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Research Article

The Effect of Uncontrolled Dumping of Solid Waste on Groundwater in Osun State, Nigeria

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Abstract: Background: This study analyzed physical, chemical and heavy metal properties of groundwater in well water and tap water (6 each) around eight dumpsites in Osun State, Nigeria. Two Batches of Samples were collected (Batch A & B) which were respectively obtained in January and July. Heavy metals were determined using Atomic Absorption Spectrophotometer (AAS) and this led to the investigation of the impacts of open dumpsite on groundwater quality, the concentration of the examined variables where compared with World Health Organization (WHO) standard limits of drinking water. **Results:** The pH in water samples range from 5.2-8.6, conductivity in samples range from 100-260 µS. Nitrate in water samples range from 3.1151 mg/L-12.179 mg/L, chloride in water samples range from 15.2 mg/L-151.6 mg/L. Total Hardness (TH) in water samples range from 34 mg/L-146 mg/L, lead in well water range from none detected to 0.97 mg/L and tap water range from 0.00 mg/L-1.00 mg/L. Cadmium in well water range from none detected to 0.007 mg/L and all samples in tap water range from 0.069 mg/L-0.240 mg/L. Some of these parameters were found to exceed the World Health Organization standard limit in well water and tap water. Concentrations of heavy metals and chemicals parameters such as chromium, lead, and iron were found to be higher in groundwater in batch B tap water and batch A well water, while, total hardness and NO^-_3 were the chemical parameters with higher concentrations in most water samples. **Conclusion:** The result shows that some groundwater sources are unfitted for the consumption in Osun State.

***Keywords*:** groundwater, dumpsites, heavy metals, total hardness

1. Background

In African nations, thousands of tons of solid garbage are produced every day.[1] Less than half of the solid waste produced in Nigeria is collected, and 95% of that quantity is either randomly dumped at numerous dumping sites outside of metropolitan centers or dispersed around the city on a variety of so-called temporary sites.[2] Through the introduction of various toxicants, including heavy metals in well and tap, the indiscriminate and open disposal of trash can lead to environmental deterioration.[3]

Humans depend on water for survival, surface water contamination has a profound impact on population stress. Depending on whether the pace of conveyance increases the flow of contaminants into surface water, rainfall events may

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either reduce or increase toxicity. Municipal solid trash is disposed in rivers and streams. The assimilative capacities of the receiving water bodies are typically given little to no thought when waste is discharged into them.[4]

Solid waste management is one of the biggest issues facing the communities and municipalities, and open dumping of municipal waste is a frequent practice in Nigeria.[5] According to the recent survey, most municipalities dispose of their municipal solid trash in open places, ignoring important residential zones, road edges, drainage areas, rivers, riversides, and woods. Hazardous compounds, such as heavy metals, are subsequently introduced into the ecology of water.[5]

However, a thorough and in-depth investigation is required to determine the physiochemical characteristics of the tap and well water near Nigeria solid waste disposal sites, as well as their heavy metal content. Further research on the presence of heavy metals in the tap and water around dump sites has been suggested.[6] Heavy metal overexposure has a negative impact on the quality of ground and surface water and ultimately becomes hazardous to human health at the top of the food chain.[7]

Additionally, most waterways (natural surface drainage lines) that flow into the neighboring wells and streams may have a negative impact on the environment and public health. Now there are no unauthorized settlements in the vicinity of the dumpsite. Although there are no settlers in the surrounding area, it is well known that solid waste poses a number of risks to public health and negatively affects the quality of water, especially when it is not disposed of properly.[8]

From investigation, the management and characteristics of municipal solid waste in Nigeria, We find that one of the biggest problems facing environmental protection organizations in developing nations, particularly Nigeria, is the management of urban solid garbage. Improper disposal, inadequate coverage of the collection system, and ineffective collecting methods characterize solid waste management.[9] By conducting research on the characterization of domestic and commercial solid waste at the source in the Lagos metropolitan and came to a conclusion was made that waste management is a crucial aspect of environmental protection. Accurate characterization of municipal solid waste is being essential for the planning of municipal waste management services.[10]

Fresh water is a vital resource for people and calls for numerous measures, including a strong legal, social, and cultural framework as well as improved ecosystem services for the neighborhood and the entire planet.[11] Similar to this, the local population heavily utilizes the river close to Osogbo Local Government Area Osun State solid waste dump site for drinking, bathing, and irrigation.

There hasn't been a study done yet that demonstrates the degree of water pollution in comparison to values recommended by national and international guidelines. Therefore, the purpose of this research is to evaluate the impact of uncontrolled dumping of solid waste on groundwater in Osun State, Nigeria.

2. Methods

2.1 *Study area*

Osun State in Nigeria has a size of 47 square kilometers, and its capital city is Osogbo, which is located at 7° 46° North, 4° 34° East. The Olorunda Local Government Area and Osogbo Local Government Area both have their headquarters in Osogbo City, which is located in the city's OkeBaale neighborhood (situated atIgbonna Area of the city). It is located 88 kilometers to the north of Ibadan, 100 kilometers to the south of Ilorin, and 115 kilometers to the north of Akure. Located in the center of the state, as seen in Figure 1, Osogbo borders Ikirun, Ilesha, Ede, Egbedore, and Iragbiji and is easily accessible from any location inside the state.

The distances from Ife, Ilesha, Iwo, IKire, and Ila-Orangun are 48 km, 32 km, 46 km, 48 km, and 46 km, respectively. According to the 2006 population and housing commission census, the City has a population of approximately 156,694 people; the neighborhood's postal code is 230.

2.2 *Collection and analysis of samples*

Samples were obtained from groundwater in six (6) well water (labelled as W1, W2, W3, W4, W5 and W6) and six (6) tap water (labelled as T1, T2, T3, T4, T5 and T6) around six dumpsites in Osogbo Local Government Area, Osun State, and analysis was carried at in Department of Petroleum Chemistry, Delta State University of Science and Technology, Ozoro, Nigeria.

