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Water Quality Index Assessment of Borehole Water in the Hostels in one of the Higher Institutions in Delta State, Nigeria

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Abstract

One of the greatest challenges of our time is to provide an adequate supply of potable water due to industrialization with its attendant pollution problems to water bodies. The aim of this research is to ascertain the potability of water samples from boreholes in hostels in one of the higher institutions in Delta State, Nigeria. It is also aimed at determining the water quality level using the water quality index. Water samples were collected and analyses using standard methods. The physicochemical parameters determined includes pH, Temperature, Acidity, Turbidity, Electrical conductivity, Dissolved Oxygen, Biochemical Oxygen Demand, Nitrates, Phosphates, Chlorides, Total Alkalinity, Total Suspended Solids, Total Dissolved Solids and Total Hardness. The results obtained were compared with WHO and SON standard and were found to be below the permissible limits which indicate their fitness for domestic purposes. The water quality index was also calculated using the water quality index calculator and values ranging from 76.19-78.02 were obtained which is regarded as good based on the water quality index legend.

Keywords: Potability, boreholes, water quality, hostels, water quality index.

Introduction

Water is a universal solvent and so can dissolve so many chemicals; beneficial as well as non beneficial to man and its environment. It is however essential to all living things and its environment[1]. It is in fact one of the most essential necessities of life. Water can be described as a substance upon which every living thing depends for survival. Water is a key determinant for sustainable human health as well as general well being[2,3]. Pure water for human consumption does not always occur in nature because of the presence of impurities in most natural water bodies[4,5], because its high solvating capacity. The two major problems man has to contend with are the water quantity and quality[6]. Pollution of water bodies have been issues in the world recently because of the increase in pollution resources such as industrial, domestic and agricultural. Therefore, there is increased interest for the provision of potable water for the populace. Water quality can be specified in terms of its physical, as well as its chemical and biological parameters. Water quality is a factor of the source and the activity of man. The quality of ground water is however dependent on various chemical constituents and their concentration which are generally derived from the geological data of the particular region[7]. The fast population growth of students in the hostels with the attendant poor sanitation condition, situation in such areas causes serious quality degradation of both surface and ground water[8].

Water quality index is an statistical tool used to transform large quantities of water quality data into a single cumulatively derived number which resembles the degree of pollution. It was first developed by Horton in the early 1970s based on weighed arithmetical calculations[9]. Students in the hostels of this institution depend solely on the water from the boreholes provided for them by the institution. The research is therefore to ascertain the potability of the water from these boreholes as well as assess the water quality using the water quality index (WQI) calculator (internet, downloaded 19/6/13).

Methodology

Sampling: Sampling and preservation of water samples were done as prescribed by APHA methods[10]. The samples were collected in 1 litre polythene plastic containers that have be previously been thoroughly washed and acidified (pH 1.5) with analar grade of nitric acid. They were then kept in an iced block chest and transported to the laboratory. They were then preserved in a refrigerator before other analyses were carried out. Non conservable parameters such as temperature, pH, dissolved oxygen (DO), were measured and recorded immediately at the site. The temperature was measured using a mercury thermometer with degree Celsius calibration, pH with a portable pH meter (portable pH meter Hanna equipment), dissolved oxygen was measured with portable DO meter (DO analyzer JPG 607) and conductivity and Turbidity were measured with a turbidity/conductivity meter (hanna equipment). Biochemical oxygen demand (BOD) was measured as using the relationship BOD = DO- DO_5 APHA[10]. Alkalinity was determined by the titration method by titrating a known volume of sample with 0.02MHCl[11]. Total dissolved solid (TDS) was determined gravimetrically by evaporating a known volume of water sample to dryness in a pre- weighed crucible

on a steam bath[11]. Total suspended solid (TSS) was determined by filtering a known volume of water sample through a thoroughly dried filter paper and the residue weighed. Total hardness was determined by titrating a sample with EDTA using Eriochrome black T as an indicator[11]. Chloride was determined by argentiometric method, phosphate by Vanadate-molybdate method, sulphate by turbidimetric method and nitrate by UV Spectrophotometric method (UV-Visible Spectrophotometer 221). Heavy metals were determined with an Atomic Absorption Spectrophotometer (AAS Searchtech AA 320N), after acid digestion. Blank sample was prepared for a background correction. Each sample was analyzed in triplicate and the mean result reported. General laboratory quality assurance measures were always maintained.

