**International Journal of Chemistry Studies**
**ISSN: 2581-348X; Impact Factor: RJIF 5.44**
**Received: 08-01-2019; Accepted: 12-02-2019**
**www.chemistryjournal.in**
**Volume 3; Issue 2; March 2019; Page No. 11-13**

# Assessing the pollution indicator in groundwater in Hadejia metropolis, Jigawa state, Nigeria

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**Abstract**
Study was carried out to determine the nitrate levels in groundwater samples in Hadejia Metropolis Jigawa State, Nigeria. Water samples were collected from 20 selected hand pumps in the area, the CHEMetrics nitrate vacu-visuals test kit was used which employs the cadmium reduction method. The results obtained from the study shows that Sample sites of Majema, Matsaro, Hudu and Gagulmari have the highest concentration of 34.50 ± 0.25, 32.73 ± 0.03, 28.78 ± 0.02 and 21.59 ± 0.01 respectively. Kofar Yamma and Titin Yahai have moderate nitrate concentration among the sampling sites of 14.83 ±0.03 and 13.31 ± 0.09 respectively. Eleven sampling sites recorded least concentrations, while nitrate was not detected in three sampling sites of Unguwar Mu'azu, Sabon Garu and Dallah. It can be concluded that all the water samples which contained nitrate have its concentration below the maximum permissible level of 50mg/L recommended by WHO implying that the water is safe for human consumption from the point of view of nitrate concentration.

**Keywords:** groundwater, nitrate, Hadejia metropolis

## 1. Introduction

Water is a ubiquitous chemical substance that is essential for the survival of all known forms of life. It is an incredibly important aspect of our daily lives. Water is absolutely essential to the human body's survival because a person can live for about two weeks without food but under optimal condition can live for only ten days without water (Belcastro and Gold, 1993) [5]. Accessibility and availability of fresh clean water is a key to sustainable development and an essential element in health, food production and poverty reduction. A communiqué issued after the third World Water Forum on water in 2003, reported that an estimated 1.2 billion people around the world lack access to safe water and close to 2.5 billion are not provided with adequate sanitation (Adekwule *et al*., 2003) [1]. Safe and portable water supplies in urban centres in Nigeria are still inadequate in-spite of over five decades of independence and several efforts from various governments. In Hadejia, Jigawa state, despite the intervention of the World Bank and the state government, a gap still exists in the processing of safe drinking water, as a result a certain proportion of the population is forced to rely on hand pump borehole water for drinking source as the alternative to the inconsistent flow of pipe borne water supply, which could have been more reliable source of safe water for the growing population.

Pollutants such as heavy metals, nitrates, phosphate among others have been known to be present at very high concentrations in waters that are not properly treated. Nitrate is a natural contaminant of waters, soil, plant and food (Groen *et al*., 1988) [9]. It is formed when microorganisms in the environment breakdown organic materials such as plants, inorganic fertilizers, animal manure, and sewage (Groen *et al*., 1988) [9]. Nitrate ($NO_3^-$) can get into drinking water from runoff or sewage into groundwater from farms and gardens. Other sources of nitrate in water include landfills, poorly damaged animal feedlots, faulty septic systems, and also poorly constructed or improperly located wells. Nitrate in groundwater drinking water systems is of concern because private self-supplied drinking water systems, which primarily draw from groundwater, are not federally regulated. It is the owner's responsibility to test and treat their own well for nitrate and other pollutants. While nitrate does occur naturally in groundwater, concentrations greater than 3 mg/L generally indicate contamination (Madison and Brunett, 1985) [13], and a more recent nationwide study found that concentrations over 1 mg/L nitrate indicate human activity (Dubrovsky *et al*. 2010) [12]. EPA's maximum contaminant level (MCL) for nitrate set to protect against blue-baby syndrome is 10 mg/L.

The acute health hazard associated with drinking water contaminated with nitrate occurs when bacteria in the digestive system transform nitrate to nitrile. The nitrile reacts with iron in the hemoglobin of red blood cells to form methemoglobin, which lacks the oxygen carrying ability of hemoglobin. This creates the condition known as methemoglobinemia (sometimes referred to as blue baby syndrome) in which blood lacks the ability to carry sufficient oxygen to the individual body cells. Infants under one year of age have the highest risk of developing methemoglobinemia (Met Hb). The reduction of nitrate to nitrite by gastric bacteria is also higher in infants because of low gastric acidity. The level of nitrate in breast milk is relatively low; when bottle-fed, however, these young infants are at risk because of the potential for exposure to nitrate/nitrite in drinking- water and the relatively high intake of water in relation to body weight. The higher reduction of nitrate to nitrite in young infants is not very well quantified, but it appears that gastrointestinal infections exacerbate the conversion from nitrate to nitrite (BGS, 2009) [6].

