PHYSICO-CHEMICAL CHARACTERISTICS OF WARRI RIVER IN THE NIGER DELTA REGION OF NIGERIA

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ABSTRACT

The discharge of excessive quantities of organic matter is undoubted by the oldest and even today the most widespread form of water pollution. Warri River is an example of Niger Delta River receiving effluent from sewage and several industries, factories and markets. These wastes result in loss of productivity of natural water as well as deterioration of water quality. Physico-chemical characteristics of the Warri River in Nigeria were examined in this study. The results show that physico-chemical parameters differ significantly in respect to locations. Thermal pollution as well as Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), pH and Total Dissolved Solid (TDS) exceeded stipulated permissible limit by EEC and WHO for drinking water and to protect the health of fish. In order to stall further deterioration of water quality in the river, it is mandatory to place the river under surveillance.
Keywords: *Physico-chemical condition, Warri River, water quality, fish health.*

INTRODUCTION

The Warri River in Delta State of Nigeria is an example of inland water receiving effluents and sewage from several industries, factories and markets. These wastes often contain significant spectrum of organic and inorganic substances capable of producing adverse effects on the physical, chemical and biotic components of the environment either directly or indirectly on human health (Aghoghovwia, 2008). The rapid increase in human population, inadequate infrastructural facilities, lack of good/proper facilities for waste disposal as well as problem of refuse collection and disposal, have contributed to the environmental decay (Odiete, 1990). Although Ezemonye, Ogeleka and Okieimen (2007) and Egborge (2001) have done some work in terms of making available data on the physico-chemical characteristics and fish production of the river, there is still need to keep modern trend (extrapolatory studies). Dissolve oxygen is important for the evaluation of surface water quality and waste treatment control (Okayi, 2003). Oxygen is an essential and limiting factor for maintaining life. It is an important factor limiting abundance, distribution composition and survival of aquatic organisms. The depletion of oxygen leads to increase in ammonia toxicity and susceptibility of aquatic organisms (especially fish) to infection (Ukoli and Jeje, 1992). Therefore, the aim of this study is to assess the physico-chemical characteristics of Warri River in the Niger Delta Region of Nigeria.

MATERIALS AND METHODS

The study was carried out at Warri River in Delta State, Nigeria. The Warri River flows through the adjourning mangrove swamp forest area of the southern part of Nigeria, where the drainage and catchment areas are probably very rich in decaying organic matter and humus. Warri River stretches within latitude $5^{o}21^{l}$ - $6^{o}00^{l}$N and longitude $5^{o}24^{l}$ - $6^{o}2^{l}$E. Its source is around Utagba Uno and runs in a Southwest direction passing between Oviorie and Ovu-inland and southwards at Odiete through Agbarho to Otokutu and Ugbolokposo (Egborge, 2001). It turns southward to Effurun and forms a 'W' between Effurun and Warri. Important land marks in this River stretch are Enerhen, Igbudu, Ovwian and Aladja (steel town), Warri Ports, main Warri market, NNPC Refinery, Globe star, etc (fig. 1). Nine locations were chosen for this study seven of them are points of effluent recipient, while two are the terminals up and down stream, which served as controls.

The physical factors such as temperature, water level and transparency were examined on site. Water samples for chemical analysis were collected in 250mls sampling bottles and transported in ice to the laboratory for subsequent analysis. Total dissolved solid (TDS) and conductivity were measured using Perkin Elmer UV/VIS spectrometer Landa EZ-20, while pH was measured by means of Philips PW 9409 potable digital pH meter. Dissolved oxygen (DO) was measured with a potable YS I Model 54 Oxygen meter. Other parameters such as salinity, nitrate nitrogen, ammonia, sulphate, BOD and COD and phosphorus were measured by APHA (1998) method. Data obtained were subjected to analysis of variance (ANOVA) and mean separations where there were significant differences, were separated by Duncan multiple range F - test using Statistical Analysis System (SAS, 1995) package.

