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Dry Season Assessment of Portable Quality of *Okpuruala* Stream in Okoko Item, Bende LGA of Abia State, Nigeria

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Abstract

The physicochemical properties and trace metal levels of *Okpuruala* Stream were evaluated. The results of the physicochemical parameters analyzed were found to be within the permissible limit except the pH that ranged from 4.90 – 5.56 with sample point A being more acidic. The result of the trace metals showed that Mn, Ca, Mg, K, Na, Ag and Cu were all within permissible limit. Chromium levels showed little percentage deviation from the acceptable limit. Lead (Pb) and Cadmium (Cd) levels were found be quite high above the permissible limit with Pb concentration (mg/l) levels of 0.3590, 2.9018 and 0.6624 at the various sample points A, B and C respectively.

Keywords

Assessment, Physicochemical Properties, Quality, Trace Metals, Water

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1. Introduction

Water has proven to be a very indispensable resource owing to the wide variety of its usage. This has caused the emergence of more regulatory bodies that set standard limits which should not be exceeded if water intended for any usage must be of good quality. Water quality is characterized by its physical, chemical and biological characteristics (Diesing, 2009). The quality is a measure of the condition of water relative to the requirements of one or more biotic species and to any human need or purpose (Johnson *et al.*, 1997). Water may be considered polluted because of an excess or burden of a gaseous, liquid or solid constituent. The capacity of water to withstand pollution will also be reflected in the level of pollution that already exists in the river. Any river will only have a limited capacity to absorb contaminants before detrimental effects are noticed.

The list of substances that may pollute water is almost endless. Industrialization and agricultural activities are responsible for the pollution of most water bodies. The major pollutants that are likely to be present in *Okpuruala* Stream include living agents, plant nutrients and agricultural agents. The living agents include – bacterial, virus and other microorganisms that cause disease. These organisms may enter water through domestic sewage or through certain kinds of industrial wastes such as oil spillage. The two plant nutrients' principal water polluting elements are nitrogen and phosphorus; but trace amount of other elements are also present. These materials which are usually present in small amounts are contributed by sewage. Certain industrial wastes and human drainages from fertilizers, lands and underground materials in high rates are also contributory to the amount of nitrogen and phosphorus found in streams. Agricultural practices, including the processing of agricultural products such as sediments from the erosion of croplands, animal wastes, pesticides used to destroy crops, pests and fertilizers also contain phosphorus and nitrogen. Furthermore,

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agricultural run-off from farms and ranches contains unsavory levels of bacteria, hormones, pesticides, herbicides, excrement and fertilizers as well as large amount of sediments. Industries too are responsible for such massive amount of toxic chemical pollution that has entered drinking water supplies.

The pollution of the water environment by industrial waste has become a threat to biotic life and ultimately threat to the quality of life. Polluted water may be unsightly odorous, corrosive, hard and unpleasant to taste (Turk and Turks, 1972; Jenkins, 1978). Pollution and degradation of ecosystem have assumed a more general importance owing to the increase in human population growth and spread of industries in recent time.

According to Harrison (1992), water is such a wide spread material that its presence is acceptable though its importance is more appreciated when there is its shortage. Wright (1982) and Arunsi (1995) stated that the problems of water resources are of increasing concern in both rural and urban areas. A lot of discharges and destruction and abuse have been done to the water resources. These include the dumping of solid waste, discharge of sewage, sludge and industrial effluent into rivers and stream without consideration of the consequences.