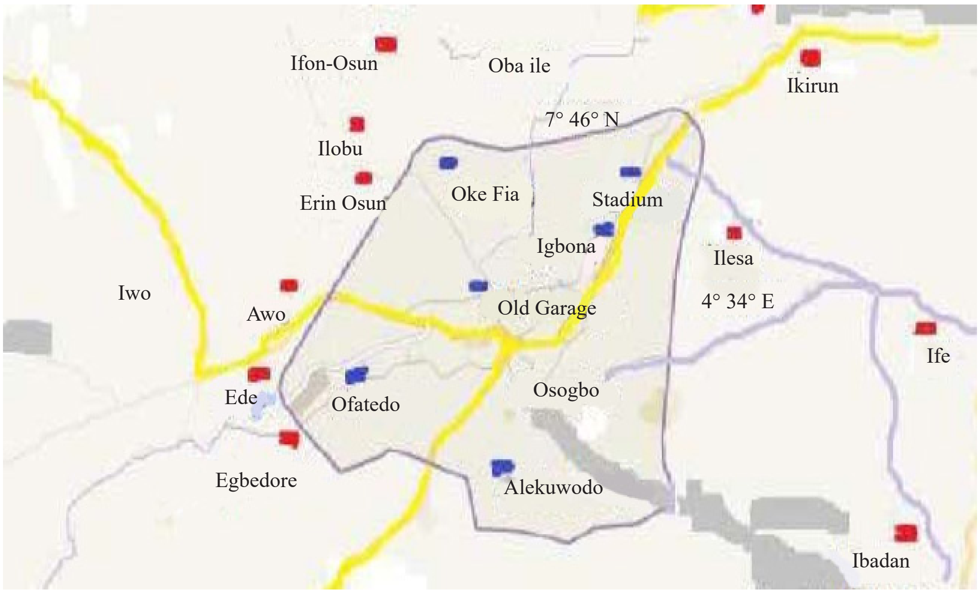

Figure 1. Map showing Osun State with it capital city Osogbo and other neighboring town

2.3 *Parameters examined*

Temperature (°C), pH, Nitrate (NO^{-3}), Chloride (Cl^{-}), Total Hardness (TH), Electrical Conductivity (EC), Iron (Fe), Chromium (Cr^{3+}), Silver (Ag), Copper (Cu) Cadmium (Cd), Nickel (Ni), and Lead (Pb) were among the physical and chemical characteristics studied in this study. The rationale for choosing these characteristics are based on the fact that they are prevalent pollutant components found in groundwater near dumpsites.

2.4 *Test on water*

Basically, there are two main types of tests carried out on the water samples which Include:

a. Chemical testing.

b. Physical testing.

Physical Testing: Temperature, color, turbidity test and odor test.

Chemical Testing: The water samples were collected in plastic containers and sample bottles. All samples were brought to the laboratory and then analyzed for various physicochemical parameters.

2.5 *Precaution for collection of samples*

In the process of sample collection, adequate care was taken while obtain the samples at the sampling point and also during the course of handling the sample so that it does not deteriorate or alter before it reaches the laboratory. In order to achieve this, preservation or sample bottles is usually used in conveying the sample to the laboratory. When collecting samples bottles were washed two times with water and labeled for a proper and easy identification.

Identity data includes:

- Name of sample collected.
- The point of sample collected > The time of sample collected.
- The date of sample collected.

2.6 *Analytical techniques and laboratory analysis*

The techniques of analysis used for the study of all elements in water followed the American Public Health Association (APHA) standard proposal from 2005. Specified physical, chemical, and heavy metals properties were examined in all samples.

pH test: The pH of the water sample was determined by using pH meter. The pH meter was simply immersed into the water and the values were noted and recorded.

Temperature: The temperature of the water was determined using thermometer. The thermometer was immersed into the water at the site of collection and the readings were recorded.

Electrical conductivity: The conductivity of the water sample was determined by using conductivity meter. The electrode of the device was immersed into the water sample and the readings were taken.

Total hardness: 50 mL of properly stirred water was pipetted into a conical flask, followed by 1 mL of ammonium buffer and 2-3 drops of Eriochrome Black-T indicator. The solution is titrated against 0.01 M Ethylenediaminetetraacetic Acid (EDTA) until the wine-red color changes to pale blue at the end point.

Nitrate test: In a hot water bath, a specified amount (50 ml) of the sample of water was pipetted into a porcelain dish and evaporated to dryness. By constantly swirling with a glass-stirring rod, 2 mL of phenoldisulfonic acid was introduced to disintegrate the residue. To make it becoming alkaline, a concentrated solution of sodium hydroxide or concentrated ammonium hydroxide was mixed with distilled water and stirred in. This was filtered into a Nessler's tube and distilled water was used to make up to 50 mL. After colour maturation, the absorbance was read with a spectrophotometer at 410 nm. Concentration was displayed on the X-axis, while spectrophotometric measurements (absorbance) are plotted on the Y-axis. The nitrate valuation was calculated by equating the sample's absorbance to the standard curve and is expressed in mg/L.

Chloride test: About 50 ml of water sample was pipetted into a conical flask and 0.5 ml of chromatic indicator was added and then titrated against silver nitrate ($AgNO_3$) solution to end point.

Heavy metal analysis: About (100 ml) of water sample was measured into a conical flask and 5 ml of nitric acid (HNO_3) is added and heated at 350 °C on a hot plate till about 20-25 ml is evaporated. On cooling filtered and made up to 100 ml with distilled water and analyzed the heavy metals (cadmium, zinc, copper, lead, chromium and nickel) with Atomic Absorbance Spectrometer (AAS) machine. Blank is using distilled water.

3. Results

3.1 *Data presentation and analysis*

Water samples were evaluated to understand the effect of solid waste on the quality of underground water samples in surrounding areas. The data is presented in the form of a tables and test for effective data results presented. Batch A represents samples collected on the 15th of January, 2021 while batch B represents samples collected on the 28th of July, 2021.

Table 1. Physical variables of batch A well water

S/N	Temperature (°C)	Turbidity	Appearance	Odour
WHO standard	35-40	Clear	CL	ODL
W1	27.2	Not Clear	C	Unpleasant
W2	28.1	Clear	CL	ODL
W3	27.9	Not Clear	C	Unpleasant
W4	27.0	Clear	CL	ODL
W5	27.7	Clear	CL	ODL
W6	27.5	Clear	CL	ODL

CL: Colourless; C: Colourful; ODL: Odourless

The result above represents physical variables of batch A well water. Well 4 had the lowest temperature of 27.0 °C while well 2 had the highest temperature of 28.1 °C but none exceeded WHO standard limit. Well 1 and well 3 were found to exceed WHO standard of drinking water in turbidity, appearance and odor (Table 1).

