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Full Length Research Paper

Some physicochemical parameters of potable water supply in Warri, Niger Delta area of Nigeria

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Some physiochemical parameters of potable water supply in relation to surface water, shallow well and borehole water in Warri area of Niger Delta region of Nigeria were assessed to determine their pollution profiles. Parameters such pH, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), sulphate, phosphate, chloride and bicarbonate in the different water supply were determined. With few exceptions, the ranking of physicochemical parameters is in the order: surface water > shallow well water > borehole water. Some of the parameters were above WHO standard for drinking water, so there is need for strict monitoring to ensure quality water supply for human health.

Key words: Physicochemical parameters, potable water supply, pollution profile, Warri, Niger Delta.

INTRODUCTION

Warri, a major oil producing community in the Niger Delta Area of Nigeria believed by many to be one of the treasure beds of the country, is characterized by interwoven network of streams, rivulets, ponds, ditches, lakes, rivers, estuaries and a characteristic shallow water table which incidentally is the only source of domestic and industrial water supply (Figure 1). Oil exploration and drilling are the predominant activities in the area for more than forty years. These have impacted negatively on the arable land and aquatic ecosystem. An ecotoxicological study of the Niger-Delta area of the River Niger with sampling stations from Onitsha in Anambra State (Source), Ishiukwa in Ndokwa East, Delta State (middle point) and Adai in Ndoni, River State (tail point) showed high heavy metals and volatile solids (Orisakwe et al., 2001). Since streams and rivers are considered convenient means of clearing and carrying wastes as well as transporting various fractions of petroleum and crude oil and its fraction from the discharge point, most river in urban areas are highly loaded with urban and industrial wastes (Smith and Wohlaman, 1987; Garric et al., 1993). Streams, shallow wells and boreholes form the main sources of potable water supply in the different comm.-unities in the Niger Delta. Turbidity, total suspended solids, chemical oxygen demand, dissolved oxygen, sulphate, phosphate, chloride and bicarbonate in portable water supply in Warri and its environs are important physicochemical parameters of water with public health implications which have been investigated in the present work. This study is part of the research on the ecotoxicology of Warri aimed at documenting the distribution, migration and fate of micro pollutants in the potable water of the area. It is hoped that results of this study will serve as baseline against which future anthropogenic effects can be measured.

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MATERIALS AND METHODS

Sample collection

Water samples were collected from eight districts (Ekpan, Ubeji, Agbaro, NPA, Udu, Markava, Aladja and Otokutu) that make up Warri municipality. In each district, surface, shallow well and borehole water were collected and used for analysis. A total of twenty four water samples were taken (8 surface water, 8 shallow well water and 8 deep borehole water). Sampling sites were selec-ted based on their closeness to oil exploration activities, loading and offloading jetties, industrial manufacture such as Delta Steel Company (DSC) Aladja and closeness to market. pH was determined *in situ*. The water samples after collection with plastic containers (1L)