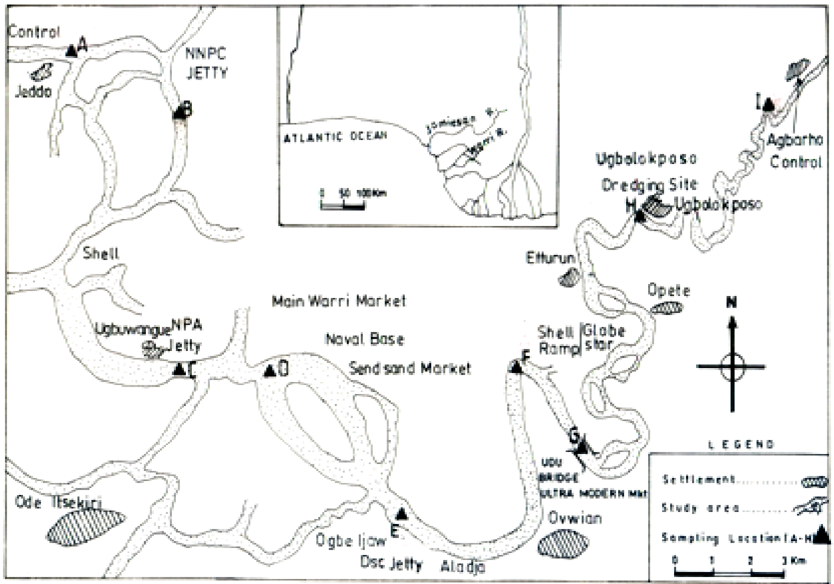

Fig 2 Map of Warri River showing the Sampling Locations
SOURCE:- ADAPTED FROM NIGERIA PORTS, WARRI 2005

RESULTS AND DISCUSSION

The result of the water quality parameters are presented on Table 1. All Physico-chemical parameters differed significantly in the Warri River water in respect to locations. On the other hand, there was no significant difference between seasons, with respect to all the Physico-chemical parameters, except for conductivity, water temperature and salinity. The maximum and least data generated for respective parameter were water depth 15.0m at DSC Jetty; and 7.8m at Jeddo, transparency 50.30 cm at Udu Bridge/Market and 12.65 cm at main Warri market, conductivity at main Warri Market and 3.96 Sm-1 at NNPC Jetty, temperature 28.50°C at DSC Jetty, and 26.15°C at Agbarho, TDS 901.42mgl^{-1} at main Warri market and 1.96mgl^{-1} at NNPC Jetty, DO 7.30mgl^{-1} at Shell Ramp/Globestar and 5.24 mgl^{-1} at NNPC Jetty, pH 6.65 at NPA Jetty and 6.15 at Ugbolokposo dredging site, NH_3 1.70mgl^{-1} at main Warri Market and 0.98mgl^{-1} at Udu Bridge/market, Chloride 0.83 mg^{-1} at Agbarho and 0.13 mgl^{-1} at NNPC Jetty.

Highest values of other parameters obtained were 4.05 CODl^{-1} at DSC Jetty, 13.97mgSO^{2-}_4l^{-1} at Ugbolokposo dredging site, 16.19mg NO^-_3l^{-1} at NPA Jetty, 18.79mg PO^2_4l^{-1} at NNPC Jetty and Salinity concentration 35.18ppm at Udu Bridge/market. The least corresponding values of COD, SO^{2-}_4, NO^-_3, PO^{2-}_4 and salinity were 2.22ppm at Jeddo, 2.67ppm at NNPC Jetty, 5.90ppm at Jeddo, 3.42mgl^{-1} and 0.25ppm both at Agbarho respectively. The discharge of effluents from the various industries (Delta steel, Nigeria ports, NNPC refinery, main Warri markets and drains) into the Warri River have greatly influenced its physical and chemical characteristics. Similar findings were made by Oluwande, Sridhar, Bammeke and Okubadejo (1983); Ogbeibu and Ezeunara (2002) on selected Rivers of Nigeria and Ikpoba River in Benin City respectively. Values of all physico-chemical parameters differed significantly between sampling locations.

The water temperatures were generally higher at all points of effluent discharge of the sampled locations. This might not be unconnected with the direct discharge of effluents, which usually have higher temperature than recipient water. Similar assertion was made by UNIDO (1981) and Abel (1996). Water temperature was relatively lower in the rainy season (24.5-28.6°C) compared to those of the dry season (25.8-29.5°C) with the peak observed in January at Aladja. This agrees with earlier findings reported by Egborge (2001) in the Warri River. Temperature also differed significantly between seasons. The minimum and maximum temperature of 24.5 - 29.5 C according to Okayi (2003) is normal for tropical waters for optimal growth of organisms. Transparency were low at downstream of the river at locations B (NNPC Jetty), C (NPA Jetty), D (main Warri Market) and E (DSC Jetty), probably because of colloids, suspended solids in effluents of industries besides influx of market wastes and drainage channels into the river.

The values recorded in this study were lower than those reported by Egborge (2001) respectively on the Warri River but higher than those documented by Ogbeibu and Ezeunara (2002) for Ikpoba River in Benin City. This is because of the several industries, sawmills and market along the shores of the Warri River which are more compared to Ikpoba River in Benin City which is bounded by the Nigerian brewery as the sole industry that discharges effluents and pollutant into the river.

