PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (10B Supplementary) 3369-3376 October, 2024

Assessment of some Heavy Metals and Physicochemical Parameters in Water from Hand-Dug Wells in Demsa and Environs in Adamawa State, Nigeria

[1]BALOGUN, FO; [2*]EBOMWONYI, O; [3]EJAIRU, K; [4]AMINU, U; [1]ANDARAWUS, Y; [1]MUSA, N

[1]Department of Geology, Federal University, Lafia, Nasarawa State, Nigeria.
*[2]*Department of Physics, University of Benin, Benin City, Edo State, Nigeria.*
[3]Western Delta University, Oghara, Delta State, Nigeria.
[4]National Open University, Abuja, Nigeria.
[5]Department of Geology, Federal University, Lafia, Nasarawa State, Nigeria.
[6]Department of Geology, Federal University, Lafia, Nasarawa State, Nigeria.

*Corresponding Author Email: osarodion.ebomwonyi@uniben.edu
*ORCID: https://orcid.org/0000-0002-1264-5389
*Tel: +2348058865721

Co-Authors Email: fo.balogun@science.fulafia.edu.ng; kingsley-ovonami.ejairu.etu@univ.lille.fr; noun162901702@noun.edu.ng; yohana.andarawus@science.fulafia.edu.ng; n.musa@science.fulafia.edu.ng

ABSTRACT: Predominantly, the inhabitants of Demsa and environs use shallow hand-dug wells as a primary source of drinking water but this water source is vulnerable to contamination from various external sources due to lack of protection, thus, the geological conditions and anthropogenic activities of the people living in the area. Therefore, the objective of this paper is to assess the levels of some heavy metals and physicochemical parameters in water from Hand-Dug Wells in Demsa and Environs in Adamawa State, Nigeria using appropriate standard methods. The results obtained reveals that the mean concentrations (mg/L) of metals and physicochemical parameters were calcium (4.236), magnesium (3.702), cadmium (0.104), sodium (9.400), copper (0.003), iron (0.132), potassium (14.200), manganese (0.148), zinc (0.004), lead (0.000), chromium (0.000), arsenic (0.000), nickel (0.008), sulphide (0.473), chloride (0.450), phosphate (4.040), fluoride (0.286) and nitrate (46.19). The results further showed that the concentration (mg/L) values for magnesium (3.702), cadmium (0.104), phosphate (4.040) and nitrate (46.19) were all above the acceptable limits of WHO, FEPA and NSDWQ. As a precaution, a systematic approach to removing heavy metals from groundwater sources in the study area is proposed, using techniques like chemical precipitation, ion exchange, or reverse osmosis.

DOI: https://dx.doi.org/10.4314/jasem.v28i10.52

Cite this Article as: BALOGUN, F. O; EBOMWONYI, O; EJAIRU, K; AMINU, U; ANDARAWUS, Y; MUSA, N. (2024). Assessment of some Heavy Metals and Physicochemical Parameters in Water from Hand-Dug Wells in Demsa and Environs in Adamawa State, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (10B Supplementary) 3369-3376

Dates: Received: 21 August 2024; Revised: 29 September 2024; Accepted: 08 October 2024 Published: 31 October 2024

Keywords: Contamination; hand-dug wells; heavy metals; physiochemical characteristics; groundwater

In Africa, the supply and amount of freshwater continue to decline every now and then. Unfortunately, sub-Saharan Africa often falls short in meeting its water requirements for domestic and industrial uses. Groundwater usually has a good chemical constituents, but higher concentrations of certain elements can compromise water usability (Gebrehiwot *et al*., 2011). However, in Demsa town and environs, the main source of drinking water comes from shallow hand-dug wells and accounts for

*Corresponding Author Email: osarodion.ebomwonyi@uniben.edu
*ORCID: https://orcid.org/0000-0002-1264-5389
*Tel: +2348058865721