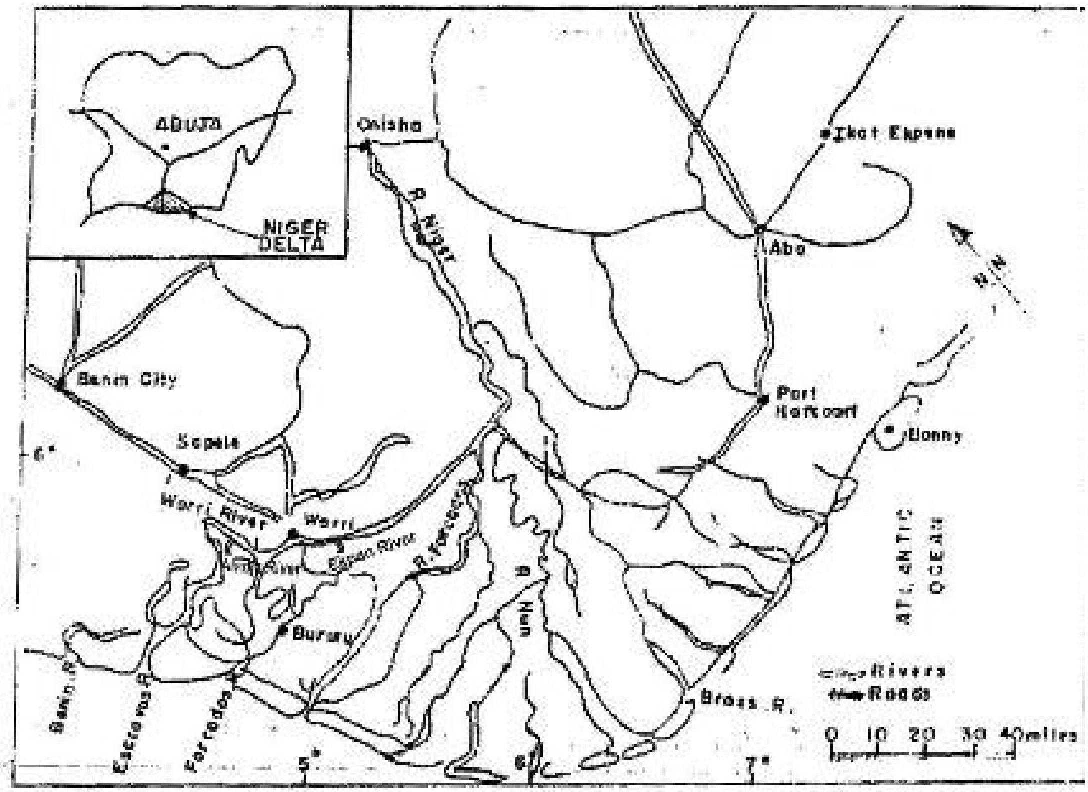

Figure 1. Geographical map of the Niger Delta Region showing the study area. Insert: Map of Nigeria showing the Niger Delta.

(1 L) was put into plastic buckets covered with ice blocks and laboratory analysis for other parameters commenced within 5 h of samples collection.

In each sample nine parameters; pH, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), sulphate, phosphate, chloride and bicarbonate were analysed.

Determination of chloride, turbidity, TSS and pH

The chloride content was determined by colorimetric method while turbidity was determined using turbidity meter (Vogel, 1975; National Water Supply Training Network, 1997). The TSS was determined by recording the increase in weight of a dried glass fiber filter paper with pore size of 5 µm after 100 ml of the sample was filtered by suction dried at 110^0C and weighted until a constant weight was obtained (Bertram and Balance, 1996).

$$TSS = [(A - B)/C] \times 10^6 \text{ mg/l}$$

Where A = weight of filter + solids (g); B = weight of filter (g); C = volume of sample filtered (ml). pH was measured using a pH meter.

Determination of COD and DO

DO was determined electrochemically (Bertram and balance, 1996) while COD was determined by the dichromate method (Theroux, 1943).

Determination of phosphate, sulphate and bicarbonate phosphate was determined as PO^3_4. It was determined by mixing 25 cm^3 of each sample with 4 ml of molybdate reagent (0.5% ammonium molybdate in distilled water) acidified with H_2SO_4 and 10 drops of stannous chloride in glycerol and left for 10 min. The phosphate concentration was read on the UNICAN spectrophotometer at 690 nm wavelength after an intense blue colour had developed Ademoroti (1996). Determination of sulphate was done by titrimetric methods using EDTA. Bicarbonate was determined by electrometric titration (Bertram and Balance, 1996).

RESULTS AND DISCUSSION

The pH, turbidity, TSS, COD and DO in potable water sources in Warri, Niger Delta is shown in Table 1. All the physicochemical parameters were highest in Nigeria Ports Authority NPA River, whereas the borehole samples from the eight sampling sites had lowest values of the studied parameters. Ubeji and NPA boreholes had lowest pH values of 5 whereas the highest pH of 8.50 was seen in UDU River. Table 2 shows the sulphate, phosphate, chloride and bicarbonate in the water samples from the eight sampling sites. Ubeji river and Ekpan shallow well had the highest and lowest levels of sulphate respectively, while phosphate was highest (above 1 mg/l) in Ubeji and Ekpan rivers. Chloride was highest in Agbaro well and lowest in NPA well (less than 1 mg/l). The highest level of bicarbonate was Ekpan well and least was found in Agbaro River. In all the shallow well samples

Table 1. Some physicochemical properties of potable water in Warri, Nigeria.

