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Hydrochemical Evaluation of Ground Water Quality in the Vicinity of Dumpsites

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Abstract

The groundwater quality around selected dumpsites in the Okpe Local Government Area, Delta State Nigeria was investigated. The hydrochemical parameters were analyzed using appropriate instruments and procedures. The findings revealed that; the temperature of groundwater was below the permissible level of potable water. The pH of some of the groundwater samples was alkaline while the level of electrical conductivity and chloride ions is below the allowable limit of drinkable water, suggesting no contamination by EC and chloride ions. The level of nitrate and phosphate is above the acceptable limit of drinkable water standard except location 2 well for nitrate (1.4 mg/l). Sulphate ion is within the level of drinkable water in all the sample wells. The concentration of calcium and magnesium in all the wells samples is below the recommended limit of water standard, this indicates no pollution by calcium and magnesium, and the concentration of zinc is fairly low. The concentration of iron is above the potable water standard, and this could be attributed to natural sources because the control sample is within the same range as the other samples. This study has shown that groundwater from all the wells is fairly contaminated. Therefore, remediation of temperature, pH, alkalinity, nitrate, phosphate, and iron nitrate is needed for groundwater in this location this is to safeguard public health and protection of water resources.

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Introduction

Water pollution is a challenge throughout the globe, water is an important resource to society, it is one of the important resources because society cannot survive in the absence of water. In the planning and operation systems, water is categorized as drinking, agro-industries, irrigation, non-agricultural industries, hydropower, and ecology (Loucks and van Beek, 2017). The main sources of water throughout the globe are surface water and groundwater (Samuel *et al.*, 2023). Over the years these two sources are over-exploited due to rapid growth in population and urbanization. Contamination of surface and groundwater resources due to activities of man is also a problem affecting the quality of water supply (Emegbetere *et al.*, 2014) particularly groundwater. The quality of the ground comprises physico-chemical and microbiological properties (Ogheneoruese *et al.*, 2022). Numerous authors have identified landfill wastes as one of the contaminants that pollute groundwater (Edo, 2023). Pollution of groundwater also results in the buildup of surface water contamination as a result of interconnectivity between groundwater and surface water amongst others.

The system of waste disposal practice in many places of the world is below the recommended standard (Edo *et al.*, 2024). Waste disposal sites are a source of groundwater and soil pollution due to the migration of leachate through refuse (Ugbune *et al.*, 2021., Akpoghelie *et al.*, 2024). The migration of leachate poses a risk to groundwater if not managed properly (Ugbune *et* al., 2023). Water has a unique physicochemical property as a result of its polarity and hydrogen bond, this properties enable water to dissolve many different compounds (Kontogeorgis *et al.*, 2022). Groundwater contamination from waste disposal sites is a major health challenge in developing countries (Igboama *et al.*, 2022). Many inorganic and organic pollutants such as nitrates, heavy metals, chloride, phosphate, and polycyclic aromatic hydrocarbons have been reported in groundwater (Zhang et al., 2023). Over 50% of the global population depends on groundwater for drinking (Liu *et al.*, 2021), it is only the source of water that satisfies the daily requirements globally (Sheng et al, 2023). In many urban areas, there is a threat to groundwater due to the rapid increase of refuse at the waste disposal sites. The main cause of groundwater pollution in this site is contamination by leachate from waste disposal sites that lack compliance with environmental measures (Lawal, 2017., Ugbune *et al.*, 2018.). Therefore, the present study is to examine the quality of groundwater in Okpe disposal sites. The Physicochemical knowledge of the contamination level of groundwater is necessary to support agencies of government and policy-makers in formulating and implementing good environmental management methods and measures to ensure the sustainability of water resources and water security.

Materials and Methods

A two-dumpsite location was adopted in this study, in each of the locations, four wells were drilled around the dumpsite and the control well was drilled a hundred meters away from the dumpsites. A total of 10 wells were sampled, five from each location.
Temperature, pH, electrical conductivity (EC), and biochemical oxygen demand (BOD) were analyzed in situ with the aid of a thermometer, EC, pH, and EC meter respectively. Two drops of HNO_3 was added to the water sample used, this is to prevent metallic ions from adhering to the walls of the container. Samples were stored in a refrigerator, which prevented the drop of ions.
Total dissolved solid (TDS) was analyzed using a gravimetric procedure (Al-Kubaish, Salama, and Al-Jurayan, 2024). Titrimetric methods were used for alkalinity and sulphate ion analysis following (Al-Kubaish *et al.*, 2024). Chloride ion was quantified by silver nitrate method (Al-Kubaish *et al.*, 2024). Nitrates, phosphate, and sulphate were analyzed following coulometric methods. An atomic absorption spectrophotometer was used in the analysis of metals and cations.

