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Effect of Refuse Dump on Ground Water Quality at Farin-Gida Area of Mando, Kaduna State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study shows the effect s of solid waste dumpsite on ground water quality in Farin-gida, Kaduna State Nigeria. Water samples were collected from six (6) different wells in three(3) strategic areas that have major dumpsites in Farin-gida. These samples were collected in November from both bore holes and hand dug wells within (0-50 meters) to the dumpsite. The following physico-chemical properties of well water was tested for, in the laboratory thus; Total Dissolve Solid, Total Alkalinity, Fluoride, PH, Turbidity and Electrical Conductivity. The results obtained as shown in table 1,2 and 3 respectively indicate that all the wells have varying levels of physico-chemical concentration that is different from the standard as recommended by World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ), which implies that the water from the study areas are not safe for drinking. Hence, should be treated.

Keywords: Ground water quality, refuse, dumpsite, physico-chemical concentration, analysis.

1. INTRODUCTION

Farin-Gida is a large area in Mando. During the pre-colonial era, the rate of natural population increase was very low because of the inter-tribal wars coupled with high mortality rate which also balanced the high fertility. Mando, a town located in Igabi L.G.A within Kaduna metropolis has

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been growing rapidly and steadily in recent time. According to Ajadike [1] Human activities on earth give rise to residual materials which are not of immediate use where they arise. These residual materials may be recycled, reclaimed, or reused; otherwise they constitute waste which will ultimately be released to the environment in mobile form or insitu [2]. The biosphere has the capacity to transform many wastes over time, either into harmless products or into nutrients which can be used again. However, the natural assimilative capacity of the environment can easily be exceeded if wastes particularly from anthropogenic origins are not controlled and managed in an integrated manner. Waste is generated universally and is a direct consequence of all human activities. The disposal of solid waste into the land has been recognized as the major source of groundwater contamination. Waste disposal by land fill has led to pollution of groundwater resources under a wide range of conditions around the globe [3]. Waste is defined as unwanted or undesired materials accumulating after the completion of a process [4]. Waste is also characterized as items that are no longer used for any significant function. They are classified as items with hazardous properties. Such hazardous wastes include household dump items, sewage, sludge, waste from manufacturing industries etc. The United Nations Environmental Program defines waste as those materials which the initial user has no further use for either purposes of production, transformation or consumption and of which can be disposed off . Wastes generally exist as solid, liquid and gas. Liquid waste are wastes that are free flowing such as fluids, waste water, fats, oil, or grease. They are usually generated from industrial activities like refineries, textile industries, waste water treatment plants etc. These wastes are usually emitted and disposed off on land thereby causing land pollution and also at times in water bodies causing water pollution. Gaseous waste on the other hand comprises gases and small particles emitted from open fires, incinerators, and vehicles, or produced by agricultural and industrial processes. Once released, the effects of these gases and particles are hard to control. These wastes include gases like carbon dioxide, carbon monoxide, Sulphur, chlorofluorocarbon etc.

Solid waste is defined as nuisance, unwanted or discarded material with insufficient liquid content or gas for free movement. Cointreau [5] defined solid waste as non-air and sewage emission created within and disposed off by a municipality, including household garbage, commercial refuse, construction and demolition debris, dead animals and abandoned vehicles. Solid waste is a major health hazard in most urban areas in Nigeria. Adebibu [6] grouped solid wastes into eight classes, namely domestic, municipal, industrial, agricultural, pesticides, residential and hazardous wastes. However, solid waste can be classified as biodegradable, or non-biodegradable, soluble or insoluble, organic or inorganic, toxic or non-toxic [1]. Irrespective of the classification of solid wastes, most of the urban wastes are degradable which aid the rate of leachate formation and migration compared to non-biodegradable that can last for many years without any sign of decomposition. There is therefore possibility of leachates generation, plume extension and migration at the base of urban land fill owing to the decomposition of discarded materials and frequent surface water ingression from urban precipitation. Furthermore, groundwater may not be contaminated at the inception of waste deposition in the landfill as the age of the landfill significantly affects the quality of leachate formed.