Sampling point	pH	Turbidity (NTU)	TSS (mg/L)	COD (mg/L)	DO (mg/L)
Ekpan river	6.80	40.30	38.00	15.00	4.40
Ekpan well	7.60	7.10	12.00	8.00	1.10
Ekpan borehole	5.30	3.10	10.00	6.00	3.60
Ubeji river	6.30	20.60	14.00	10.00	3.20
Ubeji well	7.80	8.70	14.00	10.00	2.10
Ubeji borehole	5.00	4.70	4.80	4.00	4.10
Agbaro river	8.00	10.00	14.00	12.00	2.70
Agbaro well	8.60	8.80	12.00	7.00	4.10
Agbaro borehole	7.30	3.20	6.00	5.00	1.70
NPA river	7.00	68.70	120.00	18.00	3.10
NPA well	6.70	10.00	16.00	12.80	5.40
NPA borehole	5.00	8.20	10.00	6.00	3.60
UDU river	8.50	10.00	16.00	10.00	2.20
UDU well	8.20	5.10	12.00	12.00	4.10
UDU borehole	6.50	8.30	10.00	6.00	3.40
Markava river	7.40	18.20	14.00	10.00	3.20
Markava well	8.30	6.40	10.00	6.00	2.72
Markava borehole	5.80	3.80	6.00	2.00	1.85
Aladja river	7.80	12.70	10.00	12.00	4.25
Aladja well	8.00	10.00	10.00	7.00	2.78
Aladja borehole	6.50	4.80	8.00	4.00	2.20
Otokutu river	8.40	14.20	12.00	10.00	3.50
Otokutu well	7.30	8.90	10.00	8.00	2.15
Otokutu borehole	6.80	6.40	4.00	5.00	1.12

Table 2. Anion levels of potable water in Warri, Nigeria.

Sampling point	SO_4^{2-} (mg/L)	PO_4^{3-} (mg/L)	Chloride (mg/L)	Bicarbonate (mg/L)
Ekpan River	2.43	1.14	11.01	16.00
Ekpan well	5.26	0.12	9.51	89.00
Ekpan borehole	3.16	0.08	7.50	8.00
Ubeji River	6.17	1.28	12.01	19.00
Ubeji well	4.18	0.84	8.00	9.00
Ubeji borehole	1.28	0.04	8.00	11.00
Agbaro River	1.10	0.52	10.51	5.00
Agbaro well	2.73	0.14	32.53	58.00
Agbaro borehole	1.14	0.08	7.00	18.00
NPA River	4.16	0.40	9.00	13.00
NPA well	4.18	0.25	0.51	22.00
NPA borehole	2.10	0.08	12.01	9.00
Udu River	2.16	0.84	11.52	18.00
Udu well	1.72	0.28	14.01	15.00
Udu borehole	1.10	0.04	7.51	16.00
Markava River	2.25	0.12	14.20	19.00
Markava well	2.16	0.10	9.00	20.00
Markava borehole	1.08	0.03	8.51	10.00
Aladja River	2.10	0.20	9.00	13.00
Aladja well	1.40	0.06	8.51	22.00

Table 2. Continued

Aladja borehole	1.12	0.03	7.01	19.00
Otokutu River	0.28	0.15	9.00	15.00
Otokutu well	1.70	0.20	15.01	18.00
Otokutu borehole	1.25	0.10	11.50	8.00

had higher levels of anions from all the sampling sites.