Table 2. Physical variables of batch B well water

S/N	Temperature (°C)	Turbidity	Appearance	Odour
WHO standard	35-40	Clear	CL	ODL
W1	27.0	Not Clear	C	Unpleasant
W2	27.3	Clear	CL	ODL
W3	28.0	Not Clear	C	Unpleasant
W4	26.9	Clear	CL	ODL
W5	27.8	Clear	CL	ODL
W6	27.6	Clear	CL	ODL

CL: Colourless; C: Colourful; ODL: Odourless

Table 2 depicts the physical variables of batch B well water. Well 4 had the lowest temperature of 26.9 °C while well 3 had the highest temperature of 28.0 °C but none exceeded WHO standard limit. Well 1 and well 3 were found to exceed WHO standard of drinking water in turbidity, appearance and odor.

Table 3. Physical variables of batch A tap water

S/N	Temperature (°C)	Turbidity	Appearance	Odour
WHO standard	35-40	Clear	CL	ODL
T1	29.3	Clear	CL	ODL
T2	27.0	Clear	CL	ODL
T3	27.5	Clear	CL	ODL
T4	26.9	Clear	CL	ODL
T5	27.7	Clear	CL	ODL
T6	28.1	Clear	CL	ODL

CL: Colourless; C: Colourful; ODL: Odourless

The result above shows physical variables of batch A tap water. Tap 4 had the lowest temperature of 26.9 °C while tap 1 had the highest temperature of 29.3 °C but none exceeded WHO standard limit. All other samples were found to be within WHO standard of drinking water in turbidity, appearance and odor (Table 3).

Table 4 shows the physical variables of batch B tap water. Tap 4 had the lowest temperature of 26.9 °C while tap 1 had the highest temperature of 29.3 °C but none exceeded WHO standard limit. All other samples were found to be within WHO standard of drinking water in turbidity, appearance and odor.

Table 4. Physical variables of batch B tap water

S/N	Temperature (°C)	Turbidity	Appearance	Odour
WHO standard	35-40	Clear	CL	ODL
T1	29.3	Clear	CL	ODL
T2	27.0	Clear	CL	ODL
T3	27.5	Clear	CL	ODL
T4	26.9	Clear	CL	ODL
T5	27.7	Clear	CL	ODL
T6	28.1	Clear	CL	ODL

CL: Colourless; C: Colourful; ODL: Odourless

The result below represents the analysis of pH in tap and well water (batch A and B). For batch A tap water pH was below WHO standard in tap 3 with a value of 5.2, in tap 6 (8.6) pH exceeds the WHO standard. Meanwhile, other samples were within WHO standard limit of drinking water. While, for batch B tap water pH was found to exceed WHO standard in tap 3 with a value of 5.2, other samples were within WHO standard limit of drinking water. Also, for batch A well water pH was found to exceed WHO standard in well 3 with a value of 5.6 and well 4 with a value of 5.9 other samples were within WHO standard limit of drinking water. In addition, it was noticed that batch B well water pH in all samples was found to be within WHO standard except well 3 with a value of 5.2 that exceeded WHO standard of drinking water (Figure 2).

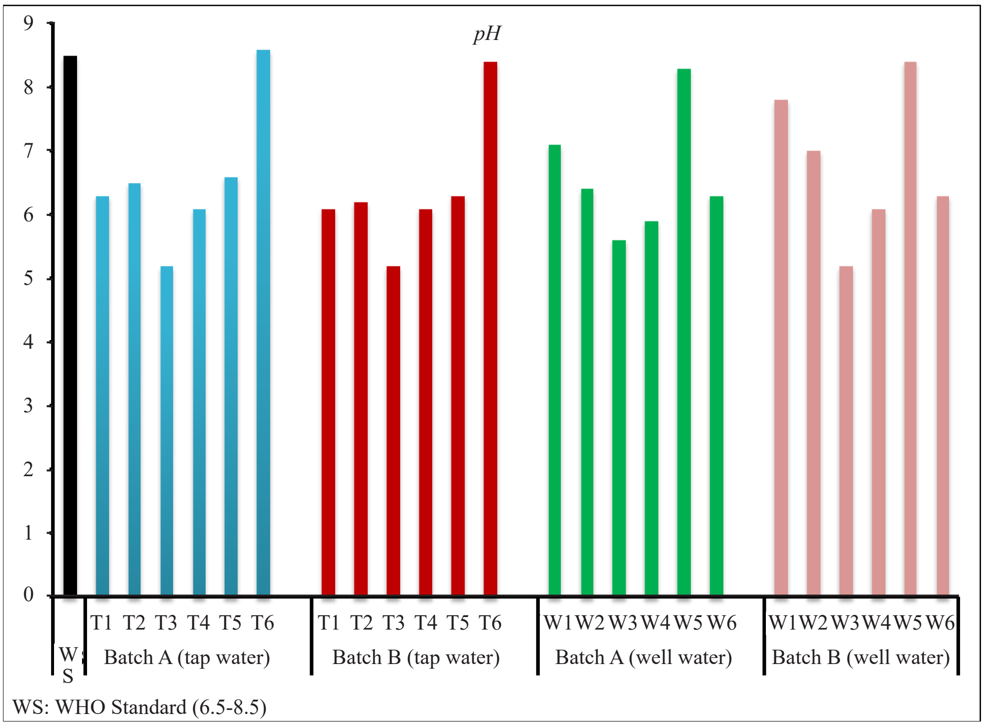

Figure 2. Analysis of pH in tap water and well water (Batch A and B)

The results shown in Figure 3 depict that batch A tap water shows that the conductivity ranges from 140 µS-181 µS. While for batch B tap water, it ranges from 100 µS-158 µS. The conductivity for Batch A well water was from 133 µS-260 µS. Meanwhile batch B well water ranges from 121 µS-161 µS. (Figure 3).