The ageing of a landfill is accompanied by increased quantity of leachate. Leachate generated at the initial period of waste deposition (up to five years) in refuse dumpsite show a pH value range of 3.5-6.5 indicating the presence of carboxylic acids and bicarbonate ions. With time, pH of leachate becomes neutral or weakly alkaline ranging between 7.0 and 7.6. Landfills exploited for long period of time gives rise to alkaline leacheate with pH range of 8.0 to 8.55 [7]. Waste placed in landfills or open dumpsites are subjected to either underflow or infiltration from precipitation. Areas near landfills have great possibility of groundwater contamination because of potential pollution source of leachate originating from the natural environment. Naturally depth from surface, soil type, bed rock, geology, permeability of sediments and climatic variation affect groundwater quality. Solid waste disposal or dumping creates environmental problems in two main ways. First, much of it is not disposed off and collected on time. In essence the rate of waste dumping is faster than the rate at which it is disposed or cleared. Much of it is burnt or dumped along the streets or haphazardly in illegal landfills. This inevitably creates health hazards, blocking drainages, initiate flooding and contamination of ground water quality. Secondly, because of the inability to sort wastes at source, household and industrial wastes including toxic wastes are often handled together leading to soil and underground water pollution. Water is a common chemical substance that is essential for the survival of all known life form. Water normally exist in three forms namely Solid, Liquid and Gas. Next to air, water is the most essential element for all form of biological activities, comprising over 70% of the earth surface [8] Annan [9] described potable water as precious, we cannot live without it, and human activities have a profound impact on the quality and quantity of water available. Water is inarguably of great importance for domestic industrial, agricultural, religious and recreational uses.

Water is classified under two main categories based on its location and these are surface and groundwater [10]. Groundwater refers to any subsurface water that occurs beneath the water table in soil and other geologic forms. Scientists estimate that groundwater makes up to 95% of all fresh water available for drinking. Groundwater is a significant source of water for many municipal water systems, and residents withdrawing their waters from wells, also rely upon groundwater. Surface water refers to water occurring in lakes, rivers, streams ponds and sea and they are found over the surface of the earth. Surface water occupies a vast part of the earth surface (about 70%). Surface water is naturally replenished by precipitation and naturally lost through discharge to evaporation and sub-surface seepage. Contrary to the widely held theoretical view of groundwater being the “safest” water for consumption, some wells are found to be polluted in terms of temperature, mineral contents, particles solute, organic matter and bacterial concentration [10] These contaminations are mainly gotten from municipal land fill leachates which are highly concentrated complex effluents that contain dissolved organic matters; inorganic compounds such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, chlorides, copper, lead, nickel, zinc and xenobiotic organic substances [11] Therefore, supply of adequate fresh water in large quantity to meet man’s demand and maintaining the quality is now a thing of concern [12]. Hence, contamination of groundwater through the infiltration of leachates via the soil and rocks need to be avoided. The contamination normally takes many years and takes place within a particular distance from the dumpsite. It is very important to avoid the contamination, since pipe borne water is not readily available in many parts of Nigeria, both in urban and rural areas [13] Obviously there is need for alternative sources of water supply like groundwater, but due to lack of proper waste management, the groundwater system is usually affected by refuse dumpsite [12]. Water is said to be polluted when the water body is adversely affected by organic and inorganic contaminants [5].

Inadequate solid waste management is a major environmental problem in Nigeria in general and in Farin-Gida Area of Kaduna metropolis in particular. The contributing factors range from technical problems, to financial and institutional constraints. There is a near absence of any functional solid waste disposal facility in Farin-gida, therefore posing contamination risk to both ground and surface water. The pollutant species in the dumpsites will continue to migrate and attenuate through the soil strata and after certain period of time might contaminate the groundwater system, if there is no action taken to prevent the phenomenon [14].

The aim of this study is to assess the effect of leachate from solid waste dumpsites on groundwater quality in Farin-Gida Area, Mando, Kaduna state, Nigeria. The following are the specific objectives:

i. To establish the proximity of dumpsites to and from wells within the study area and ascertain there level of conformity to standard practices.

ii. To determine the physico-chemical characteristics (Turbidity, Total Dissolved Solid (TDS), temperature, electrical conductivity, iron, fluoride and pH) of water from ground water abstraction structures within the study area with a view to compare findings with acceptable local and international standard.

1.1 Scope of the Study

The research work is mainly on groundwater quality of shallow wells (hand dug wells) and deep wells (bore holes) within Farin-Gida Area. Three major dumpsites were used as reference points for this research work (i.e. the dumpsites in Farin-gida, New Extension Farin-gida Mando, and that of Gwari road area of Farin-Gida). The study is essentially an over view of the nature and characteristics of solid waste dumpsites in the area and the effects they have on wells (boreholes and hand-dug wells) around them.

