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THE IMPACT OF 2018 EARTH TREMORS ON GROUNDWATER QUALITY IN THE FEDERAL CAPITAL TERRITORY, ABUJA

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ABSTRACT

The impact of 2018 earth tremors on groundwater quality in the Federal Capital Territory, Abuja. Twenty water samples were collected from five locations within the study area: Mpape, Maitama, Gwarinpa, Jahi, Wuse. The methods used in the study included data collection, and data analysis. One and a half EVA cans were used to collect each water sample, ensuring that the equipment was sterilized and samples were properly preserved for analysis. Seismographs were used to measure and record the earthquakes that occurred in 2018. The results showed heavy metal concentrations of Pb (0.013 – 0.050 mg/l; WHO limit 0.01 mg/l), Cd (0.113 – 0.170 mg/l; WHO limit 0.003 mg/l), Hg (0.001 – 0.609 mg/l; WHO limit 0.006 mg/l), Cr (0.001 – 0.065 mg/l; WHO limit 0.05 mg/l), and As (0.016 – 0.064 mg/l; WHO limit 0.01 mg/l respectively, which are slightly higher than the permissible limits set by WHO. Drinking from these water sources poses significant health risks to the people in the study areas. However, the study helps to identify potential high-risk areas and their likely impact on water quality parameters. The findings will support the development of response and mitigation strategies to protect groundwater resources from contamination caused by seismic activity. In conclusion, the concentrations of heavy metals exceeded the limit approved by WHO.

Keywords: Abuja Nigeria, Earthquakes, Groundwater samples, Heavy metal concentrations

INTRODUCTION

Earthquakes have the potential to significantly impact groundwater quality due to changes in the geological structure and likely release of harmful substances such as asbestos, lead, and other toxic materials (United States Geological Survey Agency, 2018). Understanding the potential impact and developing models to predict and mitigate the effects of earth tremors on groundwater quality is crucial for safeguarding our water resources. Factors such as ground shaking, fracturing, and shifting of underground layers can all contribute to changes in water quality. Additionally, the release of harmful substances from geological formations during an earthquake can further contaminate groundwater. Groundwater levels in wells can oscillate up and down when seismic waves pass (USGS, 2018). The water level might remain higher or lower for a period of time after the seismic waves end, but sometimes a long-term offset of groundwater levels follows an earthquake. Water quality can also be affected by earthquakes, typically in locations where the shaking was at least strong enough to be felt. Well water might become turbid as shaking dislodges loose sediment from pores and cracks in the rocks supplying water to the well (USGS, 2018). This is often temporary, lasting only hours or days. More serious impacts on water quality can occur when strong earthquake shaking damages sewer lines, gas lines, or any infrastructure containing hazardous materials, releasing contaminants into the water (USGS, 2018).

The word "tremors" can be defined as an earthquake especially of low or moderate intensity (Merriam – Webster Dictionary, 2016). An earthquake is the shaking of the surface of the earth resulting from a sudden release of energy in the earth lithosphere that creates seismic waves (Watson *et al.* 2009). Earthquakes are highly destructive natural disasters, leading to significant loss of life, extensive damage to properties, and disrupt access to clean water. Groundwater, which is often the primary source of drinking water in many regions of the world, can be impacted by earthquakes through changes in the quality and quantity of aquifers. During the recent earth tremors in Nigeria which occurred from 5th - 7th September, 2018. Macro seismic Intensity data showed that the impact was felt at Jahi, Maitama, and Mpape areas in the Federal Capital Territory, Abuja. The epicenter of the event was located at Mpape, a suburb of the Territory. Following the development, the Nigerian government set up a Presidential Technical Committee in 2019 to determine the causes of the earth tremor and impacts on humans and structures. The committee was headed by the former Director General of National Space Research and Development Agency (NASRDA), Prof. Seidu Oneilo Mohammed. However, the presidential committee in its findings disputed on whether that the quarry activities at Mpape were responsible for the earth tremors (National Space Research and Development Agency, 2018). According to the findings, some spots and locations have been identified and considered to be earthquake prone in Nigeria, particularly in Abuja. One of the reasons adduced to the probable causes of the event by the Committee was indiscriminate sinking of boreholes in the FCT. Ogugua

Seismic disturbance induce changes in the surface as well as in the subsurface. Surface features include the ruptures in the land, broken roads, disturbed building etc. In the subsurface, changes can be noticed in the aquifer system. Few studies through models have explained the impact on groundwater on aquifers due to earthquakes like; water expelled from the crust because of co-seismic elastic strain (Hailer *et al*. 2018), water release from the upper crust due to fractures developed by earthquake (Wang *et al.* 2014) and water release due to seismic liquefaction (Wang *et al.* 2001).