approximately 80% of the public's water needs (Getchew, 2004). In Demsa Community, determination of heavy metal concentrations and the physicochemical parameters of water from hand-dug wells have not been carried out in the past; and there is need for this to be done and compared with the minimum requirements of World Health Organization (WHO) and the Nigeria Standard Agencies (FEPA, NSDWQ and MPL). The presence of heavy metals is particularly worrisome, as they can cause harm even at very low concentrations (Marcovecchio *et al*., 2007). Some of these metals are lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenide (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), platinum (Pt) and manganese (Mn). Though, some heavy metals are necessary in trace amounts, high doses can be very toxic. The propensity of heavy metals to bioaccumulate and reach toxic levels make them a significant health risk. Anthropogenic sources such as mining, fuel burning, farming and poor waste disposal practices, contribute to high metal concentrations in natural water bodies. Consequently, this study is aimed at assessing the amount of concentration of some heavy metals and chemical parameters of water samples from hand-dug well collected from Demsa Community and environs in Adamawa State, Nigeria. Hand-dug wells serve as a crucial source of domestic water for most of the inhabitants residing in the study area. Water is life, hence, precious and essential for domestic utilization by the inhabitants of the study area for sustainable economic development as it is the second most vital resource for human existence, after air. It underscores the crucial importance of water for human survival. Groundwater is a highly valued resource, intensively exploited for a range of purposes including private, domestic and industrial activities. In urban settlements with piped and borehole water, the growing demand for clean drinking water is fueled by population growth, industrialization, and economic development (Magaji, 2009; Ogunlaja and Ogunlaja, 2007). However, hand-dug wells have become an alternative sources of groundwater, particularly in the rural areas. The depth of hand-dug wells are normally within the range of 0.71 to 6.31m depending on the geology of the subsurface. The well is lined with bricks, and recently cemented rings (Huisman, 1986; Ajibade *et al*., 2014). More also, methods of completion of hand-dug wells vary from one hand-dug well to another. More so, in the rural areas, 85% of the population of the dwellers hinge essentially on hand-dug wells. A common means of accessing groundwater is through hand-dug wells. This groundwater obtained from these hand-dug wells in the study area is hardly examined nor treated before consumption. Before now, pumps were not installed along with most of the hand-dug wells in the study area. Furthermore, chemical spills, leaks, or improper disposal on land can lead to groundwater contamination through runoff or infiltration into the aquifers. The kind of severity of water contamination is often directly related to the anthropogenic activities, which can be measured in terms of land use pattern and intensity in the source regions of water to streams and aquifers. It is assumed that groundwater flow and run-off into the hand-dug wells is responsible for the transportation of the heavy metals present within the hand-dug wells vicinity. In the study area, there is this difficulty in identifying and locating heavy metals source(s) like underground fuel tanks that are leaking and septic systems that are buried. In many instances, these sources can be inferred from the type and intensity of land use within the area of interest. However, heavy metals movement from their source can be affected by the following factors; properties of the soil and aquifer in terms of physical attributes, nature of the chemical contaminant, methods as well as materials used for hand-dug well completion, direction and speed of the groundwater and timing of recharge. Heavy metals solubility in soils and hand-dug wells are greatly influenced by pH, quantity of heavy metals, capacity of cation exchange, organic carbon concentration, mineral components oxidation states and the redox potential of the system (Magaji, 2009; Huisman, 1986; Kennish, 1992). The quality of water is compromised by the contamination of groundwater by chemicals, bacteria and heat to an extent that it does not need to create a general health hazard. However, it can render the water unsuitable for household, municipal and industrial purposes. Natural water systems usually carry some small amount of trace elements. Their presence in hand-dug wells (groundwater) as well as surface water can be as a result of natural sources like dissolved natural minerals in the soil or aquifer that contains trace elements, human activities like iron ore smelting, mining and improper disposal of domestic, municipal and industrial wastes (Kennish, 1992; Martinez and Motto, 2000). The earth's crust consists of heavy metals which are natural components of it. These heavy metals cause numerous risks to human health. Examples of such heavy metals are manganese, iron, mercury, cadmium, copper, lead, nickel, etc. These heavy metals are transported through water ways like rivers and streams. They are transported as either species dissolved in water or as a major part of a substance suspended on the water surface which could be hazardous to aquatic life. Also, heavy metals are ingested to a small degree through consumption of food, water and inhalation of air. However, some heavy metals like copper, zinc and others are important to sustain the metabolism of the human body, their concentration above acceptable limits can be dangerous. Poisoning from heavy metals could be from contamination of drinking water as a result of rust from lead pipes, high concentrations of ambient air close to emission sources, or ingestion through the food chain (Musa *et al*., 2013). The danger associated with heavy metals is as a result of their bio-accumulation tendency. Bio-accumulation is an increase in the chemical concentration in a biological organism over a period of time in comparison to the natural chemical concentration in the environment. Water supply can be contaminated with heavy metals from household and industrial wastes, or from acidic rain leading to breakdown of soils, thus releasing the heavy metals into water bodies like lakes, rivers, streams and groundwater (Ajibade *et al*., 2011). Concentration of heavy metals can be altered slightly as a result of natural or anthropogenic factors. This can result in serious environmental hazards and subsequent health challenges. As a result, it is very important to carry out investigation on heavy metals. Therefore, in this study, we seek to investigate the concentration of heavy metals in hand-dug wells in Demsa Community and environs, with the intention to find out if the water from these hand-dug wells is safe for human consumption. Like many communities in Adamawa, a large population of the inhabitants in the study area are dependent largely on hand-dug wells as the main source of water supply. As captured by the Demsa Health Centre, there are high cases of diseases related to contaminated water within the study area (Demsa Primary Health Care, 2012). Almost all the hand-dug wells are shallow with depths ranging between 15 to 20 feet, which made them vulnerable to contamination. This study intends to investigate the impact of heavy metals contamination in hand-dug wells in the study area. Adverse effects of the presence of heavy metals concentration in the hand dug-wells on the well-being of the inhabitants of the Damsa community and environs have become imperative to research due to the health challenges often recorded. In spite of several regulations for potable water consumption and standard organization agencies permissible limits, the situation seems to be worsening day after day with a subsequent increase in risk to the health of the inhabitants and environment at large. This has necessitated the choice of this project topic, hence the need to investigate and assess the extent of heavy metal concentrations in the hand-dug wells within the area of interest through analyses and interpretation of the samples collected from the studied hand-dug wells, and proffer measures to mitigate and ameliorate its hazardous effect on the inhabitants dwelling in the study area. Thus, the motivation for this study which intends to bridge the existing knowledge gap between the inhabitants, health workers and the policy makers of the Demsa community and environs. Hence, the objective of this paper is to assess the levels of some heavy metals and physicochemical parameters in water from Hand-Dug Wells in Demsa and environs in Adamawa State, Nigeria.

