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Physicochemical Analysis of Selected Surface Water in Warri, Nigeria

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Abstract—The physicochemical analysis of five rivers labeled (A, B, C, D, E) from Warri in Delta state of Nigeria was carried out to evaluate the quality of the water which serves as major supply to people living in these areas.Water samples were collected from densely populated areas close to industries for analysis using various standard methods. The parameters determined include colour, odour, total dissolved solids, total suspended solids, dissolved oxygen, pH, alkalinity, hardness, temperature, conductivity, turbidity, chloride, sulphate, nitrate, iron, copper, manganese, arsenic. The results obtained infer that most of the parameters analyzed fell within WHO permissible limit for potable water in most of the samples.

Key words: mineral elements, physicochemical parameters, pollution, quality, surface water, WHO limit, Warri and environs.

1 INTRODUCTION

Water is a universal solvent and one of the most vital natural resources for all life on earth. It is a prime necessity for life as digestion cannot function well in its absence [1]. Water resources refer to the supply of groundwater and surface water in a given area and their quality is an indicator of the socio-economic conditions, environmental conditions and awareness, and attitude of its users [2], [3]. Over 70 percent of the earth's surface is covered by water. However, the real issue is the amount of freshwater available [4]. This is because virtually all human uses require fresh water. About 97 percent of all water on earth is salt water leaving about 3 percent only as fresh water. Nearly 70 percent of that fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground acquifers as groundwater not accessible to human use. About 1 percent of the world's fresh water is accessible for direct human uses. This is found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost [4]. Uses of water include agricultural, domestic, industrial, recreational and environmental activities. Water pollution has become a major global problem that requires ongoing evaluation and revision of water resource policy at all levels. It has been suggested that it is the leading worldwide cause of deaths and diseases, and that it accounts for the death of more than 14,000 people daily [1].Water is considered polluted when it is altered in composition and condition such that it becomes less suitable for any or all of the functions and purposes for which it will be suitable in its natural state [5], [6]. The implication is that such water becomes dangerous to water plants and animals; and unsafe for humans. In Nigeria, there is heavy dependence on fresh water due to increase in population and the scarce fresh water is decreasing in quality because of an increase in pollution and the destruction of river catchments, caused by urbanization, deforestation, damming of rivers, destruction of wetlands, industry, mining, exploration, agriculture, energy use, and accidental water pollution and poor waste treatment practices [1], [3].Warri is a densely populated area in the oil-rich Delta state of Nigeria. It has a population range of 500,000 and 1 million. The town is located between longitude 5⁰45′08″East and latitude 5⁰35′45″North. It is bounded by towns and rivers and houses so many industries including food-based industries, breweries, textile, refineries and petrochemical industries e.t.c.; as a result, the waste water generated is high and is often discharged untreated into nearby surface water bodies [1], [7]. The people living in this area lack good pipe-borne water and since many of them are low income earners, tapping water from underground sources is not considered, so, many resort to any available surface water to meet their needs. This research was therefore conducted to evaluate the quality of some of these water bodies since the WHO has estimated that up to 80 percent of all diseases and sicknesses in the world are caused by inadequate sanitation, polluted water or unavailabilty of water[1], [8].

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2 MATERIALS AND METHODS

2.1 Collection of Water Samples

The water samples were obtained from five different rivers in Warri. The rivers are *Pessu*, *Ovwian*, *Ekete, Ekpan,* and *Effurun* rivers (A, B, C, D, E) respectively. Strategic sampling was carried out before collection so as to obtain true representation of the area under study. Three water samples each were collected from different points of each sample station, and sensory examination was done on-site. Water samples were then transferred into one liter plastic containers which were washed thoroughly, rinsed with deionised water, and labeled $A_{(x,y,z)}$ to $E_{(x,y,z)}$ for easy identification.The labeled cans were corked immediately and then preserved in a refrigerator for analysis.

2.2 Sensory examination

The colour was determined by using a lovibond comparator while turbidity was obtained b comparison with a series of

Fuller's earth standards.