Table-1
Physicochemical properties of borehole water in the students' Hostel of one of the Higher Institutions in Delta State, Nigeria

Parameter/Sampling Points	Site 1	Site 2	Site 3	Site 4
pH	6.33±0.06	6.57±0.06	6.23±0.06	6.63±0.06
Temperature (^oC)	30.2±1.71	29.33±1.70	30.00±1.00	31.40±0.35
Electrical Conductivity (us/cm^{-1})	51.63±0.06	49.07±0.29	46.53±0.21	52.80±0.69
Turbidity (NTU)	4.67±0.12	3.42±0.06	2.67±0.05	1.63±0.06
Hardness (mg/l)	0.45±0.05	0.67±0.06	0.87±0.06	0.64±0.06
Dissolved Oxygen (DO) mg/l	3.89±0.09	3.57±0.12	5.91±0.02	5.82±0.01
Biochemical Oxygen Demand (BOD) mg/l	1.20±0.01	1.23±0.03	1.24±0.05	1.07±0.01
NO_3^- (mg/l)	0.35±0.01	0.15±0.01	0.24±0.01	0.47±0.06
SO_4^- (mg/l)	0.11±0.01	0.04±0.01	0.41±0.17	0.29±0.01
Cl^- (mg/l)	7.37±0.06	6.23±0.12	6.23±0.06	4.39±0.06
PO_4^- (mg/l)	0.04±0.01	0.02±0.01	0.02±0.01	0.06±0.00
Alkalinity (mg/l)	1.27±0.03	2.42±0.02	1.21±0.01	1.22±0.01
TSS (mg/l)	4.31±0.54	2.42±0.01	2.71±0.01	4.30±0.01
TDS (mg/l)	0.63±0.03	0.90±0.01	0.77±0.01	0.71±0.01
Acidity (mg/l)	0.30±0.01	0.67±0.03	0.33±0.06	0.37±0.06
Pb (ppm)	0.01	ND	ND	0.01
Cd (ppm)	0.01	0.01	ND	ND
Fe (ppm)	1.64	0.04	0.05	0.18
Cu (ppm)	0.03	0.01	ND	0.03
Ca (ppm)	123.47	131.40	94.84	101.76
Mg (ppm)	11.16	12.70	13.40	8.43
K (ppm)	2.47	1.94	1.98	2.07
Na (ppm)	0.07	0.10	0.06	1.00

ND= Not Detected

Table-2
Physicochemical Parameters of water from various sites

Parameters/Sites	Range1	Range2	Range3	Range4	WHO[12] permissible limits	SON[13]
pH	6.3-6.4	6.5-6.6	6.2-6.3	6.6-6.7	6.5-8.5	6.5-8.5
Temperature (^0C)	28.4-31.8	27.6-31.0	29.0-31.0	31.0-31.6	30-35	-
Electrical Conductivity (us/cm^{-1})	51.6-51.7	48.9-49.4	46.3-46.7	52.4-53.6	900	1000
Turbidity (NTU)	4.6-4.8	3.42-3.43	2.61-2.7	1.6-1.7	5.0	5.0
Hardness (mg/l)	0.4-0.5	0.6-0.7	0.8-0.9	0.6-0.7	100-150	100
Dissolved Oxygen (DO) (mg/l)	3.84-4.0	3.43-3.64	5.9-5.94	5.82-5.83	5.0-7.0	-
Biochemical Oxygen Demand (BOD) (mg/l)	1.2-1.25	1.2-1.25	1.21-1.30	1.06-1.08	-	-
NO_3^- (mg/l)	0.34-0.36	0.14-0.16	0.24-0.25	0.40-0.50	10	10
SO_4^{2-} (mg/l)	0.11-0.12	0.04-0.05	0.40-0.43	0.28-0.30	200	100
Cl^- (mg/l)	7.3-7.4	6.1-6.3	6.2-6.3	4.36-4.46	200-600	-
PO_4^- (mg/l)	0.03-0.04	0.02-0.03	0.02-0.03	0.06-0.06	0.1	-
Alkalinity (mg/l)	1.25-1.3	2.4-2.43	1.2-1.22	1.21-1.22	100	100
TSS (mg/l)	4.0-4.94	2.41-2.43	2.7-2.71	4.3-4.31	500	-
TDS (mg/l)	0.60-0.65	0.89-0.90	0.77-0.78	0.70-0.71	500-1500	-
Acidity (mg/l)	0.29-0.30	0.65-0.7	0.32-0.33	0.3-0.4	-	-