MATERIALS AND METHODS

Location of the Study Area: Demsa is the administrative headquarters of Demsa Local Government Area of Adamawa State in Nigeria and lies on the Benue River. Inhabitants of Demsa are the Bachama (Bwatiye) Batta, Yandang, Bille, Mbula, Maya, Bare and Fulani ethnic groups. Adamawa has a coordinate of latitude 9^0 19' 59.9988'' N and longitude 12^0 30' 0.0000"E..

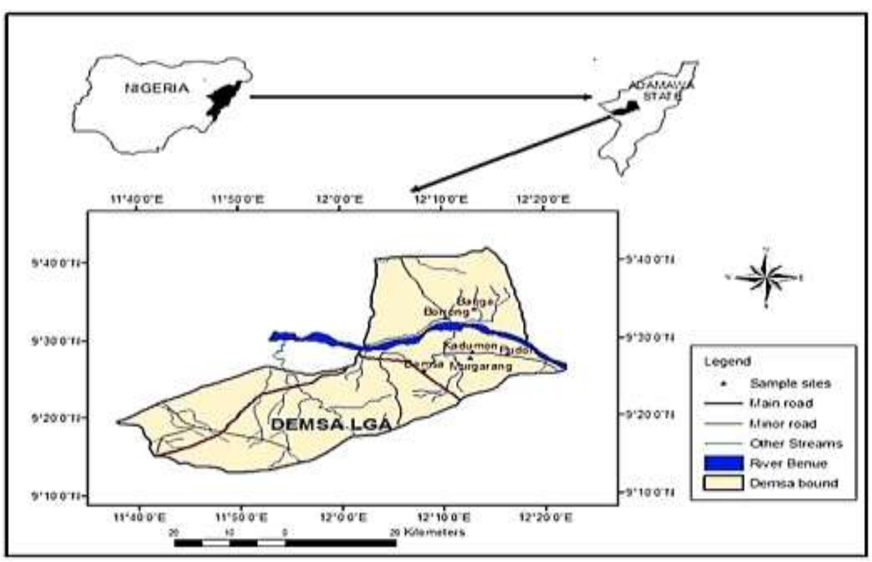

Fig. 1: Study area

The total area of the state is estimated to be close to 14,250 square miles. Also, the study area is characterized by sedimentary rocks such as limestones, shelly limestones, shales with intercalations of sandstone, calcareous sandstones and feldspathic sandstones (Lar *et al*., 2023). The study area is located at the confluence of the Yola and Gongola arms of the Benue trough. This is under the control of several depositional cycles that led to the formation of the Albian and Cenomanian sedimentary rocks of different compositions and ages