2.3 Determination of pH and Temperature

This was determined by using a digital pH meter. The temperatures of the samples were also obtained from the meter printer.

2.4 Determination of Conductivity

The procedure for determining this has been described by [9], [10]. A conductometer was used to obtain the conductivity of the water samples.

2.5 Determination of Alkalinity

This was obtained by titrimetry as described by [11], [12]. The samples were titrated with standard solutions of acid. All reagents used were of analytical grade.

2.6 Determination of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

The total suspended solids in the water samples were obtained by the method described by [13]. The TDS was by gravimetry as described by [14].

2.7 Determination of Dissolved Oxygen (DO)

Dissolved oxygen was analyzed using a Jenway dissolved oxygen meter (Model 970).

2.8 Determination of Ions (anions and cations)

The chloride and sulphate (Cl^-, SO_4^{2-}) content were determined as described by [14]. Nitrate concentrations (NO_3^{2-}) were obtained by using an ultraviolet spectrophotometer (APEL PD-3000, Japan). However, iron, copper, manganese, and arsenic concentrations were obtained using atomic absorption spectrophotometer (ALFA 4, Talbot Scientific Ltd, and Cheshire, UK).

2.9 Statistical analysis

All analyses were carried out in triplicate and data were analyzed by analysis of variance (ANOVA). Duncan's multiple range test was used to compare mean variance. Significance was accepted at 5% level of probability ($P<0.05$) following procedures described by [15].

3 Results and Discussion

The results of the sensory examination are shown in table 1. All water samples were light yellowish in colour. This may have resulted from the presence of suspended and dissolved particles. The mean concentrations and World Health Organization (WHO) limit of specific parameters in the water samples are shown in table 2. Water is considered safe if the concentrations of undesired substances do not exceed the WHO safe limit [16].

TABLE 1
Sensory Examination Results

TEST	A	B	C	D	E	WHO Limit-2011
Colour	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	-
Odour	-	-	-	-	-	-
Turbidity-(NTU)	10	15	22	35	20	5

Turbidity simply refers to how clear the water samples were. The greater the amount of total suspended solids in water, the murkier it appears and the higher the measured turbidity. Table 1 shows that all samples were relatively turbid ranging from 10-35NTU which is above WHO safe limit. This may have been caused by the presence of phytoplankton; particulate like clay and silts from shoreline erosion and resuspended bottom sediments, increased flow rate, floods and movement of fish in the water body. The effect of this is aesthetic.

Table 2 shows a pH range of 7.21 ± 0.15 - 7.46 ± 0.32 at 28.5^{0}C which is not above the WHO safe limit. Sample C had the least pH value (7.21 ± 0.15) while E had the highest (7.46± 0.32).There was no significant difference between all samples.

TABLE 2
Some Physical Parameters

PARAMETER	A	B	C	D	E	WHO LIMIT
pH @28.5^{0}C	7.36 ±0.02	7.40 ±0.22	7.21 ±0.15	7.30 ±0.05	7.46 ±0.32	6.5-9.2
Conductivity (µS/cm)	520.00 ±11.28	152.08 ±1.17	488.00 ±17.24	350.00 ±7.51	540.00 ±15.28	1400
TDS(mg/L)	260.00 ±5.77	76.00 ±1.15	244.00 ±3.05	175.00 ±12.22	270.00 ±5.77	1200
TSS(mg/L)	0.14 ±0.12	0.23 ±0.02	0.45 ±0.04	0.54 ±0.03	0.32 ±0.01	<30
DO(mg/L)	7.11 ±0.14	6.82 ±0.05	6.68 ±0.18	5.00 ±0.25	7.20 ±0.03	5
Alkalinity (mg/L)	19.87 ±0.03	8.89 ±0.17	16.28 ±0.13	20.88 ±0.83	17.57 ±0.25	50
Total Hardness (mg/L)	141.00 ±5.50	12.03 ±1.14	50.00 ±2.64	7.45 ±0.53	69.00 ±1.15	500

This is acceptable because a highly acidic or alkaline water body cannot support fish life. Also, the presence of acids and alkalis influence the toxicity of inorganic pollutants such as ammonia (NH_3), hydrogen sulphide (H_2S), and cyanides to fish.example, the toxicity of NH_3 is enhanced at high pH while those of cyanide and sulphide are encouraged at acidic conditions [18]. Alkaline waters with pH above 8.5 may tend to have bitter taste [17].