Concentration of nitrate above 100mg/L can affect pregnant women and those adults with a rare metabolic phosphate dehydrogenase deficiency (Ayobe *et al*., 1997) [4]. Chronic nitrate toxicity has also been implicated in spontaneous abortion, infant and foetal deaths, reduced vitality, increasing still births, slow weight gain in livestock, central nervous system, birth defects, diabetes and changes to the immune system (Gupta, *et al*., 2000) [10]. Long term effects of lifetime exposure to nitrate above maximum contamination level (50mg/L) include duiresis, increased starchy deposits and haemorrhaging of the spleen. The amount of annual recharge from precipitation will influence the amounts of nitrate in groundwater through dilution effects so that in arid or semi-arid regions concentrations will be proportionately greater than for an equivalent environment in a humid region. It is important to recognize that other sources of groundwater nitrate exist (Edmunds and Gaye, 1997) [8]. These include:

- Geological sources, such as the saltpetre deposits of Northern Chile;
- naturally high baseline concentrations in semi-arid areas, thought to be derived from nitrogen fixing indigenous plants, such as the acacia species found in areas of the Sahara/Sahel region of North Africa;
- Atmospheric deposition.

The study was aimed at investigating the nitrate level in the groundwater of Hadejia local government area and to compare with WHO drinking water standards and to predict its suitability for domestic use.

## 2. Materials and Methods

### 2.1 Study area

Hadejia local government lies on the northern-bank of the River Hadejia which drained into lake Chad, it lies in the north eastern corner of Jigawa state (120 131 – 130 601N latitude and 90 221 – 11000E longitude). The area is underlain by rock and younger sediments of the Chad formation, which are of quaternary age. The topography of the area is dominated by the river which at some points is 1-2 metres above the surrounding plains including the town. The relief is generally undulating, usually below 400 metres above sea level. The climate of the area is semi-arid. It is characterized by a long dry season and a short wet season from June to September. The climatic variables vary considerably during the year. However, the micro- climate is modified by the local effect of the Hadejia River system, making the temperature slightly cooler in the southern parts. The mean annual temperature is about 25oC but the mean monthly values range between 21oC in the coolest month and 31oC in the hottest month. The total annual rainfall ranges from 600 mm in the northern part to 762 mm in the southern areas. The regional vegetation falls within the Sudan Savannah type. Extensive open grasslands with few scattered trees are characteristic of the vegetation.

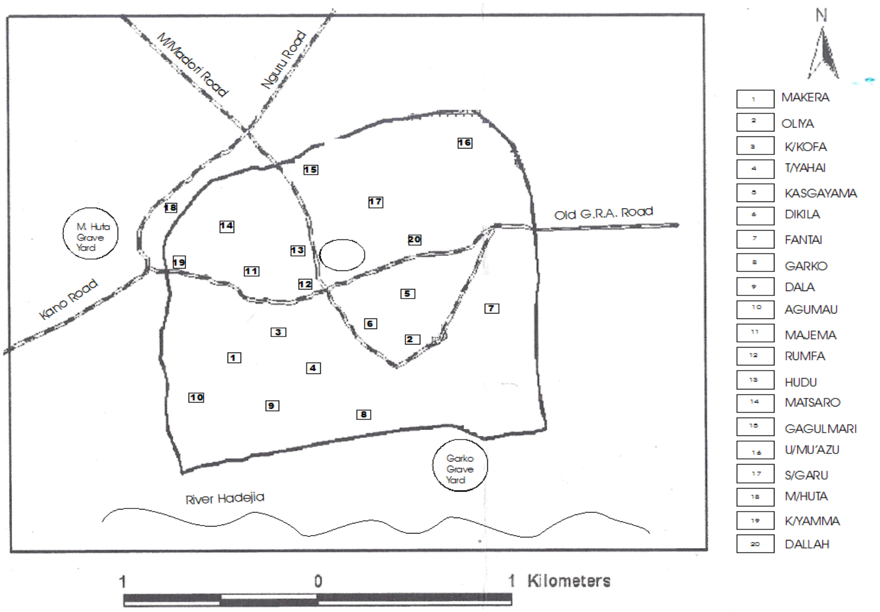


**Fig 1:** Map of Hadejia local Government area showing sampling sites

### 2.2 Sample Collection

Twenty sampling sites were selected to cover the study. The choice of location was guided by availability of borehole (hand pumps). One litre (1L) of the water samples from the boreholes from each station were collected using 1L polyethylene bottles, after washing with detergent and rinsed with 5% nitric acid and deionized water. The borehole were allowed to flow for about 3 minutes before the water is collected, and the containers were thoroughly washed and rinsed with the water to be collected. The samples were preserved in a freezer at $4^{o}C$ pending analysis (ASTM, 2004) [3].