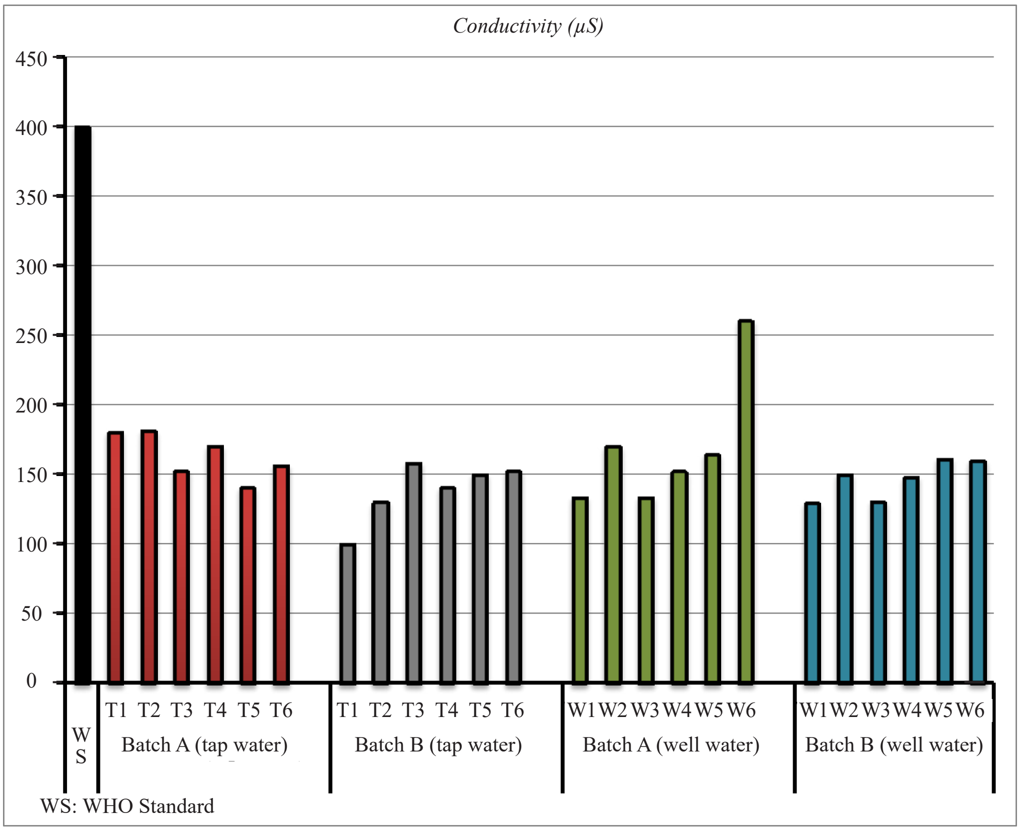

Figure 3. Analysis of conductivity in tap water and well water (Batch A and B)

Figure 4 show that tap 4 had the lowest nitrate of 3.1151 mg/L while tap 1 had the highest nitrate of 9.681 mg/L in batch A tap water. For batch B tap water it shows that tap 5 had the lowest nitrate of 3.985 mg/L while tap 1 had the highest nitrate of 9.485 mg/L. Also, batch A well water shows that well 2 had the lowest nitrate of 4.2915 mg/L while tap 1 had the highest nitrate of 11.7332 mg/L. Furthermore, it was recorded that in batch B well water well 6 had the lowest nitrate of 4.626 mg/L while tap 1 had the highest nitrate of 12.179 mg/L. (Figure 4).

The result shown in Figure 5 illustrates the value of chloride present in the samples. For batch A and B tap water, chloride ranges from 32 mg/L-61.1 mg/L and 31.9 mg/L-71.9mg/L respectively. Meanwhile for batch A and B well water chloride ranges from 31.3 mg/L-151.6 mg/L and 15.2 mg/L-121.3 mg/L respectively (Figure 5).

Figure 6 shows the total hardness of all four samples. In batch A tap water, tap 1 had the lowest total hardness of 42 mg/L while tap 3 had the highest total hardness of 66 mg/L but none exceeded WHO standard limit. Tap 5 had the lowest total hardness of 34 mg/L while tap 6 had the highest total hardness of 62 mg/L in batch B tap water but none exceeded WHO standard limit. Meanwhile, in batch A well water total hardness was found to exceed WHO standard in well 4 with a value of 110 mg/L and well 5 with a value of 146 mg/L other samples were within WHO standard limit of drinking water. In batch B well water, Total hardness was found to exceed WHO standard in well 4 with a value of 108 mg/L and well 5 with a value of 142 mg/L other samples were within WHO standard limit of drinking water (Figure 6).

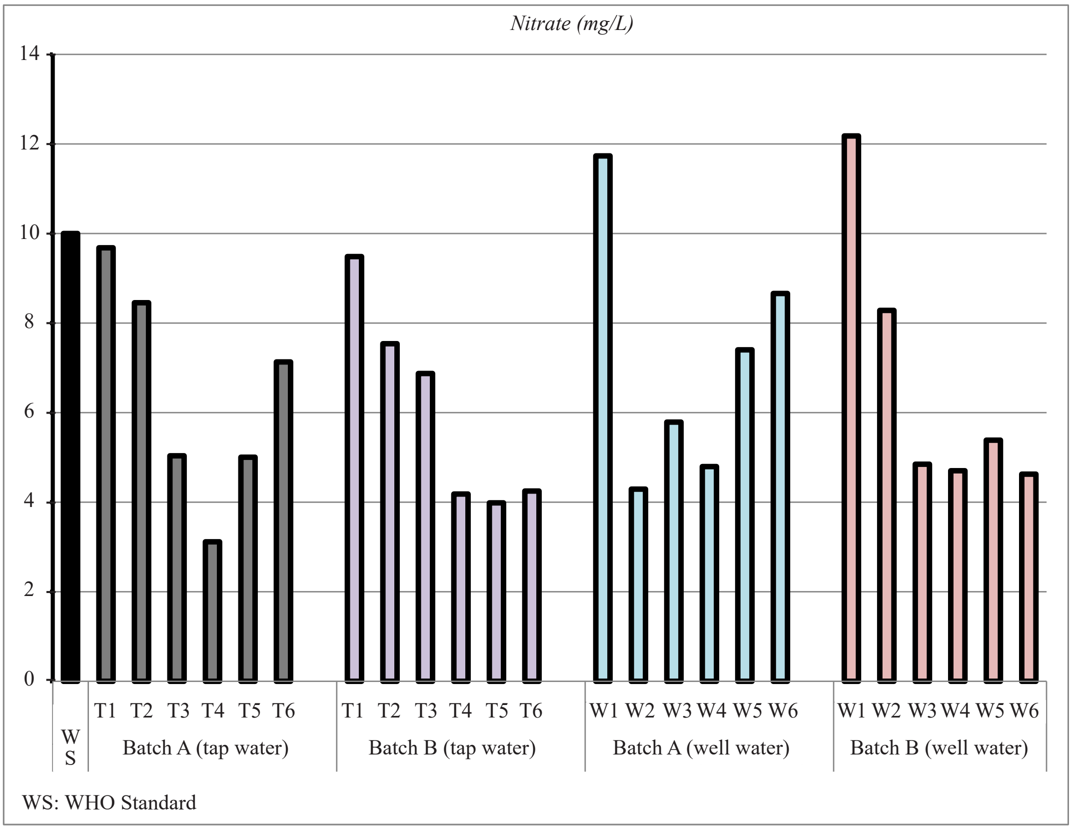

Figure 4. Analysis of nitrate in tap water and well water (Batch A and B)