Quality Assurance and Processing of Data

Standard laboratory-grade chemicals were used for chemical analysis. Standard procedures were adopted in groundwater sampling, this is to ensure good quality and reliable results. Triplicate analysis was done on each sample while data presentations were carried out using mean standard deviation and relevant tables.

Results and Discussion

Samples of groundwater were analyzed to understand the impacts of disposed wastes on the quality of groundwater in the locations. Characterization of the physical properties of the ground (Table 1) revealed that temperature is below the recommended standard of 35°C - 40°C, suggesting the presence of biological contaminants such as micro-organisms in the water.

Table 1: Physico-chemical properties of groundwater

Location	Well	Temperature (ºC)	pH	EC
	1	27.6 ±0.2	7.8±0.2	70.57±0.3
1	2	27.9 ±0.1	7.9±0.2	70. 67 ±0.2
	3	28.1±0.2	7.9 ±0.2	86.5 ±0.2
	4	28.2 ±0.1	8.7±0.1	120. 4 ±0.3
	5 (control)	27.0±0.2	7.2±0.1	69.4±0.2
	1	27.6±0.1	7.8±0.2	70.57 ±0.3
2	2	27.9 ±0.2	7.9 ±0.2	70. 67±0.3
	3	28.1±0.2	7.9 ±0.2	86.5 ±0.2
	4	28.2±0.2	8.7±0.2	120. 4±0.3
	5 (control)	27.0±0.1	7.2±0.2	69.4±0.2

The pH level falls within 7. 8±0.2 to 8.7±0.2, with many samples in the range of 6.5 to 8.5 WHO limit. The elevated pH value found in some of the locations, suggests that the water is alkaline. The high concentration signifies that leachate from domestic wastes could contaminate the water. Electrical conductivity (EC) of water is the ability of water to conduct electric current; EC is an important indicator in water analysis. The conductivity of water samples ranges from 68 to 245µs/cm respectively, the conductivity of sample 4 location 2 gave the highest EC, this may be due to the closeness well to the dumpsites. The EC is below 1000 µs/cm, the permissible drinking water as specified by (Skevington et al., 2004). The total dissolved solid (89.4 to 90.8 mg/l) is within the level reported by(Ferreira., 2023).

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Level of Total Alkalinity, Chloride Ion, Nitrate, Phosphate, and Sulphate

The total alkalinity of water is the capacity of water to neutralize acid, this parameter controls pH changes in water. The concentration of alkalinity (Table 1) exceeds WHO standards for potable, elevated levels of alkalinity is not injurious to human health but may lead to an unpleasant taste (Naseem e*t al.*, 2022).

Table 2 : Level of total alkalinity, chloride ion, nitrate, phpsphate and sulphate

Location	well	Total alkalinity	Chloride ion	Nitrate	Phosphate	Sulphate
	1	200.6 ±0.3	64.6±0.2	10.6±0.1	10.7±0.2	3.6±0.01
	2	200.5±0.2	87.2±0.2	10.8±0.2	10.2±0.2	3.1±0.02
1	3	200.6±0.3	12.1±0.2	10.2±0.2	10.4±0.1	2.2±0.01
	4	200.0±0.2	10.1±0.2	10.3±0.2	10.2±0.2	2.1±0.02
	5 (control)	120.4±0.3	11.4±0.2	2.1±0.01	.4±0.01	2.1±0.01
	1	200.6±0.3	64.6±0.3	10.6±0.2	10.7±0.2	3.6±0.02
	2	200.5 ±0.3	87.2±0.3	4.8±0.03	10.2±0.1	3.1±0.01
2	3	200.4±0.3	12.1±0.2	10.2±0.2	10.4±0.1	2.2±0.01
	4	200.6±0.4	10.1±0.1	10.3±0.1	10.2±0.2	2.1±0.01
	5 (control)	12.0±0.2	11.4±0.2	2.1±0.01	1.5±0.01	2.1±0.02

