



Analysis of Stream and Well Water Quality for Domestic Use in Minna Metropolis, Niger State, Nigeria

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Abstract

This study analyzed stream and well water quality for domestic use in Minna Metropolis, Niger State, Nigeria. Water sources have become critically contaminated due to anthropogenic activities. Samples of stream and well water were taken for laboratory test. The laboratory tests analysed twenty four constituents (5 physical elements, 5 metal elements, 13 chemical elements and one microbial element) that were compared with World Health Organization (WHO) standard for domestic drinking water to ascertain the safety of the water. The result showed that temperature rise (29.2⁰C) of water was common in both stream and well waters. Other parameters were within the WHO recommended allowable limits. The study has suggested environmental education and water treatment strategies to curb the menace of contaminated water in Minna city, Niger State, Nigeria without further delay.

Keywords: Analysis, Domestic, Stream, Water, Well

1. Introduction

Water is one important resource for the survival of human on planet earth. The global use of water has risen to six-times in the past century and is growing 1% per annum since 1980s (Xu, Yang et al., 2022). Thus, increased water consumption is facing serious challenges in this contemporary period. The advent of industrial sector, practice of agriculture and life in urban centers have adversely resulted to pollution of water sources such as rivers and well waters, which are necessary for life. The effect of polluted water has negatively impacted on human health and sustainable social development. Over 80% of industrial and municipal wastewater is discharged to the environment without being treated having adverse effect on human health and the ecosystem. This effect is higher in less developed countries where sanitation and wastewater treatment facilities are severely lacking (Yassin et al., 2006).

Contaminated water has greater effects on human health. UNESCO World Water Development Report of 2021 showed that 829,000 people die per year from diarrhea caused by unsafe drinking water, sanitation and poor hygiene; and 300,000 children under the age of five die per annum because of contaminated water and poor hygiene (Yassin et al., 2006). Tap water, bottled water, stream and well water are sources of gastrointestinal disease. Lack of water and sanitation services can raise the incidence of diseases such as cholera, trachoma, schistosomiasis and helminthiasis (Payment, 2007). A study from



developing country has shown a clear relationship between cholera and contaminated household water (Gundry, 2004). Thus, in addition to disease, unsafe drinking water and poor environmental hygiene can result to gastrointestinal illness, inhibiting nutrient absorption and malnutrition especially in children.

Globally, bodies of water are the main reservoir and common disposal of waste and substances from industries, public sewage as well as discharge from agricultural wastes. Both surface and underground water dissolve natural minerals and chemicals generated by humans. These waste and effluent can alter the physical, chemical and biological components of the water bodies thereby degrading the quality of water (Sandoyin, 2001). Sometimes, water bodies easily assimilate waste in contact with them without actually deteriorating to a large degree (Fair, 2001). The first effect of waste is to degrade the physical quality of water. This is followed by biological degradation by variety of living organisms in the body of water (Gray, 2009). The main sources of pollution in wells, streams, rivers, surface and underground water is through human activities caused by poor water management and uncultured living habit. This can be accelerated by unhealthy practices by factories, industries and corporate institutions leading to discharge of untreated waste and effluent to the water bodies (Akpan, and Offem, 2003)

Proliferation of industries and unhealthy use of chemicals fertilizers as well as pesticides are causing heavy chemical loading in the water bodies. The use of these chemicals cause varied pollution to the aquatic environment resulting to lower water quality and death of water biota (Firozia and Kumar, 2012). These contaminants can be in the form of microbes, different inorganic contaminants, variety of pesticides, herbicides, radioactive substances and organic chemical contaminants (Steve, 2009). Also, pollution of coastal water bodies could result to changes in nutrient levels surplus, biomass and diversity of organism, bioaccumulation of organic and inorganic compounds and alteration of trophic interaction among species (Gupta and Shukle, 2006). Most water on the earth surface is saline in nature, few are freshwater which has made it a scarce commodity due to pollution and overexploitation of the water resources (Patil and Tijare, 2001; Singh and Mathur, 2005).

2. Methodology

This study took samples from Minna stream and well water for laboratory test. The laboratory tests analysed twenty four constituents (5 physical elements, 5 metal elements, 13 chemical elements and 2 microbial elements) were compared with World Health Organization (WHO) standard for domestic drinking water to ascertain the safety of the water. Samples were taken to laboratory for test on physical and chemical suitability of each water source. Table 1 shows the parameters, description and methodology used in the laboratory tests.