The prevalence of boreholes in the Federal Capital Territory Abuja can be a source of concern for earthquake like activities. However, there is limited data on how seismic activity affects groundwater in FCT Abuja, leaving hydrologists, engineers, seismologist, and geologists with uncertainties when assessing the safety and sustainability of this essential resource. This study thus aims to investigate and highlight the impacts of the 2018 earth tremors on groundwater quality in the FCT, providing valuable insights for professionals working in water resource management and seismic rick mitigation. This can be achieved by **c**ollecting baseline data on groundwater quality in the FCT, including pH, turbidity, conductivity, total dissolved solids (TDS), and the presence of contaminants like heavy metals, bacteria, and other pollutants. The earth tremors in the FCT, including their location, magnitude, and intensity is intended to be monitored and documented. The study will also explore the influence of 2018 earth tremors on the structural integrity of groundwater wells and underground aquifers.

The area of coverage of this study is mainly Mpape, a region in the Federal Capital Territory Abuja, located at Latitude 9˚08̎29.9̎ N and Longitude 7˚29̎55.8̎ E, at 432 meters above sea level. Mpape serves as the epicenter of the 2018 Abuja earth tremor, making it a significant site for investigation due to its relevance to the event and its proximity to others affected areas within the FCT.

The study is important to determine the concentrations of heavy metals and other pollutants in groundwater, providing valuable data for assessing water safety. It identifies potential high-risk areas where groundwater quality is more likely to be affected by seismic activity, guiding future research and risk management. The findings facilitate the developmental response and mitigation strategies to protect groundwater resources from contamination caused by seismic activity.

MATERIALS AND METHODS

The following methods were adopted for this work.

Data collection

One and a half EVA cans were used to collect each water sample, ensuring that the equipment was sterilized and samples were properly preserved for analysis.

Data analysis

Data analysis is the process of using appropriate statistical or qualitative analysis techniques (Microsoft excel) to derive meaningful insights from the collected data.

The groundwater samples from the study areas were analyzed using the following procedure below for heavy metal concentrations. Heavy metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophotometer according to APHA Standard Method for the Examination of Water and Wastewater, 24th Edition (Apha, 2022).

Methodology Highlight According to APHA 2022

Sample Preparation

Samples are typical acidified to a pH of less than 2 using nitric acid to prevent metal precipitation and adsorption to container walls. This ensures the metals remain in solution until analysis.

Calibration and Standardization

Calibration involves using standard solutions with known metal concentrations. The Varian AA240 allows for precise calibration, which is crucial for ensuring accurate measurements according to APHA protocols. A calibration curve is generated by measuring the absorbance of these standards, and the sample concentrations are determined by comparing their absorbance to this curve.

Flame Atomization

The AA240 uses a flame atomization technique, typically employing an air-acetylene flame, to convert the metal ion in the sample into free atoms. This is essential for accurate absorbance measurement.

Interference Management

The APHA 2022 method outlines strategies to manage potential interferences, such as spectral overlap or chemical interactions. The Varian AA240 is equipped with features like background correction using a deuterium lamp, which helps minimize these interferences.

Quality Control

According to APHA guidelines, quality control is critical. This includes the use of blanks, spiked samples, and control standards to validate the accuracy and precision of the analysis. Regular checks ensure the instrument's performance remains consistent.

Application

This method is commonly used for analyzing trace metals such as lead, copper, zinc, cadmium, and others in water and wastewater. The AA240's capability to detect low concentrations makes it ideal for environmental monitoring and compliance with regulatory standards.

Statistical analysis using ANOVA tool

Mean: It is the summation of all the variable of a particular metal over the total number of variable. It can be represented mathematically as Mean = $\frac{\sum x}{n}$

Where,

$\sum x$ is the summation of all the variable of a particular metal

n = Total number of variable

Variance: It is the square of individual variable minus overall mean divided by total number of variable. It can be represented mathematically as

Variance = $\frac{\sum (xi - mean)^2}{n-1}$

F-statistic: It is the ratio of the between group variance to the within group variance. It can be represented mathematically as

F = $\frac{Variancebetween}{Variancewithin}$

P-value: This can be determine by using corresponding F-statistic and degrees of freedom for two groups.

Table 1: Statistical analysis using ANOVA tool

Heavy metals	$Mean_{before}$	$Mean_{after}$	F-Statistic	P-value
Lead	0.0357	0.0385	1.593	0.215
Cadmium	0.1429	0.1482	0.871	0.357
Mercury	0.4150	0.4360	0.101	0.752
Chromium	0.0335	0.0390	0.370	0.546
Arsenic	0.0363	0.0390	0.560	0.459