The lower dissolved oxygen (DO) content and higher biochemical oxygen demand respectively at locations B (NNPC Jetty), D (main Warri Market) and E (DSC Jetty), was expected owing to high level of introduction of organic matter, undergoing decomposition thus resulting in oxygen uptake. The dissolved oxygen never fell below 4.1mgl^{-1} in all-sampling points. However, the occasional fluctuation may not be unrelated to organic matter decomposition, photosynthetic activities contributing to maintenance of high oxygen level of the river. “Replenishment of oxygen may be buttressed by wind action, which causes sequential changes in circulations and thus favourable condition for mixing”. The river water showed value of DO with mean range of 4.4 - 6.5 mgl^{-1} during the dry season and 5.7 - 8.5 mgl^{-1} during the rainy season. The lower value of DO in the dry season was also proposed by Okayi (2003) for River Benue in Makurdi.

The maximum biochemical oxygen demand (BOD) of 4.7mgl^{-1} value was recorded at location E (DSC Jetty) during the dry season period. Biological Oxygen Demand (BOD) values also differed significantly between the seasons. Similar findings were made by Yusuf (2004) for Owo River and Ologe Lagoon of Ondo State. The findings of this study showed that these values fall within the natural range and that the pollution stress on the river may be considered to arise from natural sources. The Warri river flows through the adjourning mangrove swamp forest area of the southern part of Nigeria, where the drainage and catchment areas are probably very rich in decaying organic matter and humus. Similar reports were made by Zoefteman (1973) and Okayi (2003) for Hayua River in Netherland and River Benue in Nigeria.

This study also revealed that hydrogen ion was generally lower than 7.0 at all sampled locations. The only exception was at location B (NNPC Jetty), where values obtained were between 7.0 - 7.2 during the dry season period. In similar studies, Tetsola (1988) and Egborge (2001) reported that the Warri River were generally alkaline (pH above 7.0). The Lower pH values recorded at most sampled locations, could be linked with the influx of humic substances into the Warri River which were made available by proliferation of markets, sawmills and massive rural to urban drift and other anthropogenic activities. Similar assertion was made by Lund (1965) and Egborge (2001). Gas flaring as well as release of carbon by vehicles, small and medium scale industries that rely on generating sets owing to inadequacies of power from the nations energy sector in and around Warri may have generated acid rains. This in conjuction with humic substances in the industrialized Warri environment could account for the acidic nature of the waters. Egborge (2001) reported that in Iraq, Kuwait, and Saudi Arabia, acid rains were observed in 1991 as a result of gas and industrial flares. The Warri River water samples collected at most of the locations were below WHO limits for safe drinking water especially during the rainy season of 2005-2007. Okayi (2003) reported similar values in the downstream of Ologe River. Higher conductivity values above 1000scm^{-1} were obtained at locations C (NPA Jetty) D (main Warri market) and E (DSC Jetty). This has implicated them as brackish (Lund 1965; and Egborge, 1994). The other locations had values as low as 46.7scm^{-1} and 46.80scm^{-1} especially at location I (Agbarho) and H (Ugblokposo) respectively. Location B (NNPC Jetty), E (DSC Jetty) and G (Shell Ramp/globestar) had conductivity values lower than 1000scm^{-1}. Chloride and ammonia data obtained in this study (0.13-0.83mgl^{-1} and 0.98 - 1.70mgl^{-1}) respectively, are lower than the WHO (1984) standard for safe drinking water and also lower than those reported by Ogbeibu and Ezeunara (2002) for Ikpoba River, Benin City.

Salinity values obtained during the dry season ranged between 0.05 and 35.30 ppm at locations I (Agbarho) and F (ShellRamp/Globestar) respectively. Those of the rainy season were 0-33 ppm also at locations I (Agbarho) and H (Ugbolokposo dredging site). The values recorded, shows that locations I and H were fresh water. Down stream values showed that the waters were mostly fresh except at locations B(NNPC Jetty) and F (ShellRamp/Globestar), where brackish condition were prevalent for two seasons. This may be linked to oil field bleed or activities ongoing at these sites, which "has the salinity of about 300% higher than the recipient seawater". Mean range concentration of PO_4, were 4.8 - 19.58mg/l and 2.00 - 18.00 mg/l during the dry and rainy season period respectively. Values obtained for NO_3 and SO_4 were all higher at location B. This conforms with earlier report of UNIDO (1981) in implicating the petrochemical industry and refinery as major supplier of nutrients.