Table 5. Heavy metals variables of batch A tap water

S/N	Pb (mg/L)	Cd (mg/L)	Zn (mg/L)	Fe (mg/L)	Cu (mg/L)	Cr (mg/L)	Ni (mg/L)
WHO Standard	0.01	0.003	3.00	0.5-50	2.00	0.05	0.2
T1	ND	0.000	0.2003	0.726	0.021	0.236	ND
T2	0.19	0.003	0.3772	0.999	0.018	0.088	ND
T3	ND	ND	0.2962	0.504	0.023	0.103	ND
T4	0.09	0.001	0.2064	0.520	0.000	0.129	ND
T5	0.06	ND	0.5494	0.049	0.003	0.069	ND
T6	ND	0.002	0.2887	0.083	ND	0.218	ND

ND: Not Detected

Table 5 depicts the heavy metals variables of batch A tap water. Lead was not detected in T1, T3 and T6 while T2: 0.19 mg/L, T4: 0.09 mg/L and T5: 0.06 mg/L were detected and found to exceed WHO standard of drinking water. Cadmium was not detected in T3 and T5, other samples were found within the WHO standard. Zinc ranges from 0.2003 mg/L-0.999 mg/L. Iron ranges from 0.049 mg/L-0.504 mg/L. Copper was detected in all samples except tap 6 and was found to be within WHO standard. Chromium ranges from 0.088 mg/L-0.236 mg/L. Nickel was not detected in all samples.

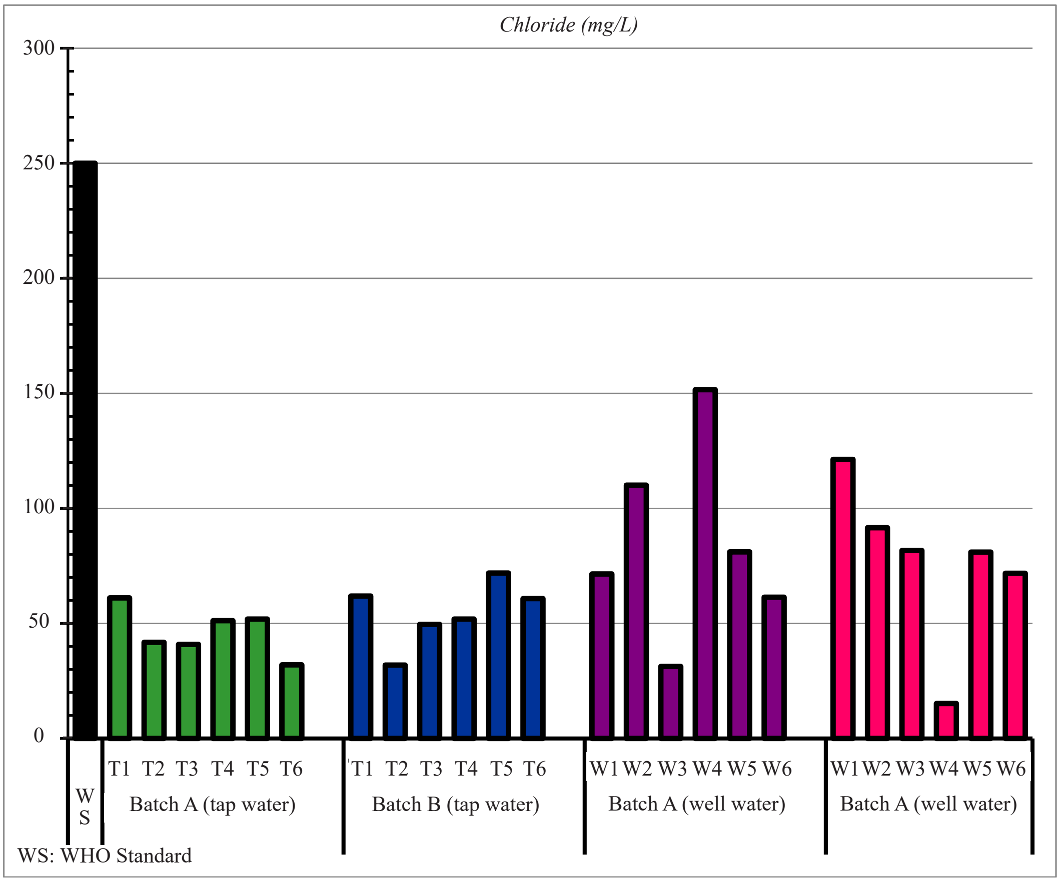

Figure 5. Analysis of chloride in tap water and well water (Batch A and B)

Table 6. Heavy metals variables of batch B tap water

S/N	Pb (mg/L)	Cd (mg/L)	Zn (mg/L)	Fe (mg/L)	Cu (mg/L)	Cr (mg/L)	Ni (mg/L)
WHO Standard	0.01	0.003	3.00	0.5-50	2.00	0.05	0.2
T1	0.17	0.002	0.1132	0.150	0.010	0.123	ND
T2	1.00	ND	0.0286	0.149	0.029	0.129	ND
T3	0.25	0.000	0.1307	0.063	0.014	0.149	ND
T4	0.10	ND	0.0188	0.072	0.003	0.210	ND
T5	0.28	0.003	ND	0.495	ND	0.104	ND
T6	0.00	ND	0.0448	0.377	0.001	0.171	ND

ND: Not Detected

The table above represents heavy metal variables of batch B tap water. Leads was detected in all samples and ranges from 0.00 mg/L-1.00 mg/L and were found to exceed WHO standard of drinking water. Cadmium was not detected in T2 and T4, other samples were found within the WHO standard. Zinc ranges from 0.0188 mg/L-0.1307 mg/L except T5 that was not detected. Iron ranges from 0.063 mg/L-0.495 mg/L. Copper was detected in all samples except tap 5 and were found in all samples to be within WHO standard. Chromium ranges from 0.104 mg/L-0.210 mg/L.