The practices of indiscriminate disposal of waste of all types in towns and villages, especially chemical waste suggest strongly that there is a widespread pollution of stream, rivers, lakes and lagoons. The visual disappearance of these water bodies in many parts of the country confirms these. Water pollution has become one of the most serious problems in Nigeria, especially in Abia (NEST, 1991). Nwaedozie (1998) and Oladimeji (1986) reported the presence of metal contaminants such as lead, mercury, cadmium and chromium in water bodies and aquatic animals. These contaminants cause unhealthy and intoxicating effects to the aquatic animals which may be transferred to man by eating the fish that is contaminated. Martin and Meybeck (1979) have elaborately investigated the effect of heavy metals on industrial waste. They reported that environmental contaminants like heavy metals such as Cd, Pb, Zn, Cu, Cr among others constitute health hazards to man and other organism when accumulated in the body. There are over 54 elemental toxicants that affect fish in rivers, lakes and seas due to pollution by untreated wastewater from industries which is being discharged into the river. (Heitmuller *et al*., 1981).

Biodegradable organic discharges originating from untreated or inadequately treated domestic and industrial sewage constitute one of the main causes of deterioration in water systems. This interferes with the oxygen dissolved in the liquid mass (Harrison, 1995). Studies have shown that fish generally concentrate metallic ions in their body organism, directly or indirectly through ingested food (Kakulu, 1987). Fish contaminant can reach man through the food chain (Nwadiaro, 1985).

Heavy metals such as cadmium, chromium, copper, and lead are important environmental pollutants, particularly in areas with high anthropogenic pressure. Their presence in the atmosphere, soil and water, even in traces can cause serious problems to all organisms and their bioaccumulation in the food chain especially can be dangerous to human health. Heavy metals intake by human populations through food chain has been reported in many countries. As human activities increase, pollution and contamination of the human food has become inevitable. Heavy metals are very harmful because of their non-biodegradable nature, long biological half lives and their potential to accumulate in different body parts. Most of the heavy metals are extremely toxic because of their solubility in water. Even low concentrations of heavy metals have damaging effects to man and animals because there is no good mechanism for their elimination from the body. Heavy metals are persistent environmental contaminants which may be deposited on the surfaces and then absorbed into the tissues of vegetables. Plants take up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from contaminated soil and water (Okoronkwo, *et al.,* 2005a, b; Okoronkwo, *et al* 2006; Suruchi *et al*, 2011). Water contamination by heavy metals in some areas is practically inevitable due to natural process (weathering of rocks) and anthropogenic activities (industrial, agricultural and domestic effluents). These elements (heavy metals) at concentrations exceeding the physiological demand of the plants, not only could administer toxic effect in them but also could enter food chains, get biomagnified and pose a potential threat to human health (Sugiyama, 1994). Heavy metals contamination of agricultural soils from wastewater irrigation is of serious concern since it has implication on human health (Mensah *et al.*, 2008).

In examining the quality of water, there are myriads of angles by which analysis could be run on water sample. The various aspects include the physical, chemical and biological characteristics. The quality of water is determined depending on its usage or intended use; hence these are parameters that qualify it as a standard for any type of use. *Okpuruala* Stream, aside other uses is majorly used for domestic purposes. This study therefore aimed at examining the quality of *Okpuruala* Stream in Okoko Item in Bende Local Government Area of Abia State, Eastern Nigeria with its longitude and latitude as 7.6166^o and 5.2333^o respectively. This would be achieved through specific objectives which include determining the physico-chemical properties and identifying the major contaminants present in the stream water which may include the presence of trace and/or heavy metals such as Cd, Cu, Zn, Fe, Cr and Pb. These parameters shall then be compared to that of European Union, United States, Nigeria and World Health Organization standard for drinking/potable water.

2. Materials and Methodology

2.1. Sample Collection/Preservation

Samples were collected in new and unused 5 liter plastic kegs. The sample kegs were filled to the brim in such a way that there was no or minimal oxygen trapped in the keg; since the presence of oxygen or bubbles in the keg could affect the correct determination of Dissolved Oxygen of the samples. The samples were stored at room temperature (22^{o}C). The water samples for analysis were collected from three different points:

- Sample A was collected from the Rock Flow-Point.
- Sample B was collected from *Elua* watercourse that runs into the stream water.
- Sample C was collected from the collection point of the stream water users.