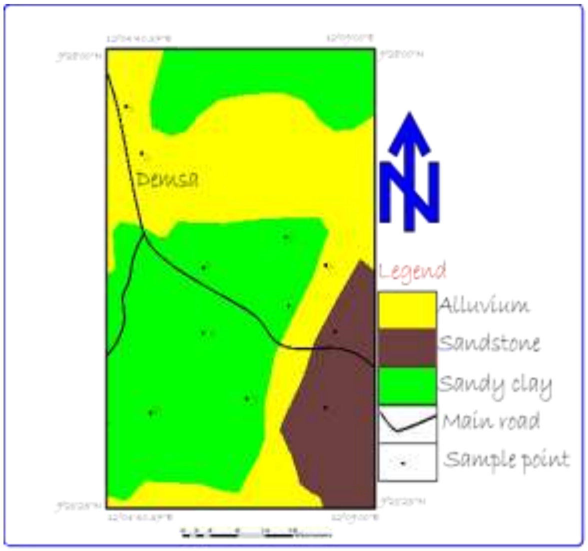

Fig. 2: Geology of the study area showing sample points

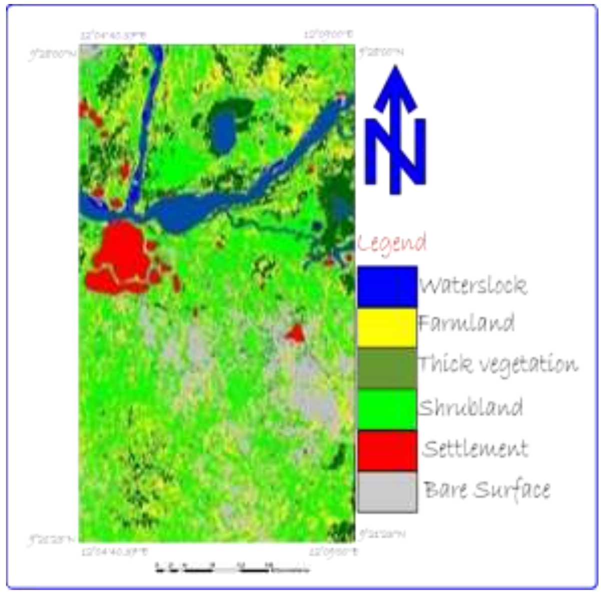

Fig. 3: Study area showing land use and land cover

Sample Collection: Samples were collected in a plastic two (2) liters capacity bottles which were thoroughly rinsed before sample collection, and thoroughly sealed after collection for onward laboratory analysis. In order for the samples not be mixed up, they were labeled before taken for laboratory analysis. This analysis was done in the laboratory of the National Centre for Petroleum Research and Development, Energy Commission of Nigeria, Water Quality Laboratory Analysis, Abubaka Tafawawa Balewa University, Bauchi, Nigeria.

Table 1: Coordinates of hand-dug wells, well depths, well covers and proximity to discharge point

Hand-dug wells (HDW)	Longitude	Latitude	Depth(m) of hand-dug well at the time of collection	Well's Cover	Discharges and their distances away from the wells
Well 1	9.46039	12.03766	6.31	Ply Wood	Soak Away – 9m
Well 2	9.45914	12.03840	1.3	Zinc Plate	Pitt latrine – 8m
Well 3	9.45742	12.03881	1.59	Ply Wood	Stream – 3m
Well 4	9.45260	12.05973	1.96	No Cover	Soak Away – 4m
Well 5	9.45069	12.05924	2.96	Cemented	Soak Away – 10m
Well 6	9.45075	12.05932	1.76	Iron Plate	Soak Away – 5m
Well 7	9.44810	12.05904	1.73	Cemented	Soak Away – 8m
Well 8	9.44814	12.05780	2.27	Wood	Soak Away – 5m
Well 9	9.44870	12.05777	1.31	Cemented	Non – 8m
Well 10	9.44699	12.05646	0.71	Ply wood	Non – 7m

Source: NCPRDEC ATBU Bauchi State Nigeria

RESULTS AND DISCUSSION

The mean values are depicted in Table 1 and the summary of heavy metals parameters in the hand-dug wells in Demsa community is presented in Table 2. The result revealed high concentration of magnesium in the entire water sample obtained from the hand-dug wells in Demsa community and environs. Table 2 shows that manganese, cadmium, magnesium, phosphate and nitrate were evident in high concentrations in some of the hand-dug wells water. As an essential mineral, magnesium acts as an electrolyte, conducting electrical charges in the human body. Magnesium is essential for multiple body functions, including maintaining bone health, cardiovascular regulation, neurotransmitter activity. Most of the body's magnesium is stored in the bones. Excessive magnesium in the bloodstream can result in heart issues, breathing difficulties and shock. This could lead to coma when the case is severe. Hypermagnesemia is an uncommon condition characterized by excessive magnesium levels in the bloodstream. Healthy people usually have relatively small amounts of magnesium circulating in their bloodstream. The gut and the kidney help to regulate the amount of magnesium being absorb by the body and the amount excreted as urine. The normal magnesium concentration range for a healthy body at all time is between 1.7 to 2.3 milligram per deciliter (mg/dL). Magnesium was seen to be high in concentration in the water from all the hand-dug wells sampled for analysis, ranging from 2.11 mg/L in HDW 5 to 6.86mg/L in HDW 2.