Range1= Range at site 1, Range 2=Range at site 2, Range 3=Range at site 3, Range 4=Range at site 4

Results and Discussion

pH: This is the scale for determining the level of acidity and alkalinity of a solution. It measures the concentration of hydrogen ion. pH 7 is regarded as the neutral point and values below 7 are said as acidic while values above 7 as alkaline. Though pH has no direct effect on human, all the biochemical reactions are pH dependant. For most reactions as well as for human beings pH 7 is considered as permissible limits in all sources. In general, the lower the value of the pH, the higher the acidity and pH is related to corrosion. The higher the acidity the higher the corrosion[14]. pH values lower than 11 usually results in irritation in the eyes, skin and mucous membrane. It also causes hair fibers to swell in humans[14]. The pH of the water samples ranged from 6.2-6.7. The water samples would be regarded as tending towards neutrality which is the ideal for pure water. These values are within the WHO[12] standard. Therefore the water is safe for agricultural, domestic and recreational uses.

Temperature: Temperature could be regarded is the measure of the degree of coldness or hotness of a substance. It is important because it is required in order to have an idea of self purification of water bodies. The temperature of drinking water is of importance because it influences the taste of water. Also almost all chemical, physical and biochemical reactions are temperature dependant. The water temperature of this sample ranged from 27.6-31.6. These values are within the WHO permissible limit and so the water could be said to be safe for drinking and other domestic uses.

Electrical Conductivity: Conductivity serves as an indicator of other water quality. Water with high mineral content tends to have higher conductivity which is a general indication of high dissolved solids concentration of the water[15]. Electrical Conductivity of water samples ranged from 46.3-53.6µS/cm. This value is far lower than the WHO recommended limit of 250µS/cm and hence the water is safe for domestic and agricultural purposes.

Hardness: Water Hardness is a measure of the ability of water to cause precipitation of insoluble Calcium and magnesium salts of higher fatty acids from soap solution. Sawyer and Mc Carty[16] classified water in terms of hardness as follows:

Hardness as $CaCO_3$ mg/L	Water Quality
0-75	Soft
75- 150	moderately hard
150- 300	hard
Above 300	very hard

The water samples had hardness ranging from 0.4- 0.9 mg/L. This showed that the water samples are all soft and could be excellent for laundry purposes.

Dissolved Oxygen (DO): This is the measure of the amount of oxygen freely available in water. The measurement of DO is an important water quality parameter since it has special significance for aquatic organisms in natural water[17]. The water samples studied had DO ranging from 3.84 to 5.94mg/L which within the Indian standard and WHO standard of 6.

Biological Oxygen Demand (BOD): This is the measure of the oxygen in water that is required by aerobic organisms. Unpolluted water should have a BOD of 5mg/L or less[18]. The result of BOD obtained (1.06-1.30mg/L) from this study is within the WHO standard which therefore suggests that the water from these boreholes is less polluted by organic materials.

Nitrates: The study of nitrate content in water is of importance since it is the final product of biochemical oxidation of ammonia. It has adverse effect on the health of human and animals. Monitoring of it in drinking water supply is therefore very important. The values obtained are far below the permissible limit of 50mg/L of WHO[12]. The values ranged from 0.14-0.36. This shows that the water samples are safe for drinking.

