.3	V
5	S5	9.6	V
6	S6	9.3	V
7	S7	13.1	V
8	S8	12.4	V
9	S9	14.3	V
10	S10	23.3	V
11	S11	24.2	V
12	S12	21.0	V
13	S13	18.1	V
14	S14	20.2	V

indices for BOD. Table 4 presents water quality classification according to Prati *et al.* and Table 5 presents the transformed new indices for BOD.

Using the Prati scale, the results recorded on the quality of sample locations can be represented as seen in Table 6. From the results of Table 6, more than half of the sample location quality falls in class V. Therefore it can be deduced that Odo Oba River is heavily polluted and placed in class V in the classical Prati *et al.* (1971) scale.

CONCLUSION

The results show that Odo Oba River is heavily polluted and contains little or no dissolved oxygen. The values of BOD_5, COD and PV show indices of gross organic pollution. Pollution control measures such as grading of the river and good awareness campaign should be initiated by the citizenry in general and the federal government of Nigeria as a whole.

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