### 2.3 Sample Analysis

Twenty hand pump water samples were used for the study. Standard method of quantitative determination of nitrate and general water analysis as described by APHA (2005) [2] was employed. The analysis was conducted at the Centre for Energy, Research and Training, Ahmadu Bello University Zaria, Nigeria using V-2000 Multi-Anaylte photometer (which is the most advanced particle micro-processor – based LED water analyzer on the market today). Packed with features, this portable instrument is pre- programmed to measure 30 analytes (including chlorine, copper, nitrate, phenols, phosphate, sulphide and many more) automatically, using CHEMEtrics Vacu-Visuals self filling ampoules. The ampoule is immersed in the sample and the tip is snapped off, the correct volume of sample is drawn in by vacuum and a small inert gas bubble remains. Sample and reagent are mixed by tilting the ampoule so the bubble travels from one end, allowing the reaction to complete and in 2 minutes or less; the colour developed measured the quantitative amount of nitrate in the sample using the V-2000 photometer. The nitrate Vacu-visuals test kit employs the cadmium reduction method (APHA, 2005) [2]. Nitrate is reduced to nitrile in the presence of cadmium. In an acidic solution, nitrile diazotizes with a primary aromatic amine and then couples with another organic molecule to produce a highly coloured azo dye. The resultant pink orange colour is proportional to nitrate concentration expressed in mg/L nitrate.

## 3. Results and Discussion

**Table 1:** Mean Value of Physico-Chemical Parameter of some selected Borehole Groundwater in Hadejia Local Government Area, Jigawa State

| Sampling Site | Mean $No_3^-$ Concentration (mg/L) |
|---|---|
| Makera | 4.80 ± 0.01 |
| Oliya | 7.51 ± 0.01 |
| Kasuwar Kofa | 1.40 ± 0.07 |
| Titin Yahai | 13.31 ± 0.09 |
| Kasgayama | 2.55 ± 0.03 |
| Dikila | 4.49 ± 0.02 |
| Fantai | 3.75 ± 0.03 |
| Garko | 1.97 ± 0.03 |
| Dala | 2.10 ± 0.03 |
| Agumau | 5.70 ± 0.02 |
| Majema | 34.50 ± 0.25 |
| Rumfa | 8.41 ± 0.03 |
| Hudu | 28.78 ± 0.02 |
| Matsaro | 32.73 ± 0.03 |
| Gagulmari | 21.59 ± 0.01 |
| Unguwar Mu‟Azu | ND |
| Sabon Garu | ND |
| M/Huta | 9.91 ± 0.01 |
| Kofar Yamma | 14.83 ±0.03 |
| Dallah | ND |
| WHO | 50mg/L |

ND = not Detected

The results in the table above showed that almost all the water samples analyzed have their nitrate concentration below the maximum permissible level of 50mg/L allowed by WHO for drinking water. Sample sites of Majema, Matsaro, Hudu and Gagulmari have the highest concentration of 34.50 ± 0.25, 32.73 ± 0.03, 28.78 ± 0.02 and 21.59 ± 0.01 respectively. Kofar Yamma and Titin Yahai has moderate nitrate concentration among the sampling sites of 14.83 ±0.03 and 13.31 ± 0.09 respectively. Eleven sampling sites recorded least concentrations while nitrate was not detected in three sampling sites of Unguwar Mu'azu, Sabon Garu and Dallah. Although all sampling sites recorded nitrate concentration below the WHO maximum permissible level, they may have their nitrate level rise above the recommended level if not properly treated or the source of nitrate was not checked and measures taken particularly the sites with high level, this is largely due to closeness of these boreholes to the refuse dumping sites which of course may attribute to the presence of nitrate in a bit higher concentration as reported.

## 4. Conclusion

The result of the study showed that the water samples analyzed were safe for human consumption with respect to their nitrate level. However, there is a need to monitor especially the three sampling sites of Majema and Matsaro and Hudu in order to be certain and possible determination of its quality i.e. increase in nitrate concentration; since health problems associated with unacceptable levels of nitrate in drinking water is on the increase globally.

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