1.2 Significance of the Study

This study is a very important and relevant study in our society today, because most people in the study area do not have a steady source of pipe borne water supply, therefore they depend on well water as their major source of water supply for their daily domestic and allied uses. The outcome of this study is significant in the following areas.

a. Highlight the relationship between the physical state of an environment and the resultant health implications of mismanaging it. This will help physical planners and health workers coordinate their activities in relation to environmental health policy issues.

b. Guide stakeholders from the environment, health water resource ministries and community based organizations with best options for public campaign towards maintaining a clean environment.

2. METHODOLOGY

2.1 The Study Area

The study area is Farin-Gida, Mando, and is located in Igabi local Government area of Kaduna State. It lies on latitude 10°26'-10°32' North and longitude 7°15'-7°31' East to the North of Kaduna- Lagos highway It is bordered on the East by National Water Resources Institute (NWRI) and Kaduna motors, on the south by Nnamdi Azikwe bye-pass and to west by the Rigassa strea [15]. The location of the study area is shown in Fig. 1.

2.2 Types and Sources of Data Required

The types of data used for this research work are essentially the physico-chemical properties which include; Turbidity, Total Dissolved Solid (TDS), total alkalinity, temperature, iron, fluoride and pH. The sources of data employed in this research work are basically of two types which are; the primary and secondary data sources. The primary data sources were gotten from the field in the form water samples. While the secondary sources of data were gotten from extensive literature review of related materials on the subject matter as well as project documents from stored data that have been collected by others (e.g government agencies, research institutions, textbooks, journals, magazines, pamphlets, academic thesis, government official gazette etc.)

2.3 Sampling Technique

[16] and [17] define sampling as a systematic process used to select a required portion of a target population or area. The sampling technique employed for this research is the purposive sampling technique, because sampling site for well water sample collection was purposively chosen. Sample collection was in November, which is the dry season and This is so, in order to observe any temporal and or seasonal variation in the well water quality of the study area. The well water samples were taken from distances ranging from less than 3 meters (3m) to greater than 7m (7m) away from the dumpsites. However, in a situation where a borehole or hand dug well is not found within the 10m range the well closest within the range of 10-150 meters were used as wells close to the dumpsite and those 150 meters away were used as wells far away from dumpsite for both the borehole and hand dug wells. A total of six(6) water samples were collected randomly for the purpose of this research. Out of the six samples, three (3) water samples were collected from shallow wells of depths between 10-20 meters and the other three (3) samples from deep wells of depths greater than twenty five (25) meters. Three of the well samples for both hand dug wells and deep well are located close to the dumpsites, while the other three were far away from the dumpsites.

2.4 Laboratory Analysis of Sample

The data analysis for this research work was carried out at the National Water Resource Institute Laboratory, where the physico-chemical properties were tested for. The chemical parameters analyzed include Turbidity, temperature, iron, Fluoride, Total Alkalinity, Total Dissolved Solid (TDS), Ph Content In The Water Samples.

2.5 Physical Analysis

2.5.1 pH

The pH is scale used to specify the acidity or basicity of an aqueous solution. Acidic solutions are measured to have lower pH values than basic or alkaline solution. The pH scale is logarithmic and inversely indicates the concentration of hydrogen ions in the solution.

- **Method of Analysis**: pH meter method
- **Apparatus**: pH meter, beaker, measuring cylinder, distilled water, sample water.
- **Procedures**
  - Rinse pH meter, beaker and measuring cylinder with distilled water then rinse again with sample water.
  - Measure 200ml of sample water in the beaker.
  - Immerse the pH meter in the beaker filled with sample water and avoid it touching the glass walls of the beaker.
  - After immersion switch on the meter, allow it to stabilize then take readings.
  - Switch the pH meter off then remove it from the beaker.

2.5.2 Iron

Iron is determined by the titration method. Surface water is prone to having iron dissolve in it due to carbon (IV) oxide coming in contact with iron salts. The presence of iron in water is generally attributed to the solution of rocks and mineral containing these metals.