The samples were well labeled and taken to the laboratory where different analyses were performed on them.

2.2. Experimental Method

The experiments were carried out based on the American Standard for Testing Materials (ASTM). The test methods are colorimetric and titrimetric. The experimental methods used in this study include: Physical: This involves the measurement of Appearance, pH, Temperature, Colour, Odour, Turbidity, Conductivity, Total Suspended Solids and Total Solids. Chemical: Total Alkalinity, Total Acidity, Chloride, Total Hardness and Dissolved Oxygen which were as described by LASEPA (2011).

2.3. Digestion of Heavy Metals

100 ml aliquot of the well mixed water sample was measured into a conical flask, 5 ml of nitric acid was added in order to precipitate or aid the release of the metals present in the sample. The mixture in the conical flask was placed in a fume cupboard that has an electric hot plate heating at 90-95^{o}C, then the mixture was heated until there was a significant decrease in volume (about 10 – 25 ml).The heated volume was allowed to cool and the volume of the mixture left was noted which is usually referred to as the digested volume, after which it was filtered using a filter paper to remove silicate or other insoluble materials that may clog the nebulizers of the Atomic Absorption Spectrophotometer (*AAS*) during analysis, then filtered volume was made up to 50 ml with distilled water. This was transferred into test tubes each representing different water samples and carefully covered with foil in order to avoid tiny particles from infiltrating into the solution thereby blocking the pore of the flame spectrophotometer which sucks the liquid solution during spectrophotometer analysis. Distilled water was firstly aspirated into the AAS to clear the line and make it free of contamination. The appropriate cathode lamp was set for each metal to be analyzed and the AAS was set to the appropriate wavelength; and the concentration of the metals was determined one after the other in all samples.

The digestion of heavy metals is important in order to reduce the interference by organic matter and to convert metals associated with particulates to a form (usually the free metal) that can be determined by atomic absorption spectrophotometer ((LASEPA, 2011).

3. Results and Discussion

3.1. Physico-chemical Parameters

The results of the physical and chemical analyses of *Okpuruala* Stream are presented in Table 1 for the three samples collected at different points of the stream.

Table 1. Results of the physical and chemical parameters of *Okpuruala* Stream

PHYSICAL PARAMETERS	SAMPLE A	SAMPLE B	SAMPLE C
Appearance	Colourless	Colourless	Colourless
Temperature (^{o}C)	27.2	27.0	27.4
pH	4.90	5.25	5.65
Odour	Odourless	Odourless	Odourless
Turbidity	Clear	Clear	Clear
Conductivity	0.08	0.08	0.13
Total Suspended Solid	0	0	0
Total solid mg/l	0	0	0
CHEMICAL			
Total Acidity	7	3	4
Total Alkalinity	60	50	65
Total Hardness	16	14	20
Chloride	3	0	0
Dissolved Oxygen	5.09	4.39	4.83

The appearance is the physical water quality parameter that is most looked out for by water users in describing and certifying a water sample with good domestic quality. The results for appearance in Table 1 shows that the three samples from different points of collection were colourless hence making them suitable with WHO standard. Also, the result for turbidity in the same table shows that samples A, B and C were quite clear making this parameter satisfactory when compared to the WHO drinking water standard.

For the result given in Table 1, conductivity for the samples A, B and C were 0.08, 0.08 and 0.13 ms/cm respectively. This result when compared to WHO standard in the same table shows that conductivity in all the samples were below the WHO standard.

The result of analysis for total suspended solid as shown in Table 1 showed that the three samples recorded zero (0) values. This is satisfactory as it is well below WHO water standard. Suspended solids are important as pollutants and pathogens are carried on the surface of particles, the smaller the particle size, the greater the total surface area per unit mass of particle, and so the higher the pollutant load that is likely to be carried.