Nickel was not detected in all samples (Table 6).

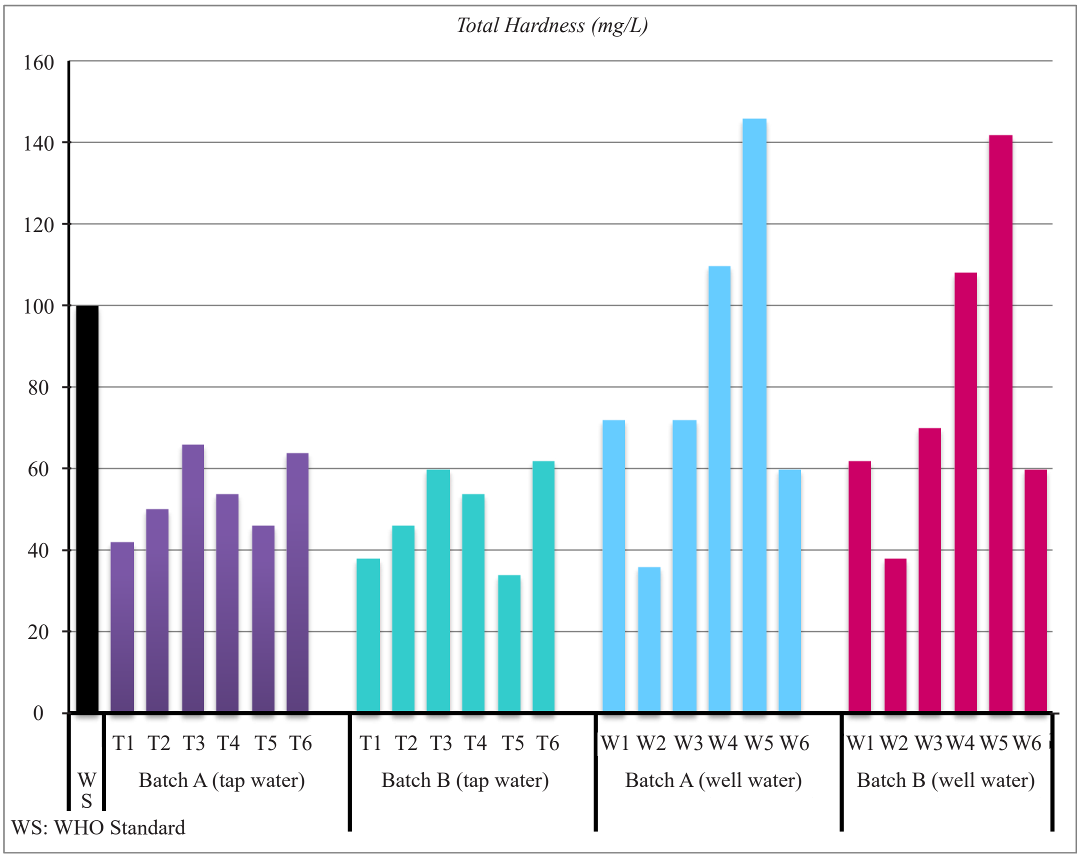

Figure 6. Analysis of total hardness in tap water and well water (Batch A and B)

Table 7. Heavy metals variables of batch A well water

S/N	Pb (mg/L)	Cd (mg/L)	Zn (mg/L)	Fe (mg/L)	Cu (mg/L)	Cr (mg/L)	Ni (mg/L)
WHO Standard	0.01	0.003	3.00	0.5-50	2.00	0.05	0.2
W1	0.09	ND	0.1649	0.818	0.013	0.217	ND
W2	ND	0.000	0.0934	1.367	0.014	0.125	ND
W3	0.16	ND	0.0719	1.139	0.015	0.214	ND
W4	ND	0.001	0.0975	2.962	0.007	0.240	ND
W5	0.04	0.001	0.0762	0.797	0.006	0.141	ND
W6	ND	0.007	0.2432	0.065	ND	0.235	ND

ND: Not Detected

The result above shows heavy metal variables of batch A well water. Lead was not detected in W2, W4 and W6 while W1: 0.09 mg/L, W3: 0.16 mg/L and W5: 0.04 mg/L were detected and found to exceed WHO standard of drinking water. Cadmium was not detected in W1 and W3, other samples were found within the WHO standard except W6 with a value of 0.007 mg/L. Zinc ranges from 0.0719 mg/L-0.2432 mg/L. Iron ranges from 0.065 mg/L-2.962 mg/L. Copper was detected in all samples except well 6 and was found in all samples to be within WHO standard. Chromium ranges from 0.125 mg/L-0.240 mg/L. Nickel was not detected in all samples (Table 7).

Table 8. Heavy metals variables of batch B well water

S/N	Pb (mg/L)	Cd (mg/L)	Zn (mg/L)	Fe (mg/L)	Cu (mg/L)	Cr (mg/L)	Ni (mg/L)
WHO Standard	0.01	0.003	3.00	0.5-50	2.00	0.05	0.2
W1	0.13	ND	0.0362	0.074	ND	0.192	ND
W2	ND	0.001	0.0666	0.011	0.002	0.172	ND
W3	ND	0.001	0.0082	0.053	ND	0.126	ND
W4	0.17	ND	0.0441	0.027	0.041	0.091	ND
W5	0.97	0.003	0.0311	0.046	0.002	0.133	ND
W6	0.17	ND	ND	0.036	ND	0.074	ND

ND: Not Detected

Table 8 depicts the heavy metal variables of batch B well water. Lead was not detected in W2 and W3, while W1: 0.13 mg/L, W4: 0.17 mg/L, W5: 0.97 mg/L and W6: 0.17 were detected and found to exceed WHO standard of drinking water. Cadmium was not detected in W1, W4 and W6, while other samples were found within the WHO standard. Zinc ranges from 0.0719 mg/L-0.2432 mg/L. Iron ranges from 0.0082 mg/L-0.0666 mg/L except for well 6 that was not detected. Copper was not detected in W1, W3 and W6, while other samples were found to be within WHO standard. Chromium ranges from 0.091 mg/L-0.192 mg/L. Nickel was not detected in all samples.