- **Method of Analysis**: Photometer method
- **Apparatus**: Spectrophotometer, sample cell, iron LR, beaker, sample water, crusher.
- **Procedure**
  - Cells were rinsed with distilled water and sample water respectively.
  - A tablet of iron LR was emptied in a cell then 25ml of sample water was put in the sample cell.
  - The iron LR tablet was then crushed using the crusher and was allowed to dissolve. A code was placed for the device to react.
  - Cell sample without iron LR was placed first, then cell containing iron LR was placed and readings were taken when the read button was pushed.
  - The values were recorded.

2.5.3 Turbidity

Turbidity is a measure of the light transmitting properties of water and is comprised of suspended and colloidal material. It is important for health and aesthetic reasons.

- **Methods of Analysis:** Meter was employed for turbidity analysis.
- **Apparatus**: Turbidity meter, sample cell, sample water, distilled water.
- **Procedure**
  - Switch on the meter first.
  - Rinse the sample cell with distilled water and sample water.
  - Calibrate the device to 0 using distilled water and by adjusting the calibration knob.
  - Standardize the turbidity meter.
  - Read the turbidity meter by inserting the sample (in cell).
  - Switch it off after use.

2.5.4 Fluoride

Fluoride is found naturally in soil, water and food. It is also produced synthetically for use in drinking water, toothpaste, mouth washes and various chemical products.

- **Method of Analysis**: Photometer method
- **Apparatus**: Photometer, sample cell, sample water, fluoride No. 1 (Zircon Chloride) and fluoride No. 2 (Eriochrome Cyanine).
- **Procedure**
  - The photometer is calibrated with the water sample to be tested
  - Cells were rinsed with distilled water and sample water respectively.
  - 25ml of sample water was put into the sample cell and a tablet of fluoride No. 1 was emptied in the cell.
  - The fluoride No. 1 was then crushed using the crusher and was allowed to dissolve before adding the fluoride No. 2 which was also crushed and allowed to dissolve.
  - Code was entered for the device to react.
  - Cell sample without fluoride No. 1 and fluoride No. 2 was placed first, then cell containing fluoride No. 1 and fluoride No. 2 was placed and readings were taken when the read button was pushed.
  - The values were recorded.