Table 2: Concentration of some heavy metals and some physicochemical parameters in water from hand-dug wells in the study area with FEPA, WHO and NSDWQ (2011) limits

S/N	Parameter	Range (mg/L)	Mean Value (mg/L)	FEPA/WHO/ NSDWQ MPL	Remark
1	Calcium	2.110-6.860	4.236	75.000	Below limit
2	Magnesium	3.583-3.765	3.702	2.000	Above limit
3	Cadmium	0.000-1.002	0.104	0.003	Above limit
4	Sodium	3.000-14.000	9.400	200.000	Below limit
5	Copper	0.000-0.070	0.003	1.000	Below limit
6	Iron	0.050-0.180	0.132	0.300	Below limit
7	Potassium	4.000-26.000	14.200	200.000	Below limit
8	Manganese	0.010-0.580	0.148	0.200	Below limit
9	Zinc	0.010-0.090	0.004	0.300	Below limit
10	Lead	0.000-0.000	0.000	0.010	Within limit
11	Chromium	0.000-0.000	0.000	0.050	Within limit
12	Arsenic	0.000-0.000	0.000	0.010	Within limit
13	Nickel	0.001-0.017	0.008	0.020	Within limit
14	Sulphide	0.246-0.677	0.473	0.500	Below limit
15	Chloride	0.186-0.987	0.450	250.00	Below limit
16	Phosphate	3.300-4.900	4.040	1.500	Above limit
17	Fluoride	0.283-0.288	0.286	1.000	Below limit
18	Nitrate	31.400-64.500	46.190	50.000	Above limit

The water samples from hand-dug wells in the study show relatively high concentrations above the permissible limits stipulated by FEPA, WHO and NSDWQ as shown in Fig. 4.

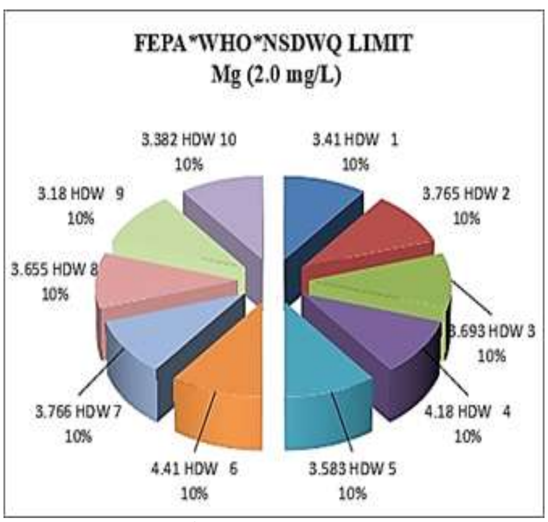

Fig. 4: Distribution of magnesium concentration in the studied hand-dug wells with the stipulated standards.

Constant exposure of water, food and air to cadmium elevates the concentration of cadmium in the kidney. This gives rise to related kidney disease. However, lung disease, bone effects, liver dysfunction and reproductive toxicity could also result due to cadmium exposure. As shown in Fig. 5, the study reveals high cadmium concentration in HDW 1 to HDW 10, with HDW 5 and HDW 6 showing higher concentration above the stipulated limits by water drinking standards of FEPA, WHO and NSDWQ. Thus, there is need for the inhabitants to be sensitize to discontinue the consumption of water particularly from HDW 5 and HDW 6.

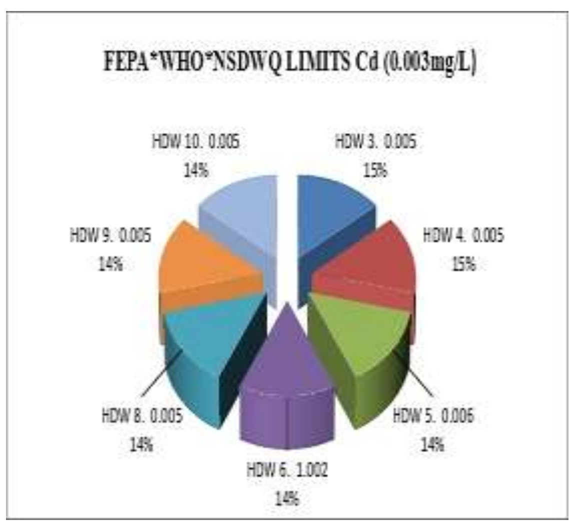

Fig. 5: Distribution of cadmium concentration in the studied hand-dug wells with the stipulated standards

Cadmium concentrations in the hand dug wells in the area vary between 0.001 to 1.002mg/L (Fig. 6). The concentrations show higher values than the permissible limits by FEPA, WHO and NSDWQ. The central, western and southern parts of the study area, account for the highest concentrations of cadmium as shown in Fig. 6. Cadmium is a widespread, non-essential trace element found in the environment. Groundwater, essential for food production and for consumption, can be contaminated with cadmium from geogenic and anthropogenic origins. Cadmium is a known human carcinogen, particularly at elevated doses. Major cadmium contributions from human activities include mining, combustion-generated air pollution and cadmium-enriched fertilizers (Andreas *et al*., 2019).