4. Discussion

Contaminants can be classified as natural or man-made. Groundwater is clear and pure because particle debris is naturally filtered out by the ground, but it is also created by humans.[12] Metals such as iron and magnesium are dissolved as groundwater runs through the subsurface and can be found in high amounts in the water. Groundwater is contaminated by chemical compounds.

All the factory discharge, urban operations, agro-based, aquifers plumage and sewage disposal have impact on water quality. Contamination such as fuel spills or toxic chemicals, pesticides and fertilizers applied to farmland can accrue and adapt to a ground water. Pesticides and herbicides that soak into compost can inevitably end up in water taken from a well that has been put on land that was originally used for something like a garbage or chemical dumping site, leakage from septic systems or waste dumps can bring microorganisms to the water. In any case, if you have a well, use it to provide potable water to your home. It's a good idea to get your well water tested for contaminants.

The analysis of the physical properties of sampled batch A and B well water (Table 1 and Table 2) shows that in all sample locations, temperature ranged between 26.9 °C-29.3 °C below the WHO standard limits of 35 °C-40 °C. Indicating the presence of foreign bodies such as active microorganisms.[13] Turbidity appearance and odor of sampled batch A and B well water was also below WHO standard except for W1 and W3 that was above the WHO standard of colorless, odorless and clear. Algae was also observed growing in and around W3 sampled. Physical properties of sampled batch A and B tap water show that in all sample locations, temperature, turbidity, appearance and odor were within the WHO standard.

The concentration of chemical properties of batch A and B well and tap water samples are shown in Figure 2, 3, 4, 5 and 6 to compare with WHO standards of drinking water.

The pH concentration of batch A tap water T1 (6.3), T3 (5.2) and T4 (6.1) was below the WHO standard (6.5-8.5) of water quality. For batch B tap water, except for T6 (8.4) all other samples where below the WHO standard of water quality. Meanwhile for Batch A well water W2 (6.4), W3 (5.4), W4 (5.9), W6 (6.3) was below the standard. Also, the pH concentration for Batch B well water, W3 (5.2), W4 (6.1) and W6 (6.3) were also below the WHO standard of water quality. This might have been as a result of the interactions of carbon dioxide, bicarbonate and carbonate systems in dumpsites that have leached and polluted the groundwater.[14] A water supply's inherent pH of 7 will typically become unbalanced when chemicals, minerals, pollutants, soil or bedrock composition, and other impurities interact with it. In summary, environmental conditions play a major role in determining the pH of water, whether it is high or low.[15] It is well recognized that a variety of chemicals and contaminants raise pH levels, which can increase water alkalinity. If there are carbonate, bicarbonate, or hydroxide chemicals in the soil or bedrock near groundwater sources, those substances dissolve and move with the water. The alkalinity of the water is likewise raised by these mineral deposits. It is indicated that a supply of drinking water is contaminated with contaminants and hazardous to drink is when the pH value changes considerably over a short period of time. Water that has a low acidic or high alkalinity can have a flat, bad smell and unpleasant taste.[16] PH is often regarded to have an indirect effect on human health.[18] The US Environmental Protection Agency claims that it can also harm pipes and hasten the wear and tear of appliances.

All samples collected both well and tap water were within the WHO standard for Electrical Conductivity (EC) in water. Although WHO has not set any guidelines for the value for EC in drinking water, it gives an indication about the level of result of contamination.[17] Additionally, the water's temperature affects conductivity. Conductivity rises as the water temperature rises. Also, conductivity increases in lakes that do not receive enough rain or stream water. This is due to the fact that salts are not removed by evaporation. Conductivity rises with salinity because dissolved salts and other Oil and other organic materials have a low electrical conductivity in water because they do not conduct electricity well.[18] Inorganic dissolved particles including sodium, magnesium, calcium, iron, and aluminum cations or chloride, nitrate, sulfate, and phosphate anions (ions with a negative charge) have an impact on conductivity in water (ions that carry a positive charge) as well. More filtration will often result in lower conductivity and fewer dissolved solids.[19]

Nitrate (NO^{-}_{3}) concentrations in all samples were found within the WHO standard limits of 10 mg/L except for Batch A and B W1, which were 11.7332 and 12.179 mg/L respectively. The presence of nitrate in these two samples might be as a result of common forms of chemicals contaminants that have leached from dumpsites into the groundwater aquifer. High nitrate level in water reduces the ability of erythrocyte to transport oxygen.[20] Ingestion of nitrate in drinking water can result in health conditions, often life-threatening, such as methemoglobinemia, or blue baby syndrome in infants under the age of six months. Runoff or leakage from fertilized soil, wastewater, landfills, animal feedlots, septic systems, or urban drainage can all contribute to high levels of nitrate in water. A high concentrations can cause the skin to turn blue or gray and more serious health effects like weariness, weakness, and dizziness.[21] Nitrate levels in drinking water might be low as a result of natural processes. Water alterations Lowering the total nitrate level in the aquarium can be accomplished by doing routine water changes using water that contains little to no nitrate. Using Deionized water (DI) or Reverse Osmosis water (RO) can assist maintain nitrate levels low when doing a water change if your local tap or well water is high in nitrate.[22]

Samples collected in January had chloride concentration that range from tap water: 32 mg/L and 61.1 mg/L, well water: 31.3 mg/L and 151.6 mg/L, while those collected in July had concentrations that varied from Tap water: 31.9 mg/L and 61.9 mg/L, well water: 15.2 mg/L and 121.3 mg/L. It was observed that 70% of samples collected in July had more comparatively high chloride concentrations than the samples collected in January. Chloride can enter groundwater by several pathways, such as soil weathering, salt-bearing geological formations, salt spray deposition, salt used for de-icing roads, wastewater discharges, and in coastal areas, salty ocean water intrusion into fresh groundwater sources.[15]

Total hardness concentrations in all samples were found within the WHO standard (100 mg/L) limit except batches A W4 (110 mg/L) and W5 (146 mg/L) as well as batch B W4 (108 mg/L) and W5 (142 mg/L). It was also observed that at sample locations with high total hardness concentration, these wells were newly made, that means total hardness in these samples was as a result of dissolved carbonates, bicarbonates and sulphates in form of cement. Being the most prevalent polyvalent cations, calcium (Ca2+) and magnesium (Mg2+) ions are typically used to represent the concentration of hardness. While they often exist in much lower amounts, other ions like iron (Fe2+) and manganese

(Mn2+) may also contribute to the hardness of water. Low TH is typically a sign of low calcium, which correlates with reduced pH (higher acidity). The pool of alkalinity will be ruined by low calcium levels. Metal objects will rust as a result of this. The railing and equipment in the pool could be a sustain damage.[23]

The concentration of heavy metal properties of batch A and B well and tap water samples are shown in Table 5, Table 6, Table 11 and Table 12 to compare with WHO standards of drinking water.