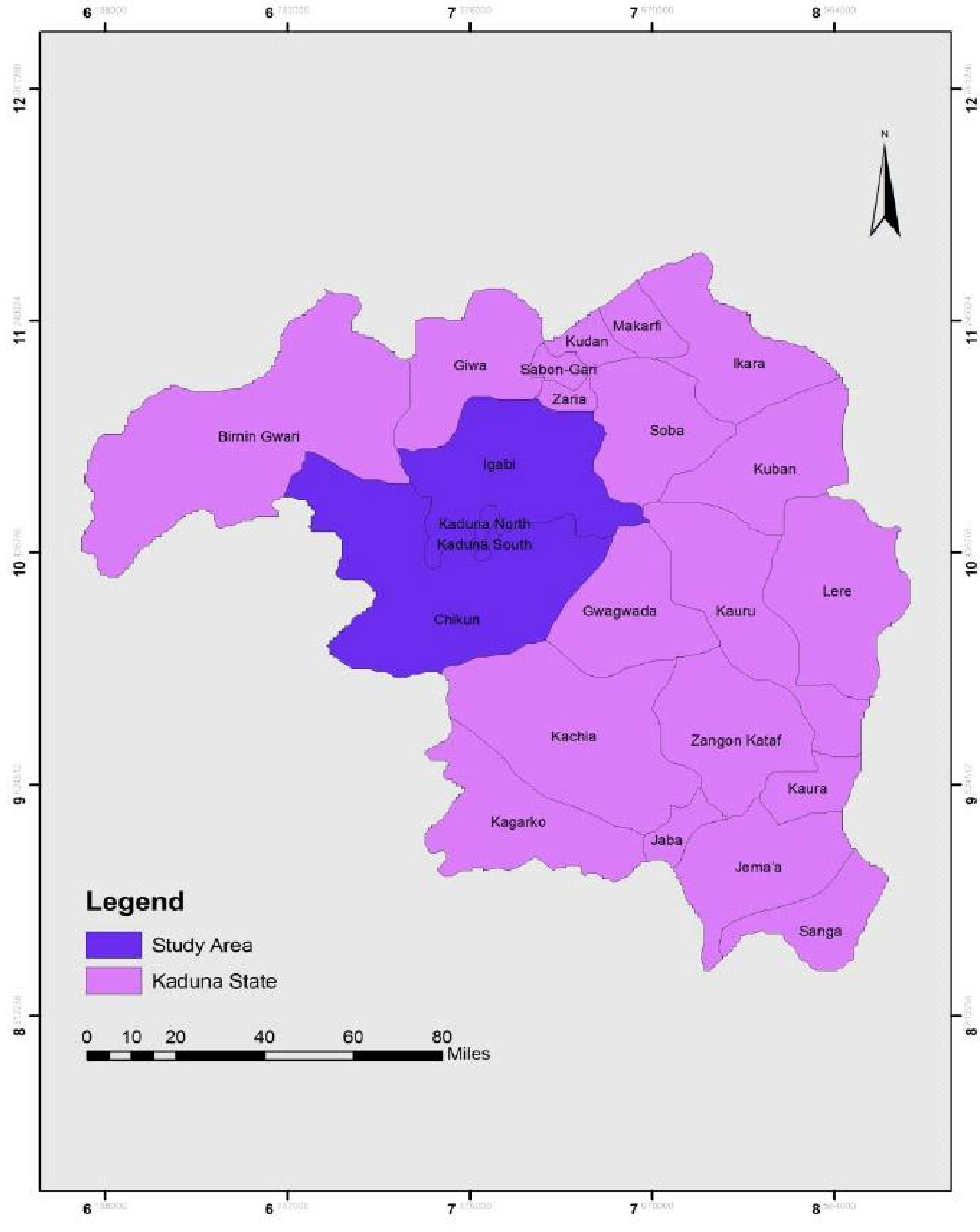

Fig. 1. Kaduna metropolis
SOURCE: GOOGLE MAP 2020

2.5.5 Total Alkalinity

- **Method of Analysis**: Titration method
- **Apparatus and reagents**: Retort stand, conical flask, measuring cylinder, distilled water, sample water, H^2SO_4, methyl orange.

- **Procedure**

- The burette was filled with H^2SO_4 acid and attached to the retort stand.
- The conical flask and measuring cylinder were rinsed with distilled water and sample water respectively.

- 100ml of sample was measured with the measuring cylinder and transferred to the conical flask.
- Two drops of methyl orange was added to the sample in the flask and placed under the burette for titration.
- Titration occurred till color changed.
- Take note of the initial reading and final reading of the burette.
- Apply formula to get the concentration of alkalinity.
- Calculation total alkalinity=final reading - initial reading x 1000/100

2.5.6 Total Dissolve Solid

- **Method of Analysis:** Conductivity meter method
- **Apparatus:** Beaker, conductivity meter, sample water.
- **Procedure**

- Rinse the beaker with distilled water then with sample water.
- Fill the beaker with sample water.
- Immerse the probe of the conductivity meter in the beaker.
- Switch on the meter and wait for it to show ready then press hold and take readings.
- Press mode to check for the next parameter.

2.5.7 Electrical Conductivity

This is the numerical expression of the ability of water to carry electrical current, measured with a conductive meter.

- **Method of Analysis**: Conductivity is commonly and easily analyzed with conductive meter.
- **Apparatus**: Electrical conductivity meter, Probe, beaker,
- **Procedures**

- Rinse a clean beaker cell with distilled water and fill the sample.
- Set the function switch and range switch to the most appropriate position to obtain the scale reading
- The electrode of the conductive meter is rinsed with water sample and dipped into a beaker containing the water sample.
- Read the conductivity of the sample directly from the meter scale in s/cm
- Record the conductivity.

3. RESULTS AND DISCUSSION

3.1 Physico-Chemical Properties of Well Water in the Study Area

The water samples collected were six (6) from different wells The six(6) water samples were gotten from different sources of both shallow wells (hand dug) and deep (bore hole) wells, at different time frames and also from different distances.

3.2 Physico-Chemical Properties of Well Water in Farin-Gida New Extension during Dry Season

The physico-chemical properties of well water in Farin-gida new extension during dry season is presented in Table 1.