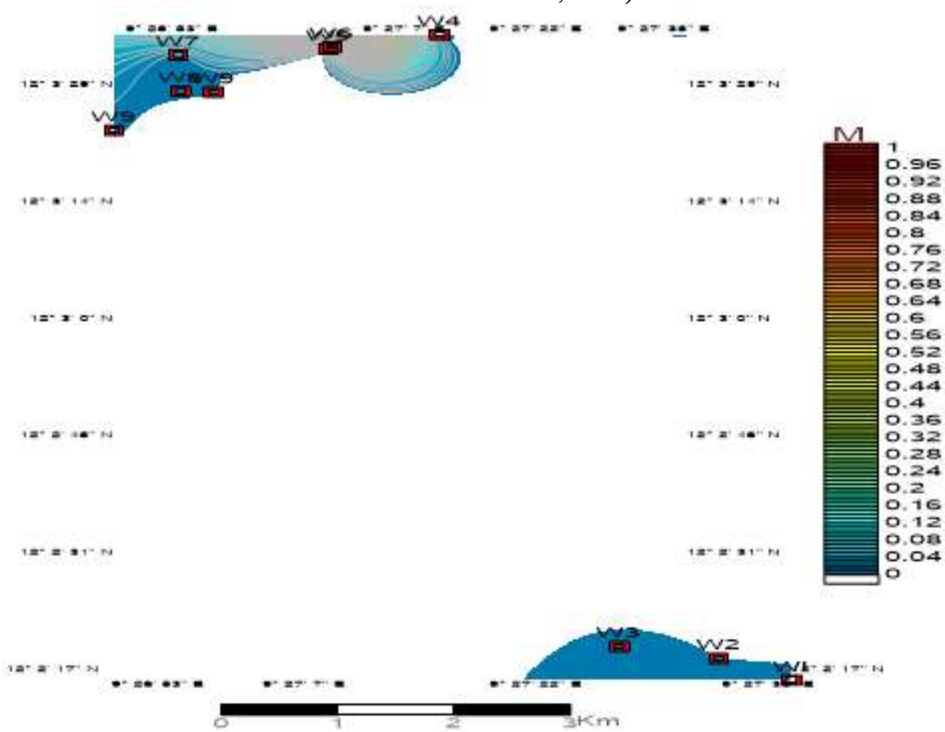

Fig. 6: Cadmium concentration distribution map of the study area

Manganese concentrations measured from hand-dug wells varied from 0.010 to 0.580 mg/L. HDW 3 and HDW 8 indicate high concentration values (Fig. 7) with an average concentration value of 0.148 mg/L obtained from statistical analysis.

Similarly, approximately 95% of the samples analyzed for manganese concentration, revealed values below the 0.2 mg/L aligning with the recommendation from three standards organizations considered in this study.

However, water samples from HDW 1 and HDW 8 showed values higher than the recommended limits. This is consistent with the notion that manganese concentrations tend to increase anaerobic groundwater environments. High manganese concentrations have been linked to an increased risk of neuro degenerative diseases, such as Alzheimer's disease, which affect the cognitive development in children under 10 (Liu *et al.*, 2020).

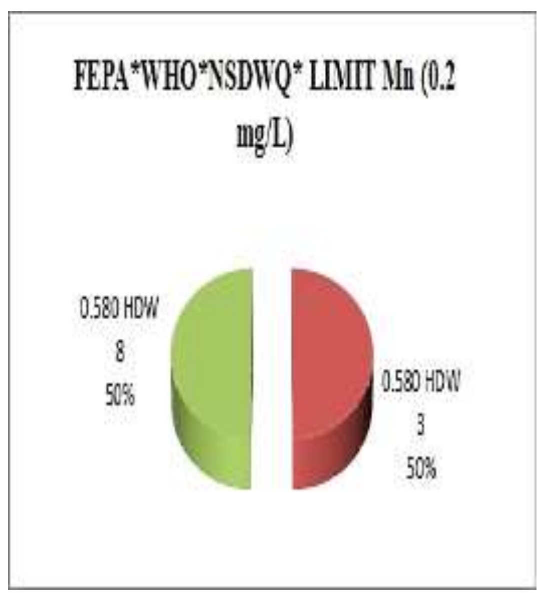

Fig. 7: Distribution of manganese concentration in the studied hand-dug wells with the stipulated standards

Manganese concentrations in the hand dug wells in the area vary between 0.010 to 0.580mg/L (Fig. 7). The concentrations show higher values both than the permissible limits by FEPA, WHO and NSDWQ. The Mn interpolated data distribution map (Fig. 8) shows that the areas with the highest concentration values are in the western, southern and central parts of the study area.