Table 2 reveals that the electrical conductivity of the samples varied between 152.08 ± 1.17µS/cm and 540.00 ± 15.28µS/cm which were lower than the WHO safe limit. Sample E had the highest value (540.00±15.28µS/cm) while B had the least value for conductivity (152.08± 1.17µS/cm). Sample A differed significantly from samples B and D. However value was comparable to those of C and E. Electrical conductivity directly related to the total amount of solids dissolved in water (TDS). It therefore indicates freshness or otherwise of the water body. It has been reported that waters with conductivity values below 1000µS/cm are fresh while those with values above 40,000µS/cm indicate marine nature of the water and those between these two limits are brackish waters [17]. All samples were fresh. This is reflected in table 2 where TDS varied between 76.00 ± 1.15mg/L and 270.00 ± 5.77mg/L and sample A differed signicantly from B and D but had comparable values with C and E. Though these values did not exceed WHO safe limit, they were still relatively high.The effects of high conductivity and elevated dissolved solids include elimination of desirable food plants and habitat-forming species; limited use of water for livestock, irrigation problems, corrosion of metallic surfaces in equipment used for domestic purposes such as water heaters, water cisterns, washing machines and dish washers.

A range of 0.32± 0.01mg/L to 0.14±0.12mg/L was obtained for the total suspended solids (TSS) as shown in table 2. Though all samples had low values, C and D had significantly higher ($P<0.05$) TSS value than A, B, and E. Total suspended solids include animal matter, industrial waste, and sewage. High concentrations of suspended solids can cause many problems for aquatic life and humans as well. This is because some of these solids may contain metals like mercury, arsenic, cadmium, chromium, cobalt, lead and zinc which are toxic. Cadmium, for example is linked with hypertension caused by kidney malfunction; bacteria in water converts mercury to methyl mercury, a soluble compound that gets into the food chain [18]. Decay of solids also produces unpleasant odour thus flourishing disease-causing microorganisms like bacteria as well as marring the natural beauty of the waterbody.

Sample E had the highest dissolved oxygen (DO) value of 7.20±0.03mg/L and differed significantly from D which had 5.00±0.25mg/L. However, no significant difference was shown between E and A, B, and C which had DO values of 7.11±0.14mg/L, 6.82±0.05mg/L, and 6.68±0.18mg/L respectively. The DO values for samples E and D were slightly higher than WHO limit while those of A, B, C were within the WHO range. Dissolved oxygen is an important indicator of a water body's ability to support aquatic life. Fish 'breathe' by absorbing dissolved oxygen through their gills. Oxygen enters water by absorption directly from the atmosphere or by aquatic plant and algae photosynthesis. It is removed from water by respiration and decomposition of animal matter. All samples would support aquatic life.

Table 2 shows that sample D had the highest alkalinity value (20.88±0.83mg/L) followed by A (19.87±0.03mg/L). D differed significantly from B, C, and E but did not differ significantly from A. All samples were well below the WHO limit. Alkalinity is important since it buffers the pH of water systems. Without this buffering capacity, small additions of acid or base will result in significant changes of pH which could be deleterious for aquatic life. It also influences the distribution of some organisms within the aquatic system. The values are acceptable.