Lead was found to exceed WHO standard in all samples except T1, T3, T6, W2, W4, W6 and W3 that were not detected. Lead mostly have gotten into groundwater through excess water additives, gasoline, rusted pipes, etc. Lead causes a variety of harmful consequences on people's wellness, especially youngsters being the most sensitive. Cadmium concentrations of all water samples were found to be within WHO standard limit except for batch B W6 that exceeded the WHO standard of 0.003 mg/L. Cadmium must have entered water through batteries and paints dumped in dumpsites. Long term exposure to cadmium can cause kidney, liver, bone and blood damage. Zinc was detected in all samples except batch B W6 that was not detected, all detected samples were found within WHO standard of 3.00 mg/L. Iron concentration in all samples exceeded WHO standard of 0.03 mg/L except for batch B W5. Iron does not really have a potential health risk as they fall within the recommended daily dietary allowance (7 mg-18 mg). Water with high iron concentration however may discolor and satin washed clothing.[24] All groundwater samples were within the stated WHO standard limit of copper except for batch A T6 that was not detected at all. Copper can enter groundwater aquifers through sources such as direct wastewater discharge, contaminated surface water infiltration, percolation of solid waste leachates etc. High intake of copper can cause stomach ache, dizziness, vomiting and diarrhea.[25] Chromium concentration in all sampled groundwater was found to exceed the WHO standard of 0.05 mg/L. Chromium might have entered groundwater from dump sites that dispose of stainless steels, products of dyes, wood preservatives, leather tanning etc. Long term exposure to chromium can cause asthma, eye irritation, perforated eardrum, kidney damage etc.[26] Nickel was not detected in all samples. This might be as a result of the absence of jewelries, kitchenware, coins and ceramic paints in their dumpsites.

In impoverished countries like Nigeria, public disposal of municipal debris is still the most common method of trash disposal. Pollution of waterways has become a major concern. Municipal solid waste management is given the lowest priority since disruptions and defects in it do not have a visible and urgent impact on civic spaces and do not elicit a response from the public.[27] Because there are no adequate municipal bodies to control the solid trash created by home, business, and industry operations, the people has elected to discard their rubbish in any accessible place within the town, which has resulted in accumulation over time. As a result, groundwater contamination from leachate penetration via topsoil and stones must be prevented.[16] However, due to a lack of adequate management of waste, groundwater is considered contaminated when the waterway is adversely affected by contaminants on both an organic and inorganic level.[28]

The nature of groundwater is as significant as its amount attributable to the appropriateness of water for different purposes.[29] Groundwater science, thusly, relies upon various factors like general topography, level of synthetic enduring of different stone sorts, nature of re-energize water and contributions from sources other than rock cooperation. Such factors and their communication bring about a mind-boggling water quality.[22] Components influencing groundwater are the nature of bedrock topography, profundity from surface soil, vegetation, climatic variety, porousness of dregs and geology, while anthropogenic are the nature of human exercises, urbanization, industrialization and waste administration removal, among others. Fundamentally, various definitive investigations of leachate crests show that they seldom broaden in excess of two or three hundred meters from the landfill, before everything except a modest bunch of the most tenacious toxins are totally lessened.[30] Waste is complex in nature, depending on source of generation and the environment status of the waste may be classified according to its source, its physical form and physicochemical properties.[31] Naturally, as the earth's population grows from million to million per year across the globe, it is very certain that the activities of the environment increase as well. So as such, these activities being influenced by the human population leads to the generation of solid waste.

5. Conclusions

Groundwater is a sustainable element that is essential to the survival of humanity and financial progress. Freshwater has become unusable in certain parts of the world due to the progress and expansion of the ground atmosphere, despite the fact that it is ample. The movement of garbage dissolved into leachate causes groundwater contamination, according to the research. This obviously limits the function of groundwater for various purposes (such as domestic, industrial, and agricultural). According to the groundwater quality assessment conducted in this study, the physical and chemical properties of shallow groundwater sources around 6 selected solid waste dumpsites show that they are seriously contaminated. This is reflected in the high concentration of many parameters, including: Turbidity, Appearance, Odor, pH, Nitrate, total hardness, Lead, Iron, Cadmium and Chromium, which were above the threshold of the World Health Organization guideline. These parameters are commonly used as indicators of man-made contamination. The concentration of certain factors was not noticed. This shows the effect of time on the reduction of parameters.

Controlling the vulnerability of groundwater contamination through landfills requires proper and adequate planning, design construction, strategic management and disposal of wastes. It is necessary to ban ordinary or garbage dumps and provide modern sanitary dumps to improve and reduce the continuous contamination of groundwater. The government should move the new sanitary landfill away from the general population to avoid contaminating the water supply. Osun State should seek national and international assistance in the field of modern technology to implement sustainable environmental sanitation best practices. In situations where leachate threatens or contaminates the aquifer, it may be appropriate to build barriers such as trenches, shear walls, or defensive pits. A detailed analysis of the hydrogeology and groundwater flow in the area is necessary to ensure exploration and development of the groundwater. Government agencies should conduct more investigations to monitor pollutant levels and plan mitigation strategies. It is also necessary to let the public understand the specific uses of groundwater in the study area. In the case of household use, the purification method required for health and safety should be adopted.

To prevent the continued pollution of groundwater through solid waste, the government needs to consider other sanitary methods for waste treatment, such as recycling. In order to reduce the occurrence of water-borne diseases, it is necessary to adopt appropriate water resource management strategies.

Conflict of interest

The authors have no competing interests.

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