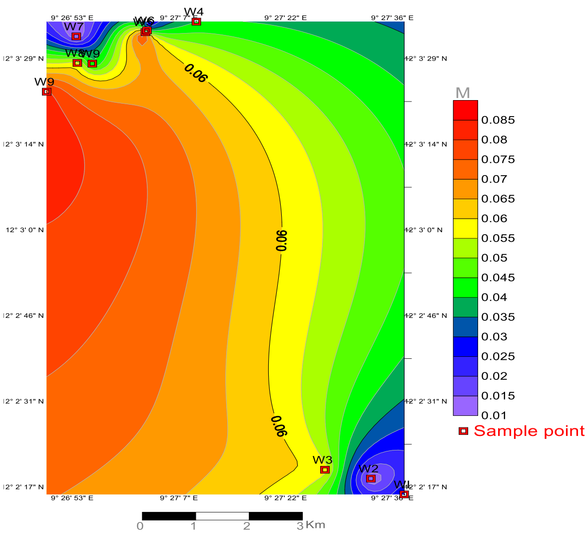

Fig. 8: Manganese concentration distribution map of the study area

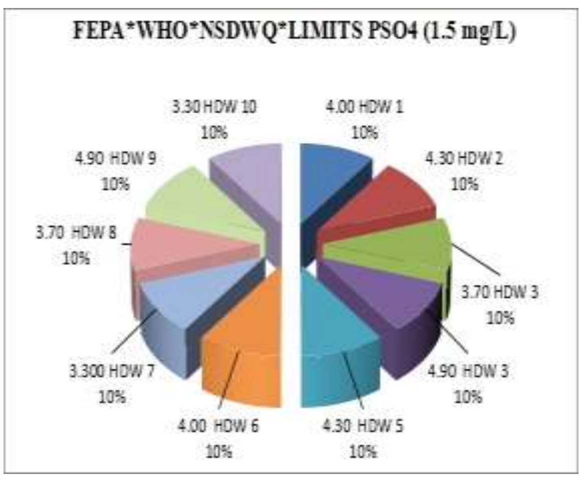

Fig. 9: Distribution of phosphate concentration in the studied hand-dug wells with the stipulated standard

However, HDW 1, 2, 6 and 7 shows high concentration of nitrate as against the stipulated concentration of FEPA, WHO and NSDWQ as shown in Fig. 10. Hence, the need for the inhabitants of Demsa community and environs be admonished of the health effect of high concentration of nitrates in the hand-dug wells. Only recently, specific facts emerged to ascertain the health impact of the consumption of water containing elevated level of nitrate on adults. Intake nitrate can affect the movement oxygen in the blood, leading to a disease condition known as methemoglobinemia (also known as blue baby syndrome).

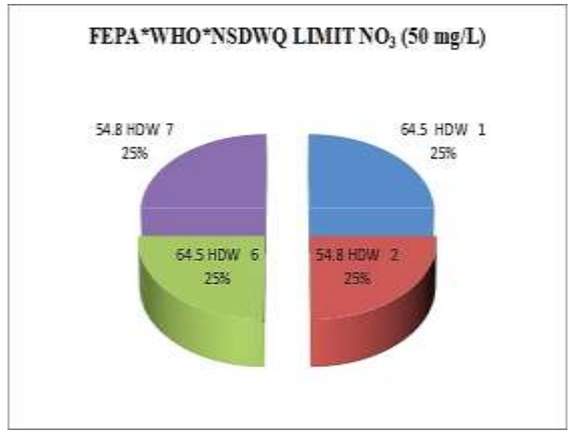

Fig. 10: Distribution of nitrate concentration in the studied hand-dug wells with the stipulated standards

Nitrate concentrations in the hand dug wells in the area vary between 31.4 to 64.5mg/L (Fig. 10). The concentrations show higher values than the permissible limits by FEPA, WHO and NSDWQ. Nitrate concentrations above 3mg/L in groundwater usually signify human-induced contamination (Madison and Brunett, 1985), and findings from a recent nationwide research indicate that nitrate concentrations above 1mg/l are linked to human activities (Dubrovsky *et al.*, 2010). However, manganese levels greater than 0.05mg/L may result in noticeable changes to water's color, smell and taste. HDW 3 and 8 was seen with a concentration of 0.580 respectively. Consuming manganese-contaminated drinking water can result in neurological damage and behavioral changes. Recent research reveals that elevated manganese concentrations in drinking water can adversely impact neurological health and brain development. Therefore, as a precaution, drinking water with manganese concentration exceeding 120µg/L should be avoided due to potential health risks. According to the US EPA, individuals should limit consumption of water with manganese above 1mg/L to no more than 10 days annually. The study reveals high cadmium concentration in HDW 1 to HDW 10, with HDW 5 and 6 showing higher concentration above the stipulated limits by water drinking standards of FEPA, WHO and NSDWQ. Thus, there is need for the inhabitants to be sensitize to discontinue the consumption of HDW 5 and 6 particularly as depicted in Fig. 5. Intake of HDW 5 and HDW 6 should be frowned at because of its deleterious health effect. However, HDW 1, HDW 2, HDW 6 and HDW 7 show high concentrations of nitrate as against the stipulated concentration of FEPA, WHO and NSDWQ as indicated in Fig. 10.