Results reveal a range of 7.45±0.53mg/L to 141.00±5.50mg/L for total hardness of the samples. All samples had values below WHO range. Sample A had the highest value of 141.00±5.50 and differed significantly from samples B, C, D, and E. Hardness is most commonly associated with the ability of water to precipitate soap. Total hardness is the sum of carbonate and non-carbonate hardness. In addition to calcium ion (Ca^{2+}) and magnesium ion (Mg^{2+}) which are the common prevalent cation in fresh water, iron (Fe^{2+}), strontium (Sr^{2+}), and manganese (Mn^{2+}) may also contribute to hardness [19]. Hardness is usually reported as equivalents of calcium carbonate (CaCO3) and generally classified as soft (<75mg/L), moderately hard (75-150mg/L), hard (150-300mg/L), and very hard (>300mg/L) [20]. Table 2 shows that sample A was moderately hard while samples B, C, D, and E were soft. Soft waters have been associated with ricket in children and have been found to be statistically related to high mortality from cardio-vascular disease. Very hard water on the other hand is not good and has been associated with rheumatic pains and goiter [21].

The total chloride for all samples ranged from 15.80±0.25 to 184.00±2.64. Samples A, C, and E had relatively high values (166.00±2.08, 164.00±4.16, 184.00±2.64)mg/L respectively while B and D had relatively low values (44.80±1.75 and 15.80±0.25)mg/L respectively. The concentrations of chloride (Cl-) for all samples were below WHO critical value as shown in table 3. This is acceptable because high concentration of chloride can make water unpalatable and therefore unfit for drinking or livestock watering [17]. Chlorine has also been noted as a potential carcinogen. It forms compounds such as tetrachloromethane (TCM) which also produces hormonal analogue that may interfere with male fertility [1].

Samples A, C, and E had relatively high values for sulphates (22.49±0.25, 22.49±0.25, 22.60±0.20)mg/L respectively as against B and D which had relatively low values (4.92±0.20 and 6.21±0.06) mg/L respectively. There was no significant difference between A, C, and E but these differed significantly from B and D at $P<0.05$. All samples were much lower than the WHO limit as shown in table 3. These concentrations could be accepted because high sulphate content in water affects the taste and sulphate over 1000mg/L can exert a laxative effect effect [17].

The nitrate content of all samples was negligible compared to WHO limit. Sample C had a relatively higher value

(1.89±0.03mg/L) than A, B, D, and E (0.04±0.01, 0.09±0.01, 0.06±0.02, 0.09±0.01)mg/L respectively. Nitrates found in water are as a result of biological activities going on in it. Organic nitrogen is decomposed to ammonia and then finally to nitrates. Nitrate ion in water not desirable because it can cause methaemoglobinaemia in infants less than 6 months old [17].

The concentrations of iron (Fe), in all samples were within the WHO permissible limits; the concentrations of copper (Cu) were negligible while those of manganese (Mn) and arsenic (As) were barely detected as presented in table 3.

TABLE 3
SOME CHEMICAL PARAMETERS

PARAMETER	A	B	C	D	E	WHO LIMIT
Chloride (mg/L)	166.00 ±2.08	44.80 ±1.75	164.00±4.16	15.80 ±0.25	184.00 ±2.64	250
Sulphate (mg/L)	22.49 ±0.25	4.92 ±0.20	22.49 ±0.25	6.21 ±0.06	22.60 ±0.20	500
Nitrate (mg/L)	0.04 ±0.01	0.09 ±0.01	1.89 ±0.02	0.06 ±0.01	0.09 ±0.01	50
Iron(mg/L)	0.28	0.25	0.19	0.33	0.40	1.0
Copper (mg/L)	0.02	<0.01	0.07	0.12	0.10	2.0
Manganese (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	0.4
Arsenic (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	0.01

4 CONCLUSION

The concentrations of the physical and chemical parameters that were investigated in ths work fell within the WHO permissible limit for most of the samples. Exceptions were the turbidity and DO concentrations. Although the chloride content of all samples fell below the WHO limit, they were still high that if care is not taken these concentrations may exceed the WHO permissible limit. Regulatory bodies should monitor industries to ensure that they treat their wastes before disposal and regular check should be carried out to find out the state of the water bodies from time to time since they still serve as major supply to people living around them.

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