Table 1: Parameters/Elements, Description and Methodology

S/N	Parameters/Elements	Description	Methodology
1	Temperature(°C)	The degree of hotness and coldness of water	The Glass thermometer was used. This involved the immersing of thermometer in the water bowl until the liquid mercury in the thermometer stops making movement. Thereafter, measurement was recorded to approximate value of 0.1 ^o c.
2	Dissolved Oxygen mg/L	The amount of oxygen available to living aquatic organisms	Using winkler method, dissolved oxygen concentration was determined by titrating with sodium thio-sulphate solution
3	Turbidity NTU	The quality or state of being cloudy because a lot of small pieces of matter are held in it.	The Nephelometric method is use to compare how light is scattered in a reference solution. An electronic hand –meter is often used to measure turbidity
4	Conductivity us/cm	This is a process by which water conducts electric current which depends on the concentration of iron in the sampled solution.	Conductivity can be measured by using 2-ac bipolar technique or by using electromagnetic induction. The bipolar technique can measure the amount of current that passes through the sampled solution which is between a pair of electrodes. The electromagnetic induction technique also measures the initiated current developed by the two coils deep in the solution.
5	Total Dissolved Solid mg/L	This takes into consideration the dry weight of the material which can be removed from a measured water volume through filtration using standard filter.	The two principal methods of measuring total dissolved solids are gravimetric analysis and conductivity. Gravimetric method involves evaporating the liquid solvent and measuring the mass of residues left.
6	pH	This measures the concentration alkali and acid in the water	The liquid colorimetric indicator was employed. This is used to change colour according to the pH concentration of water.The appeared colour was compared with a printed card that has a colour glass standard having a set of prepared liquid standards. Colorimetric methods have accuracy value of 0.2pH.
7	Flouride (f)mg/L	Flouride is a naturally occurring mineral used in many dental products to strengthen tooth enamel and prevent cavities.	SPADNS technique was used in order to have accurate measurement. In order to achieve accurate reading, reaction rate between fluoride and zirconium ions was severely influenced by acidity of the reaction mixture.
8	Manganese (Mn*)mg/L	Manganese is a chemical element with the symbol Mn. It is hard, brittle, silvery metal, often found in minerals in combination with iron.	The pre-sulphate method was employed in the presence of silver nitrate due to the fact that water use to have some trace of organic matter.
9	Ammonia (NH3)mg/L	Ammonia in water is non-toxic to human, but it is toxic to aquatic life. It is a colourless highly irritating gas with a sharp suffocating odour.	This was retrieved from the samples by alkaline distilled condition into a solution made of boric acid which was followed by titration with standard acid.



S/N	Parameters/Elements	Description	Methodology
10	Nitrate(NO ₃ ²⁻)mg/L	Nitrate is a compound that naturally occurs and has many human-made sources. In some lakes, rivers and ground water you cannot taste, smell or see nitrate in water.	The Devarda's alloy procedure was adopted to establish the concentration of Nitrate in water sample. The analysis was undertaken in both original sample and in residue from the ammonia determination due to the fact that it is an end product of aerobic breakdown of organic nitrogenous matter.
11	Sulphate (SO ₄ ²⁻)mg/L	Sulphate ion is a polyatomic anion with the empirical formula SO ₄ ²⁻ Salts, acid derivatives, and peroxides of sulphate in the food industry in a wide variety of product.	This can adopt two methods to analyse sulphate that include Titrimetric procedure and gravimetric, which involve drying of residue techniques, the former was adopted for efficient data analysis.
12	Nitrite (NO ₂)mg/L	Nitrite ion has the chemical formula of NO ₂ which is commonly used in chemical and pharmaceutical industries. The anion is a pervasive nitrogen cycle in nature.	Nitrate and Nitrite can be determined in water by liquid chromatography, down to a level of 0.1mg/l for nitrate and 0.05 mg/l for nitrite (ISO, 1992).
13	Sodium (Na)mg/L	Sodium is a key mineral in human diet. It is easily seen as sodium chloride (salt) in its natural state. It does not have smell and can easily dissolve in water to give taste of salt.	Its concentration was determined by using flame photometry.
14	Potassium (K ⁺) mg/L	Potassium is a mineral and electrolyte, meaning it conducts electricity. It is essential for all of the body's function	This was established by triggering it with sodium cobaltinitrite. There was oxidation of dipotassium sodium cobaltinitrite with standard potassium dichromate using calorimetric technique. Several standards with identified concentrations of potassium were used in each sample in order to evade the effect of change in temperature.
15	Alkalinity mg/L	Alkalinity is the capacity of water to resist acidification. It is the strength of buffer solution composed of weak acids and their conjugate	This very one use electrometric titration to determine the extent of alkalinity concentration in the sample of water. It also titrate the used sample with a standard solution of tough mineral acid.
16	Total Hardness mg/L	Total hardness is the sum of the calcium and magnesium concentrations both expressed as calcium carbonate.	Total hardness in water is determined using the preprogrammed method, T7A Total Hardness. To determine total hardness, ammonia buffer is added to a sample to adjust pH to 10.0. The sample is then titrated to the equivalence point using ethylenediaminetetraacetic acid (EDTA) titrant.
17	Calcium Hardness mg/L	Calcium Hardness is a measure of the amount of calcium ions present in the water. Hard ^o means that it has a high mineral content. Which are made up of calcium and magnesium carbonates, bicarbonates, chloride or sulfates	Calcium Hardness in water is determined using the preprogrammed method.T10 Ca Hard. To determine calcium, sodium hydroxide is added to a sample to raise the pH to 12 to13.The sample is then titrated to the equivalence point using ethylenediaminetetraacetic acid (EDTA) titrant.
18	Magnesium Hardness mg/L	Magnesium is one element that has the symbol of Mg with atomic number of 12. Magnesium is a shiny gray metal with little density, little	This one used titrimetric procedure to establish the Magnesium concentration which was done by adding EDTA to the sample of water containing magnesium and calcium ions, as it reacts with