Pure water is said to be neutral with a pH close to 7.0 at 25°C. Solutions with pH less than 7.0 are said to be acidic and solutions with a pH greater than 7.0 are basic/alkaline. The result for pH in Table 1 showed that sample A, 4.90; sample B, 5.25; and sample C, 5.65 which were lower than 7. A low pH indicates a high concentration of hydronium ions (H_3O^+). pH in its usual meaning is a measure of acidity of (dilute) aqueous solutions only (Bates *et al.,* 1973). The pH values of neutral waters lies between 6.5 - 7.5 and lower values are as a result of free CO_2. Changes in pH can also be attributed to chlorination which tends to lower the pH.

Alkalinity is a measure of the capacity of water to neutralize acids. Without this acid-neutralizing capacity, any acid added to a stream would cause an immediate change in the pH. From Table 1, results show that for samples A, B and C, total alkalinity was measured as 60, 50 and 65 respectively; these figures were quite below the WHO standard. Measuring alkalinity is important in determining the stream's ability to neutralize acidic pollution from rainfall or wastewater. It is one of the best measures of the sensitivity of the stream to acid inputs (APHA, 1992). Although total acidity standard limit was not specified by WHO the results read as 7, 3 and 4 for samples A, B and C respectively.

Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken or die. The results for DO for samples A, B and C in Table 1 showed 5.09, 4.39 and 4.83 respectively against the WHO's minimal value of 2.0 mg/L hence making it satisfactory. Maximum dissolved oxygen concentrates vary with temperature and altitude. Cold water holds more oxygen than warm water and vice versa at higher altitudes (APHA, 1992). Dissolved oxygen is one of the more important parameters available in the field of water pollution control, as it permits the evaluation of the aerobic condition of a watercourse, which receives discharge of pollutants.

The results in Table 1 showed that the total hardness of sample A was 16 mg/l, sample B had a value of 14 mg/l and sample C, a total hardness of 20 mg/l. These were quite below the WHO standard of 200 mg/l. Recommendations have been made for the maximum and minimum levels of calcium (40 – 80 ppm) and magnesium (20 – 30 ppm) in drinking water, and a total hardness expressed as the sum of the calcium and magnesium concentrations of 2 - 4 mol/l

3.2. Trace Metals Levels

The result of the trace metals concentration (mg/l) is shown in Table 2. Trace/heavy metals such as copper, silver, manganese, sodium, potassium, magnesium and calcium were all satisfactory. That is to say that they are within or below the satisfactory range of WHO standard for all drinking and domestic water samples.

Table 2. Concentration (mg/l) of trace/heavy metals levels of the different point of the stream

S/N	TRACE/TOXIC HEAVY METAL	SAMPLE A	SAMPLE B	SAMPLE C
1	Cadmium	0.2433	1.9677	0.3491
2	Iron	0.3710	0.3774	0.5149
3	Sodium	17.1840	18.9308	2.5989
4	Copper	0.0358	0.0343	0.0475
5	Zinc	1.8908	0.0819	0.0693
6	Potassium	5.2608	13.3424	0.0054
7	Silver	0.0387	0.0289	0.0389
8	Lead	0.3590	2.9018	0.6624
9	Manganese	0.1419	0.2882	0.0106
10	Chromium	0.1642	0.1821	0.1393
11	Magnesium	4.8927	6.2042	0.1413
12	Calcium	8.8339	7.9576	1.4167

It is important to note that for trace metals, sodium and potassium though satisfactory the watercourse sample B had the highest, making the watercourse contain more sodium and potassium. Silver mainly occurs in argentite and stephanite from which it is released through weathering. The drinking water guideline for silver is 0.05 mg/l. Silver oxide is harmful upon swallowing, because it irritates the eyes, respiratory tract and skin. Silver nitrate is much more harmful, because it is a strong oxidant.