The concentration of chloride ions shown in Table 2 revealed that chloride ion concentration is below the allowable limit of WHO (2003) which is 250 mg/l. (Yenugu *et al.,* 2020) suggested in their study, that excess chloride in water is a reflection of index pollution and is used as a tracer for groundwater contamination. Nitrate is also used as an index of groundwater pollution. (Ward et al., 2018) asserted that a nitrate concentration of 0.1 to 10.00 mg/l is regarded as a natural concentration of nitrate in groundwater. The nitrate level in this study is between 4.8±0.03 to 10.8±0.2 mg/l, the value of nitrate in many of the wells is above the recommended standard of 10 mg/l (WHO 2003), and the level of nitrate in this location could be due to the leaching of nitrate into groundwater. High nitrate levels in drinkable water pose a health risk to infants because they cause methemoglobinemia, and blue baby syndrome (Shaban-Al-Najar *et al.*, 2023). Elevated concentrations of nitrate in the bloodstream decrease the capacity of the red blood cells to transport oxygen (Khalil *et al*., 2023). The level of phosphate in the location is above the permissible limit of 10 mg/l (WHO 2003). The phosphate concentration in the wells varies from 10.2±0.2 to 10.7±0.2 mg/l, all the well samples fall within the permissible limit of WHO (2003).

The level of sulphate in the wells varies from 2.1±0.01 to 3.6±0.02 mg/l, the level of sulphate is low when compared with the allowable limit of 250mg/l of WHO (2003), this concentration suggests that ground in these locations are not polluted with sulphate, the level of sulphate is within the range discovered by Omeka et al., 2024). The low concentration of sulphate could be due to microbial action capable of decreasing $SO4^{2-}$ to S^{-} leading to the reduction of sulphate in this location

Level of Calcium, Magnesium, Zinc, and Iron in Groundwater

The concentration of calcium (27.7±0.2 to 28.2±0.2 mg/l) and magnesium (7.8±0.2 to 8.8±0.2 mg/l) falls below the WHO allowable limit of 75 mg/l and 50 mg/l for calcium and magnesium respectively.

Table 3: Level of calcium, magnesium, zinc and iron in groundwater

Location	well	Calcium	Magnesium	Zinc	Iron
	1	27.6±0.2	7.8±0.2	1.4±0.01	4.0±0.02
1	2	27.9±0.3	7.9±0.1	1.3±0.01	4.5±0.02
	3	28.1±0.2	7.9±0.2	1.3±0.02	4.4±0.01
	4	28.2±0.2	8.7±0.1	1.3±0.01	4.3±0.02
	5 (control)	27.0±0.1	7.2±0.2	1.2±0.01	4.0±0.02
	1	27.6±0.3	7.9±0.1	1.3±0.01	4.1±0.01
2	2	27.9±0.3	7.9±0.2	1.3±0.01	4.0±0.02
	3	28.1±0.2	7.9±0.2	1.4±0.01	4.5±0.02
	4	28.2±0.2	8.8±0.1	1.4±0.01	4.2±0.01
	5 (control)	27.0±0.1	7.2±0.2	1.3±0.01	4.0±0.01

Metals such as iron can change groundwater colouration (Boumaz *et al.*, 2021). The concentration of zinc falls from 1.3±0.01 to 1.4±0.01 mg/l while that of iron is between 4.1±0.01 to 4.5±0.02, the concentration is within the level earlier reported by Katarivas *et al.* (2017). The concentration of iron is above the recommended limit of 0.03 mg/l (WHO, 2004). The higher concentration of iron is a pointer to the higher level of industrial waste in the study area.

Conclusion

The study evaluates groundwater quality around selected dumpsites in Okpe Local Government Area, The temperature of groundwater was found to be below the permissible level of WHO. The pH of some of the wells indicates alkalinity while the level of EC and chloride ions is below the allowable limit of WHO, suggesting no contamination by EC and chloride ions. The level of nitrate and phosphate is above the acceptable limit of drinkable water standard except for location 2 well 2 for nitrate having 1.4 mg/l. Sulphate ion is within the level of drinkable water in all the sample wells. The concentration of calcium and magnesium in all the wells samples is below the recommended limit of water standard, this indicates no pollution by calcium and magnesium, and the concentration of zinc is fairly low. The concentration of iron is above the potable water standard, the higher concentration of iron in the study water could be due to natural sources because the control sample is within the same range as other samples. This study has shown that groundwater from all the wells is fairly contaminated. Therefore, groundwater in this location needs temperature, pH, alkalinity, nitrate, phosphate, and iron treatment before consumption. In addition, frequent monitoring of groundwater in the study area is recommended.

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