S/N	Parameters/Elements	Description	Methodology
19	Chloride (Cl)mg/L	melting point and great chemical reactivity. Chloride is a type of electrolyte. It works with other electrolytes such as potassium, sodium and carbondioxide (CO ₂)	calcium first before reacting with magnesium, calcium is produced as the oxalate as it is removed through filtration before titration. Silver and mercuric nitrates techniques were adopted in the titration to establish extent of chloride. However, the silver nitrate method was established in neutral or slightly alkaline solution by means of titration with standard silver nitrate by applying indicator of potassium chromate.
20	Calcium(Ca ²⁺) mg/L	It measure the amount of ions present in the water. Calcium is the measurement of dissolved calcium in hot tub or pool water	It was determined in the presence of magnesium by EDTA titration.
21	Zinc ppm	Zinc is a lustrous bluish –white metal. It is found in group IIB of the periodic table. It is brittle and crystalline at ordinary temperature, but it becomes ductile and malleable when heated between 110°C and 150°C	Fluorescence method of measuring zinc. Simply dip one strip into the water for 3 seconds, remove the strip and shake once to remove excess water, wait 20 seconds for the color to develop, and match with the closest color match to determine your concentration of zinc
22	Iron ppm	Iron is a chemical element with symbol Fe and atomic number 26.It is a metal that belongs to the first transition series and group 8 of the periodic table .it is ,by mass, the most common element on earth, just ahead of oxygen.	Total amount of iron in water can be measured using a color-changing test strip which is a kit that senses the extent of ions in the sampled water.
23	Carbonates	Carbonates in water can form hardness. Carbonate hardness is very common. Alkalinity is usually the concentration of the bicarbonate (HCO ₃ ⁻) ion in water.	This experiment employed the atomic absorption spectro-photometry (AAS) technique by tracing the elements in sample of water, as this is the main principle commonly adopted in the laboratory for analysis.
24	Total Suspended Solid	Total Suspended Solid (TSS) is the solid found in water which can be easily trapped by a filter.	A water sample is filtered through a pre-weighed glass fiber filter, capturing the solids larger than 2 um. Then, the filter is dried in an oven to remove remaining water and weighed again. The weight difference over the sample volume provides the TSS concentration in mg/l

Source: Authors Computation

3. Results

Table 2 showed results of stream collected samples in wet and dry seasons. Thus, the stream temperature in wet season had 28.7°C which was lower than stream temperature in dry season having 29.2°C. The WHO recommended limit is 23.5°C indicating that stream temperature was above WHO limit. Manganese concentration in dry season was 1.09mg/l which was above 0.2mg/L recommended by WHO standard. Therefore water from stream source could be dangerous for human health and it should be treated before domestic use.