The interaction between man's activities and the environment is gaining worldwide attention. Warri, an oil producing community in Niger Delta Area of Nigeria, is faced with environmental degradation, associated with oil pollution resulting from refinery effluents, hose failure, oil pipe leaks, failure of storage tanks, pipeline vandalization, loading and off loading operations. Since open and underground water bodies are regarded as final recipients of most environmental pollutants, this study provided data on pH, COD, DO TSS, Turbidity, sulphate, phosphate, chloride and bicarbonate of different (surface, shallow well and borehole) water sources in Warri with a view to compiling ecotoxicological data of the study area. The total suspended solid was found to be highest in all the surface water samples. Surface water and shallow wells have been known to be affected by flooding, effluent discharge and infiltration. Solids in water are defined as any matter that remains as residue upon evaporation and drying at 103^0C. They are made up of suspended and dissolved solids. Turbidity like TSS is higher in surface water samples, followed by shallow well samples and lowest in borehole samples confirming a relationship between turbidity and TSS (Bertram and Balance, 1996). Turbidity consists of suspended particles in the water and may be caused by a number of materials, organic or inorganic. The occurrence of turbi-dity of surface water may be permanent or seasonal. The WHO has set a guideline value of 0.5 NTU for turbidity. Turbidity has been long known to hinder disinfection by shielding microbes, some of them perhaps pathogens. This is the most important significance of turbidity monitoring and therefore it has been and indication of the effectiveness of filtration of water supplies (Hauser, 2001). The high turbidity values seen in this study is an indication of poor filtration process of water supply in Warri, Niger Delta. The pH of all the surface and shallow well water were within the internationally recommended standard (pH for surface water systems: 6.5 – 8.5, for ground water systems: 6.0 – 8.5).

COD provides a measure of the oxygen equivalent of that portion of the organic matter in a water sample that is susceptible to oxidation under test condition (Bertram and Balance, 1996). As expected from our study, COD was highest in the surface water. COD was highest in surface water because surface water (rivers, lakes etc) are wide open to flooding which carry various organic contaminants that are susceptible to oxidation but soil strata (layer) may act as filer to underground water.

Dissolved Oxygen (DO) of natural water is dependent on temperature, turbulence at the surface, surface area exposed to atmosphere, atmospheric pressure and amount of oxygen in the surrounding air. The dissolved oxygen of 3 mg/l is known to interfere with fish population through delayed hatching of eggs, reduced size and vigour of embryos. The average DO in the surface samples of study was 3.3 mg/l; this may adversely affect fish catch by local fishermen, since DO of 4 mg/l and above can support aquatic life. The low level of DO in our surface water samples may be attributed to constant oil spillages in the area. Dissolved oxygen is most important in potable water systems for its effect on other chemicals in the water; it oxidizes, both organic and inorganic altering their chemical and physical states and their capacity as a nuisance to the consumer. The type of life in a natural water body will depend upon the amount of DO present. Most microorganisms use free or DO for reproduction.

The introduction of phosphorus in form of phosphates in aquatic environment is a major cause of eutrophication (Wagner, 1974; Lindsy et al., 1960). Phosphorous is a vital nutrient for all living things. Cellular phosphates compounds trap energy generated from food consumed and transfer it to activities that demand it for locomotion, reproduction and growth. Without the phosphorus to build these energy compounds, cell life cannot exist. Phosphorus occurs naturally, almost solely as phosphate. Most phosphates are dissolved but some are in combination with suspended particles in the water and may contribute to turbidity. Phosphorus is normally very low (< 1 mg/l) in clean portable water sources and usually not regulated.

Sulphate is one of the least toxic anions of which WHO does not have any recommended value for drinking water, but catharsis, dehydration and gastrointestinal irritation have been linked to high sulphate concentrations in drinking water. WHO therefore suggests an urgent action by health authorities when sulphate in drinking water exceeds 500 mg/l ((Bertram and Balance, 1996). In our study, the sulphate values were below 500 mg/l. Sulphate, one of the major anions in natural waters, is of importance due to its cathartic effect in some human when present in excessive amount. Sulphate may occur due to industrial discharge, contaminant from mines, tanneries, paper mils, etc. Sulphur dioxide from combustion is converted in the atmosphere to sulphuric acid. The sulphuric acid is then driven by wind and eventually comes down to the earth, either directly (dry precipitation) or with rain (wet precipitation, also referred to as acid rain), many miles from its origin. Excessively high concentrations of sulphate may decrease pH of the water and increase its bacterial load, for example, sulphate reducing bacteria. The values determined in our study were within acceptable limits.