Table 1. Physico-chemical Properties of Well Water in Farin-Gida New Extension during Dry Season

S/N	Parameters Measured	Bore-hole (7m from dumpsite)	Hand-dug	WHO Standard (2011)	NSDWQ (2007)
	mg/L	Close to	Close to	Standard	Standard
1	pH	5.00	5.80	6.5-8.5	6.5-8.5
2	TDS	238.00	175.00	500.00	500.00
3	Turbidity	1.60	0.20	6.00	5.00
4	T/Alkalinity	20.00	21.00	500	NS
5	Electrical Conductivity	472.00	348.00	1000	1000
6	Fluoride	0.35	0.14	1.5	1.5
7	Iron	0.05	0.06	0.3	0.3

Source: Laboratory Analysis, 2019

From Table.1, it can be seen that the difference between the water quality of borehole and hand dug wells in Farin-Gida New Extension is not much, except for Total Dissolved Solid (TDS) which showed a much higher value in deep wells than the shallow wells. It was also observed that all the parameters analyzed fall within the WHO and NSDWQ standard for water quality in the wells in the study area. The high level of TDS is due to the dumpsite, it was discovered that the pH level of all the groundwater samples are generally acidic and were below the WHO and NSDWQ standard for potable water.

3.3 Physico-chemical Properties of Well Water in Farin-gida Dumpsite during the Dry Season

The physico-chemical properties of well water in Farin-Gida close to dumpsite during the dry season (November) is presented in Table 2.

Table 2 indicates that the difference between physico-chemical quality of well water in borehole and hand dug well is not high, except for pH which are acidic and they fall below the WHO and NSDWQ standard. And are not good for direct consumption, except is been boiled or undergo some chemical purification before it can be consumed.

3.4 Physico-chemical Properties of Well Water in Gwari-Road during the Dry Season

The physico-chemical properties of well water quality for borehole and hand dug wells close to dumpsites at Gwari Road during dry season (November) is presented in Table 3.

From Table .3, it can be observed that the difference between the water quality of borehole and hand dug wells in Gwari-Road is not much, except for TDS for shallow wells and deep wells that are very low in standard. It was also observed that the level of quality of all the parameters observed falls within the WHO (2011) and NSDQW (2007) limit for permissible drinking water, except for fluoride in deep wells water quality in the area which is not present in the water sample.

Table 2. Physico-chemical Properties of Well Water in Farin-gida Dumpsite during Dry Season

S/NO	Parameters Measured	Bore-hole (5m from dumpsite)	Hand-dug well (2m from ds)	WHO Standard (2011)	NSDWQ (2007)
	Mg/l	Close to	Close to	Standard	Standard
1	pH	5.40	5.60	6.5-8.5	6.5-8.5
2	TDS	63.30	340.00	500	500
3	TURBIDITY	1.50	3.10	5.00	6.00
4	T/ALKALINITY	64.00	19.00	500	NS
5	ELECTRICAL CONDUCTIVITY	127.10	683.00	1000	1000
6	FLUORIDE	0.43	0.00	1.5	1.5
7	IRON	0.06	0.01	0.3	0.3

Source: Laboratory Analysis, 2019

Table 3. Physico-chemical Properties of Well Water in Gwari-Road during Dry Season

S/NO	Parameters Measured	Bore-hole (8m from dumpsite)	Hand-dug well (6m from ds)	WHO Standard (2011)	NSDWQ (2007)
	mg/L	Close to	Close to	Standard	Standard
1	pH	5.10	5.20	6.5-8.5	6.5-8.5
2	TDS	95.40	54.70	500.00	500.00
3	TURBIDITY	1.20	1.70	5.00	6.00
4	T/ALKALINITY	19.00	15.00	500.00	NS
5	ELECTRICAL CONDUCTIVITY	191.19	109.30	1000	1000
6	FLUORIDE	0.00	0.30	1.50	1.50
7	IRON	0.79	0.01	0.30	0.30

Source: Laboratory Analysis, 2019

4. CONCLUSION

The result obtained from this study shows that the groundwater of Farin-Gida is not totally pure. A high level of contamination was recorded for some of the parameters that were analyzed. It can therefore be concluded that the groundwater of the study area especially wells close to dumpsites is not good enough for direct consumption following evidence of high Acidic concentration in most of the wells.

From the result obtained in the analysis, it can also be said that dumpsites alone is not responsible for groundwater contamination of the study area, but geology of the study area, and some previous land use practices such as mechanic shop, abattoir, soil type and geologic factors can also be responsible for groundwater contamination.

From the test and results obtained from the research it was discovered that the physico-chemical properties of well water for both shallow and deep wells in the study area fall within the acceptable limits of the WHO standards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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