Table 2: Results of Stream Water Collected Samples in Wet and Dry Seasons

S/N	Parameters	WHO Maximum Level	Wet Season	Dry Season
1	Temperature 0c	23.5	28.7	29.2
2	Dissolved Oxygen mg/l	10	5.8	6.14
3	Turbidity NTU	5	1.56	1.60
4	Conductivity μ S/cm	1000	8.7	168.0
5	Total dissolved solid mg/L	500	151.6	149.5
6	PH	8.5	8.1	8.3
7	Fluoride (F) mg/L	1.5	1.10	0.7
8	Manganese (Mn ⁺) mg/L	0.2	0.16	1.09
9	Ammonia(NH ₃) mg/L	NM	2.28	2.39
10	Nitrate (NO ₃ ²⁻) mg/L	50	11.95	9.38
11	Sulphate(SO ₄ ²⁻) mg/L	100	12.9	13.5
12	Nitrite (NO ₂ ⁻) mg/L	0.2	0.022	0.016
13	Sodium(Na ⁺) mg/L	200	28.5	16.0
14	Potassium(K ⁺) mg/L	200	38.5	71.7
15	Alkalinity mg/L	200	132.5	134.6
16	Total hardness mg/L	500	116.74	140.9
17	Calcium Hardness mg/L	150	111.57	122.8
18	Magnesium hardness mg/L	150	77.4	139.3
19	Chloride(Cl ⁻) mg/L	250	22.4	19.6
20	Calcium(Ca ²⁺) mg/L	200	36.4	41.02
21	Zinc ppm	5mg	1.13	0.93
22	Iron ppm	0.3	0.17	0.22
23	Carbonate(CO ₃ ²⁻) mg/L	400	132.2	98.6
24	Total suspended Solid(TSS)	300	137.1	127.9

Source: Authors Computation

The study also revealed in Table 3 that well water samples in wet and dry seasons were below WHO standard permissive level. Thus, chloride concentration in wet season was 17.96mg/L and 17.1mg/l in dry season which was below WHO standard. Temperature was the only parameter that was above WHO standard limit with 27^oC in wet season and 29.20^oC during dry season.

This study is contrary to the findings of John (2015) who carried out water quality assessment of tropical stream in University of Abuja, between March to May, 2014. The parameters investigated in the laboratory were electrical conductivity, pH, total solids, total hardness, permanent hardness, temporary hardness, dissolved solids, suspended solids, dissolved oxygen, biological oxygen demand, taste, odor, alkalinity, temperature, and chlorides. However, from the result it was found that dissolved oxygen ranged from 0.91 - 1.51mg/l and total hardness ranged from 120-200ppm which were above WHO permissible limit. Therefore, the study recommended that such stream water should be used for agricultural purposes such as irrigation. Also, Aryal et al. (2012) carried drinking water quality assessment in Nepal. The study analyzed 84 water samples from natural source, reservoirs and tap water, and matches them with WHO standards. Thus, 15.48% of water samples showed pH (13) higher than the WHO permissible standard. Similarly, 85.71% of



water samples showed higher Arsenic value (72) than WHO value. The result indicated that water samples were within Nepal national standard and WHO standards except arsenic. It was found that coliform contamination to be the key problem with drinking water in the study area.

Table 2: Results of Well Water Collected Samples in Wet and Dry Seasons

S/N	Parameters	WHO Maximum Level	Wet Season	Dry Season
1	Temperature °C	23.5	27	29.2
2	Dissolved Oxygen mg/l	10	5.0	5.79
3	Turbidity NTU	5	1.27	3.4
4	Conductivity µS/cm	1000	36.5	268.2
5	Total dissolved solid mg/L	500	103.1	130.4
6	PH	8.5	7.28	7.88
7	Fluoride (F) mg/L	1.5	0.61	0.66
8	Manganese (Mn ⁺) mg/L	0.2	0.125	0.81
9	Ammonia(NH ₃) mg/L	NM	1.44	118.2
10	Nitrate (NO ₃ ²⁻) mg/L	50	5.59	7.13
11	Sulphate(SO ₄ ²⁻) mg/L	100	18.66	14.6
12	Nitrite (NO ₂ ⁻) mg/L	0.2	0.013	0.005
13	Sodium(Na ⁺) mg/L	200	9.415	146.7
14	Potassium(K ⁺) mg/L	200	22.5	50.5
15	Alkalinity mg/L	200	114.3	85.8
16	Total hardness mg/L	500	106.1	129.2
17	Calcium Hardness mg/L	150	109.1	132.0
18	Magnesium hardness mg/L	150	60.2	139.6
19	Chloride(Cl ⁻) mg/L	250	17.96	17.1
20	Calcium(Ca ²⁺) mg/L	200	28.92	40.5
21	Zinc ppm	5mg	0.69	0.85
22	Iron ppm	0.3	0.22	0.21
23	Carbonate(CO ₃ ²⁻) mg/L	400	119.7	119.8
24	Total suspended Solid(TSS)	300	109.3	105.9

Source: Authors Computation

4. Conclusion

The result from the physico-chemical analysis of water samples were within WHO standard guideline. However, the study revealed that temperature rise of water was the major problem with stream and well waters. This indicated that the waters were not safe for drinking. Thus, it has become imperative for people and authorities living in the urban areas such as Minna Metropolis in Niger State, Nigeria to begin taking action on the availability of quality and sustainable water safe from contamination. The study showed that greater number of the population is at risk of drinking polluted water across the globe. It is therefore, very urgent for governments to initiate quality education on water resources management without further delay.

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