RESULTS AND DISCUSSION

Heavy Metal Results

Table 2: Shows heavy metal concentrations before 2018 earth tremor

Sample	Lead (ppm)	Cadmium (ppm)	Mercury (ppm)	Chromium (ppm)	Arsenic (ppm)
Mpape Well 1	0.039	0.134	0.526	0.001	0.028
Mpape Well 2	0.037	0.147	0.334	0.036	0.032
Lea Primary School Mpape BH1	0.009	0.108	0.154	0.012	0.013
Mpape Market BH2	0.042	0.111	0.408	0.024	0.020
Gwarimpa Village BH1	0.035	0.138	0.287	0.030	0.033
Gwarimpa BH2	0.032	0.134	0.233	0.035	0.041
Gwarimpa Well 1	0.041	0.144	0.606	0.046	0.045
Gwarimpa Well 2	0.034	0.152	0.463	0.022	0.030
Rabaram Block Industry Jahi BH1	0.032	0.156	0.446	0.040	0.054
Jahi BH2	0.027	0.148	0.385	0.051	0.044
Jahi Well 1	0.040	0.161	0.574	0.023	0.036
Jahi Well 2	0.035	0.122	0.405	0.035	0.023
Maitama Well 1	0.030	0.165	0.374	0.045	0.049
Maitama Well 2	0.042	0.134	0.596	0.051	0.030
Maitama /Aso Garden BH1	0.032	0.154	0.371	0.063	0.062
Maitama BH 2	0.041	0.156	0.429	0.025	0.044
Wuse BH1	0.031	0.133	0.590	0.048	0.015
Wuse BH2	0.038	0.153	0.414	0.053	0.024
Wuse Well 1	0.047	0.142	0.281	0.030	0.031
Wuse Well 2	0.032	0.142	0.378	0.050	0.052

Fatimah *et al.* 2018

Table 3: Shows heavy metal concentrations after 2018 earth tremors

Sample	Lead (ppm)	Cadmium (ppm)	Mercury (ppm)	Chromium (ppm)	Arsenic (ppm)
Mpape Well 1	0.046	0.149	0.606	0.001	0.034
Mpape Well 2	0.038	0.154	0.438	0.042	0.039
Lea Primary School Mpape BH1	0.013	0.113	0.159	0.015	0.016
Mpape Market BH2	0.049	0.117	0.412	0.027	0.022
Gwarimpa Village BH1	0.038	0.140	0.291	0.033	0.036
Gwarimpa BH2	0.035	0.139	0.238	0.037	0.044
Gwarimpa Well 1	0.042	0.147	0.609	0.051	0.048
Gwarimpa Well 2	0.037	0.153	0.467	0.025	0.033
Rabaram Block Industry Jahi BH1	0.035	0.160	0.448	0.043	0.056
Jahi BH2	0.030	0.151	0.387	0.054	0.047
Jahi Well 1	0.042	0.164	0.579	0.026	0.039
Jahi Well 2	0.039	0.126	0.410	0.037	0.025
Maitama Well 1	0.032	0.170	0.377	0.048	0.051
Maitama Well 2	0.045	0.136	0.601	0.054	0.032
Maitama /Aso Garden BH1	0.034	0.158	0.373	0.065	0.064
Maitama BH 2	0.045	0.161	0.432	0.029	0.045
Wuse BH1	0.033	0.137	0.592	0.051	0.019
Wuse BH2	0.041	0.156	0.418	0.057	0.028
Wuse Well 1	0.050	0.144	0.285	0.033	0.036
Wuse Well 2	0.036	0.149	0.383	0.052	0.054

Discussion of Heavy Metal Results

The results showed a slight change in the concentrations of heavy metals "Lead, Cadmium, Mercury, Chromium, and Arsenic as presented in Table 3." Cadmium is a very toxic metal which bio- accumulates in the body. This leads to neurological problems as well as organ failure which ultimately lead to death as reported by (Cima-mukul *et al*., 2019; Fatimah *et al*., 2018). However, Lead, Mercury, Chromium, Arsenic are highly toxic and can cause developmental issues in young children and pregnant women, chronic exposure can lead to kidneys and liver damage etc. The presence of these heavy metals therefore, makes the water from all the sampled well unfit for human consumption in its raw state.

P-values in table 1, for all the heavy metals (Lead, Cadmium, Mercury, Chromium, and Arsenic) are greater than 0.05, indicating no statistically significant difference in their concentrations before and after the earth tremors. This suggests that the tremors may be resilient to disturbances from moderate seismic events.

CONCLUSION

With regards to the experiment conducted, the results showed that groundwater is altered as a result of ground shaking and duration of shaking (Ofonime and Tahir, 2010). This research work will be of immense assistance in improving the knowledge on the negative impacts of 2018 earth tremor on the groundwater quality in the FCT, Abuja. Identifying potential high-risk areas and their likely impact on water quality parameters. The findings will support the development of response and mitigation strategies to protect groundwater resources from contamination caused by seismic activity. In conclusion, heavy metal concentrations were higher than the approved limit set by WHO.

RECOMMENDATION

From the result obtained, we recommend that Government should provide adequate funding for National Space Research and Development Agency (NASRDA) and Nigerian Geological Survey Agency (NGSA) and any other agencies whose mandate are for controlling geo-hazards.
We advise that earthquake early warning system should be installed to enable Centre for Geodesy and Geodynamics under national Space Research and Development Agency (NASRDA) whose mandate was specifically to carry out earth observation research as well as monitor and predict Geohazards using space geodetic and geo-physical techniques for sustainable national development.
Also, we recommend that further comprehensive water quality analysis should be conducted on all the borehole and well within the FCT, Abuja to ascertain their degree of portability. Although, some previous studies showed that Cadmium, Chromium, Arsenic, Lead, Mercury and Iron are commonly found in water samples in FCT, Abuja and environ (Unamba *et al.* 2016). Further studies are required in order to determine the sources of the contamination, be it natural soil deposits or human-induced. Findings from these future studies will guide scientists on the course of remedial actions to safeguard public health.

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