Conclusion: In conclusion, the result revealed high concentration of Magnesium in the entire water sample obtained from the hand-dug wells in Demsa community and environs. Manganese, cadmium, magnesium and phosphate revealed high concentration in some of the hand-dug well water. Therefore, the high concentration of these heavy metals, should be made known to the inhabitants. Furthermore, nitrate shows a high concentration in the water samples analyzed, this could be attributed to the anthropogenic activities and high rate of open dumping and leakages from latrines, septic tanks and unkempt drainage in the study area.

Declaration of Conflict of Interests: There is no conflict of interests among the authors.

Data Availability Statement: Data are available upon request from the first author.

REFERENCES

Andreas, K; Richard, TW; Thomas, P (2019). Cadmium in soils and groundwater: A review. *Appl. Geochem*, 108, 1–16

Ajibade, LT; Ogunkolu, AB; Ogundare, IO (2014). Physico-Chemical and Biological Characteristics of Hand Dug Well Water in Ilorin Metropolis, Nigeria. *Nig. Geo. J.*, 9, 146-162.

Ajibade, OM; Omisanya, KO; Odunsi, GO (2011). Groundwater Portability and Flow Direction of Urban Aquifer, Ibadan Southwest Nigeria. *J. Nig. Ass. Hydro.* 21, 38-55.

Demsa Primary Health Care, 2012.

Dubrovsky, NM; Burow, KR; Clark, GM; Gronberg, JM; Hamilton, PA; Hitt, KJ; Mueller, DK; Munn, MD; Nolan, BT; Puckett, LJ; Rupert, MG; Short, TM; Spahr, NE; Sprague, LA; Wilber, WG (2010). The quality of our Nation's waters-Nutrients in the Nation's streams and groundwater, 1992–2004: *U.S. Geo. Surv. Cir.* 1350

Gebrehiwot, AB; Tadesse, N; Jigar, E (2011). Application of water quality index to assess suitability of groundwater quality for drinking purposes in Hantebet watershed, Tigray, Northern Ethiopia. *ISABB J. Food and Agric. Sci.* 1 (1), 22–30.

Getchew, HM (2004). Study on groundwater and requirements for drilling and tapping ground in Ethiopia. *Proceedings of the International Conference and Exhibition on Ground in Ethiopia, UNECA Conference Center*, Addis Ababa, Ethiopia.

Huisman, L (1986). Lecture Notes on Groundwater Recovery. Belgrade, Yugoslavia, Art B 8-3-8-4

Kennish, MJ (1992). Ecology of Estuaries Anthropogenic Effects. CRC Press, Inc., Boca Raton, p 494

Lar, UA; Bata, T; Dibal, H; Yusuf, SN; Lekmang, I; Goyit, M; Yenne, E (2023). Potential petroleum prospects in the middle Benue trough, central Nigeria: Inferences from integrated applications of geological, geophysical and geochemical studies. *Sci. Afr.* 19, e01436.

Liu, W; Xin, Y; Li, Q; Shang, Y; Ping, Z; Min, J; Cahill, CM; Jack, TR; Wang, F (2020). Biomarkers of environmental manganese exposure and associations with childhood neurodevelopment: a systematic review and meta-analysis. *Environ. Hlth.* 19, 104.

Madison, RJ; Brunett, JO (1985). Overview of the occurrence of nitrate in ground water of the United States, in National Water Summary 1984-Hydrologic Events, Selected Water-Quality Trends, and Ground-Water Resources: *U.S. Geo. Sur. Water-Supply Paper* 2275, 93-105.

Magaji, JY (2009). The Impact of Waste Dump on Soil and Water Quality. A Case Study of Mpape Dumpsite, FCT, Abuja. An Unpublished Ph.D. Thesis Submitted to the Department of Geography and Environmental Management, University of Abuja, Abuja.

Marcovecchio, JE; Botte, SE; Frejie, RH (2007). Heavy metals, Major metals, Trace elements. In: Handbook of water analysis. L. M. Nollet, 2nd Edn. London: CRC press; 275-311.

Martinez, CE; Motto, HL (2000). Suitability of Lead, Zinc and CoppAdded to Mineral Soils. Environmental Pollution 107, 153-158. http://dx.doi.org/10.1016/S0269-7491(99)00111-6

Musa, OK; Shuaibu, MM; Kudamya, EA (2013). Heavy Metal Concentration in Groundwater around Obajana and Its Environs, Kogi State, North Central Nigeria. *American Inter. J. Cont. Res.* 3(8), 1.

Ogunlaja, A; Ogunlaja, OO (2007). Physico-Chemical Analysis of Water Sources in Ubeji Community and Their Histological Impact on Organs of Albino Mice. *J. Environ. Manage.* 11, 91-94.