Finally, magnesium and calcium according to the result were in little or minute traces that are far less harmful to both aquatic life and the stream water users. These two vital elements by this result had supported the physico-chemical parameter result for total hardness which were recorded as: 16, 14 and 20 for water samples A, B and C respectively against the WHO limit value of 100 mg/l; and had totally eliminated the issue of water hardness of *Okpuruala* stream to a large extent as Mg and Ca are chiefly water hardening agents. Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a determinant of water hardness because it can be found in water as Ca^{2+} ions, for example, $CaCl_2$. Calcium is a dietary requirement for all organisms apart from some insects and bacteria. Calcium is largely responsible for water hardness, and may negatively influence toxicity of other compounds. Some environmental effects of water hardness include hardening of domestic equipment, because high temperature causes carbonate hardness. This may dramatically decrease the lifespan of domestic equipment and cause an increase in domestic waste.

Unlike the above trace heavy metals that are satisfactory by WHO standard drinking and domestic water, cadmium was found to be unsatisfactory as its results showed 0.2433, 1.9677 and 0.3491 for samples A, B and C respectively in mg/l, against WHO's limit of 0.002 mg/l with sample B containing more cadmium. For trace/heavy metal, Iron was a bit high against the WHO limit value of 0.03 mg/l, water sample B had the value of 0.3774 mg/l thereby rendering the Iron concentration level in sample B unsatisfactory. Iron is a harmless, though sometimes annoying element present in public and private water supplies. High concentration of dissolved iron can result in poor tasting, unattractive water that stains both plumbing fixtures and clothing. Under the guidelines for public water supplies set by the Environmental Protection Agency (EPA), iron is considered a secondary contaminant. Secondary standards apply to substances in water that cause offensive taste, odour, colour, corrosion, foaming, or staining but have no direct effect on health (Kolega *et al*., 1989). Iron bacteria are bacteria that derive the energy they need to live and multiply by oxidizing dissolved ferrous iron which results in ferric oxide. They are known to proliferate in waters containing as low as 0.1mg/l of iron. However, at least 0.3 ppm of dissolved oxygen is needed to carry out oxidation (Sawyer *et al.*, 1967).

Again for the element zinc, sample A had the value of 1.890 mg/l against the limit value of 1.5 mg/l making the amount of zinc in sample A unsatisfactory. Samples B and C were however maintained below the WHO standards and were satisfactory.

The results for lead (Pb) showed 0.3590, 2.9018 and 0.6624 mg/l for samples A, B and C respectively, against the 0.015 mg/l WHO limit for lead in drinking and domestic water. The highest concentration of lead was recorded for the watercourse sample B. In humans, exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing foetus and infant being more sensitive than the adult. High levels of exposure in humans may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system. Lead in the environment arises from both natural and anthropogenic sources. Also, exposure can occur through drinking water, food, air, soil and dust from old paint containing lead.

The result for chromium as shown on Table 2 shows that a considerable high concentration of chromium was observed in all the water samples 0.1642, 0.1821 and 0.1393 mg/l for samples A, B and C respectively against the WHO limit value of 0.10 mg/l. Chromium is used in metal alloys and pigments for paints, cement, paper, rubber and other materials. Low level exposure can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage and also damage the circulatory and nerve tissue. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium.

The higher the value of a trace/heavy metal above the WHO limit value, the higher its exposure, the higher its bioaccumulation which in turn entails an increased effect on both the water users and aquatic life.

4. Conclusion

This study has shown that the pH and some heavy metals concentrations were found to be very high hence toxic especially when they bioaccumulate in the body which exposes the *Okpuruala* Stream users and the aquatic organisms to danger. This work is therefore open for more research and routine checkmate by this stream in order to provide safer and purer water for Okoko Item dwellers hence improving the quality of life. Since the watercourse from *Elua* Stream (Point B) contains a higher concentration of most of the trace metals that do not correspond to the WHO drinking and domestic water standard. Alternatively, water treatment plants should be put up to treat pollutants present in *Okpuruala* Stream before usage.

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