Chlorine gas is highly toxic but chloride irons are essential for life (Duffus, 1996). Though chloride anion is present in natural water, high chloride content may indicate pollution by sewage, industrial waste or intrusion of seawater or saline water into fresh water aquifer ((Bertram and Balance, 1996). Chloride occurs in all natural waters in varying concentrations. Concentration is usually greater in groundwater than surface water especially if salt deposits are in the area. Chloride in small concentrations are not harmful to humans in drinking water, and with some adaptation, the human body can tolerate water with as much as 200 mg/l chloride ion. However, above a concentration of 250 mg/l chloride, the water may taste salty (Hauser, 2001). High chloride content in process waters may promote pipe corrosion. Removal of chloride from portable water is very difficult and generally requires desalination.

Ground water is an important natural resource. The majority of the Nigerian population depends on groundwater for drinking. Thus, preservation of clean groundwater is of utmost importance. Although there are numerous sources of contaminants, they are all related to three potential roots: namely, water soluble products that are stored or spread on the land surface, substances that are deposited or stored in the ground above water table and material that is stored, disposed of or even extracted from below the water table. The problem with groundwater contamination is magnified by the fact ground water flows extremely slowly (about 1 - 10 ft per day). Thus in comparism to surface water, there is little mixing and dispersal of contaminants. The link between the use of contaminants of ground water and any specific disease cannot be easily established (Zakrzewski, 2002).

The WHO has no guideline values for most of the physicochemical parameters investigated in this survey since they occur in drinking-water at concentrations well below those at which toxic effect may occur (www.who.int/water_sanitation_health/dwq/guidelines/en. There is need for regular monitoring of these physicochemical parameters of potable water in Warri, Niger Delta to ensure quality water supply for human health.

REFERENCES

Ademoroti CMA (1996),. Standard methods for water and effluents analysis. Foludex press Ltd, Ibadan Nigeria. pp. 71-76.

Bertram J, Balance R (1996). A Practical guide to the design and implementation of freshwater, quality studies and monitoring programmes. Published on behalf of United Nations Environmental Programme (UNEP) and World Health Organization (WHO), E & FN spoon publishers pp. 172 –177, 192-196.

Duffus J (1996). Comments to Editor, Chemistry International, News Magazine of International Union of Pure and applied Chemistry (IUPAC), 18(6): 252 –253.

Garric J, Vindiman E, Ferand JF (1993). Ecotoxicology and waste water, some practical implications. Sci. Total Environment (suppl..). pp. 1085- 1103.

Hauser BA (2001). Drinking water chemistry, A laboratory manual. Turbidity herp II, 2001, Lewis publishers, A CRC Press Company Florida USA p. 71.

Lindsy T, Neese S, Thomas D (1960). Pollution Prevention. Water Qual. Inter. pp. 32-36.

National Water Supply Training Network (1997). Outreach department, National Water Resource Institute, Kaduna. (1997), pp 15,(27):, 42-45.

Orisakwe OE, Asomugha R, Obi E, Afonne OJ, Dioka CE, Akumka D, Ilondu NA (2001). Ecotoxicological Study of the Niger-Delta. Area of the River Niger. Bulletin of Environmental Contamination and toxicology. 66: 548-552.

Smith RA, Wohlaman MG (1987). Water Quality trends in the nations Rivers. Sci. 235: 1007-1015.

Theroux FR (1943). Laboratory Manual for Chemical and bacterial analysis of water and Sewage. 3rd edition, McGraw Hill book Company Inc. New York, pp. 174-176.

Vogel Text Book of Quantitative Inorganic Analysis including Elemental Instrumental Analysis (1975). English language Book Society and Longman. Fourth edition pp. 830-833).

Wagner RH (1974). Environment and Man, W.W. Norton and Company. New York. p. 28.

Zakrzewski SF (2002). Water and Land Pollution In Environmental Toxicology 3rd edition Oxford University press, pp. 199-233