CONCLUSION

This experiment was conducted to examine the physic-chemical properties of Warri River in Nigeria. It has been observed that the discharge of excessive quantities of organic matters is the most widespread form of water pollution in Nigeria. The fact that emerged from this study is that level of pollutants in effluents discharged by identified sources (NNPC Jetty, NPA Jetty, main Warri market, DSC Jetty, Shellramp/ Globestar, Udu bridge/market and Ugbolokposo dredging site) exceeded desired/ allowable limits for heavy metals and some physico-chemical parameters especially in fish tissues. The pollutants implicated to have exceeded stipulated permissible limit in effluent discharged into the river, includes Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) pH TDS and thermal pollution.

Table 1: Summary of some Physico-Chemical conditions of the Warri River

Effect	Water depth (m)	Transp. (cm)	Conduc. scm-1	Temp. oC	TDS mg/l	DO mg/l	pH	NH3 mg/l	Chloride mg/l	COD mg/l	SO4 mg/l	NO3 mg/l	PO4 mg/l	Salinity ppm
1. Location														
A	7.80a ±0.05	30.65b ±2.75	45.80a ±3.62	26.60abc ±0.43	30.24b ±4.81	7.27e ±0.23	6.60cd ±0.01	1.05ab ±0.05	0.16a ±0.00	2.22a ±0.02	3.35ab ±0.05	5.90a ±0.21	13.53e ±0.24	30.80b ±3.28
B	8.95bc ±0.03	14.65a ±0.43	3.96a ±0.04	27.70de ±1.10	1.96a ±0.00	5.24a ±0.37	6.60cd ±4.02	1.41c ±0.03	0.13a ±0.00	3.36cd ±0.29	2.67a ±0.16	8.05b ±0.31	18.79g* ±0.26	33.9b ±3.07
C	10.80e ±0.41	14.70a ±0.38	1719.60c ±80.00	27.55cde ±0.12	826.00f ±11.20	6.86de ±0.14	6.65d* ±0.01	1.21b ±0.00	0.15a ±0.00	3.13bc ±0.04	4.54c ±0.34	16.19e* ±0.61	16.56f ±0.32	30.56b ±2.15
D	9.80d ±0.26	12.65a ±0.18	1868.25c* ±418.00	27.35bcde ±0.26	901.42g* ±12.93	5.76abc ±0.05	6.45bcd ±0.01	1.70d* ±0.00	0.16a ±0.00	3.61de ±0.06	2.76a ±0.01	8.20b ±0.35	7.90c ±0.22	30.56b ±2.15
E	15.00f* ±0.10	13.65a ±0.58	615.25b ±4.80	28.15e* ±0.39	596.83e ±27.13	5.32ab ±0.07	6.35abc ±0.02	1.19b ±0.00	0.41a ±0.00	4.05f* ±0.08	3.70b ±0.03	9.43c ±0.24	10.44d ±0.31	31.56b ±2.08
F	9.55cd ±0.36	30.52b ±4.11	687.05b ±179.56	26.35ab ±0.25	332.50d ±169.98	7.30e* ±0.08	6.65d* ±0.01	1.56cd ±0.00	0.17a ±0.00	3.10bc ±0.06	0.44e ±0.04	11.59d ±0.40	8.35c ±0.25	31.16b ±2.10
G	7.80a ±0.08	50.30d* ±2.19	500.50ab ±9.35	26.80abcd ±0.19	248.83c ±9.45	6.38cd ±0.03	6.56bcd ±0.01	0.98a ±0.00	0.16a ±0.00	3.00b ±0.05	9.64d ±0.01	11.94d ±0.43	11.69d ±0.40	35.18c* ±2.50
H	14.50f ±0.34	44.50c ±8.23	46.80a ±1.84	26.5ab ±0.10	24.98b ±2.66	7.13e ±0.19	6.15a ±0.03	1.50c ±0.04	0.80b ±0.00	3.7bef ±0.02	13.97f* ±0.20	9.34c ±0.61	6.30b ±0.11	21.50a ±0.98
I	8.85b ±0.72	47.50cd ±7.22	46.75a ±1.63	26.15a ±0.25	24.56b ±3.03	5.92bc ±0.57	6.30ab ±0.05	1.50c ±0.01	0.83b* ±0.00	3.15bc ±0.08	13.80f ±0.10	8.90bc ±0.36	3.42a ±0.05	0.25a ±0.02
2. Season														
Dry	9.849	27.30a	556.17a	27.40b	334.04a	4.11a	6.48a	1.31a	0.36a	3.29a	7.97a	10.95a	11.99a	29.31b
Rainy	10.83a	30.28a	673.49b	26.63a	329.74a	4.92a	6.47a	1.38a	0.30a	3.30a	6.45a	8.94a	9.56a	25.42a

Note: Means in the same column with the same letters are not significantly different ($P > 0.05$). * Location with highest levels of a particular parameter

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