Chlorides: The presence of chloride where it does not occur naturally indicates possible water pollution. Chloride contaminates rivers and ground water and can make it unsuitable for human consumption. High level of chloride kills plants and wild life[19- 21]. The value of chloride ranged from 4.36-7.40mg/L as against the WHO permissible standard of 250-500mg/L. These water samples would be regard as potable and suitable for domestic use.

Alkalinity: The alkalinity of water is caused mainly by the presence OH^-, HCO_3^- and CO_2^- ions.Alkalinity is an estimate of the ability of water to resist change in pH upon addition of acid. Alkalinity is a big problem for industries since alkaline water if used in boilers for steam generation may lead to precipitation of sludge, deposition of scales and cause caustic embrittlement. Alkalinity in the studied sample ranged from 1.21-2.43mg/L. These values are within the WHO standard of 100mg/L.

Total Suspended Solids (TSS): High suspended solids in any water body may be aesthetically unsatisfactory for bath and other domestic purposes. The total suspended solids are composed of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, sodium, potassium, manganese, organic matter, silt and other particles. The effect of high TSS is turbidity which is an indication of pollution. The TSS of water samples studied ranged from 2.41-4.31mg/L. This is very reasonable as compared with WHO limits.

Acidity: The acidity of a water sample is its capacity to neutralize hydroxide ions which is dependent on the hydrogen ion concentration. Acidity may be caused by mineral acids such as sulphuric, hydrochloric acid or dissolved carbon dioxide. Generally in drinking water, carbon dioxide is the principle

cause of acidity. Acidity increases the corrosive behaviour of water. Therefore drinking water with high acidity is likely to be corrosive to copper water pipes and the solder which joins those pipes. High acidity of water usually causes metals such as lead and copper present in pipes used for delivery water to dissolve in it when the water is allowed to stand in these pipes for some period of time, thereby creating a possible health hazard due to the dissolved metal ions. Also acidity in water can cause copper plumbing to develop pinhole leaks after a few years. The water samples acidity ranged from 0.3-0.7mg/L.

Phosphate: Phosphates are only toxic to both man and animals when present in very high levels. Levels of phosphate greater than 1.0mg/L may interfere with coagulation in water treatment plants; in which case the organic particles that are present in micro-organism may not be completely removed before water distribution. Phosphate occurs in natural water in low quantity as many aquatic plants absorb and store phosphorus many times their actual immediate needs. The phosphate level of the water samples ranged from 0.02-0.06mg/L which is within the WHO standards.

Turbidity: Turbidity is the term used to describe the suspension of particles in water that interferes with the passage of light. Turbidity is caused by a wide variety of suspended matter which range in size from colloidal to coarse dispersion depending upon the degree of turbulence. It also ranges from pure inorganic substances to those that are highly organic in nature. Turbid waters are undesirable from an aesthetic point of view in drinking water supplies. The value for turbidity is from 1.6-4.8NTU. This figure is within the WHO value of 5.0NTU.

Total Dissolved Solids (TDS): Total dissolved solids in water are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium, and manganese, organic materials. The values of the total dissolved solids ranged from 0.6-0.78mg/L which is far below the WHO limit of 600mg/L.

Table-3
Water Quality Index (WQI) - Water Quality Index Legend

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

http://www.water-research.net/watrqualindex/waterquality index.htm

Water quality index is one of the most effective tools to monitor surface as well as ground water pollution status. The aim of the water quality index is to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of a number of precise water quality characteristics[22]. The water quality index provides information on a rating scale from zero to hundred. A high value of WQI indicates better quality of water and a lower shows a poor water quality. In the calculation parameters are assigned weights according to its relative importance in the overall quality of the water for drinking purposes. The maximum weight of 5 has been assigned to nitrate due to its major importance in water quality assessment while magnesium is given the minimum of 1 as magnesium by itself may not be harmful[23]. The water index calculator was used for this work. The results showed ranges from 76.19-78.02. This indicates that water from these boreholes is suitable for drinking purposes. However improvement could be achieved by subjecting the water in some form of treatment.

Conclusion

In this study, it was observed that the parameters studied had values within the WHO permissible limits. The water quality index also indicated the water from these boreholes is suitable for domestic purposes.

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