Current Journal of Applied Science and Technology

39(8): 7-11, 2020; Article no.CJAST.55963
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Spatial Variability of Nitrate Levels in Groundwater of Lokoja Town, Kogi State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author ALO created the procedures for the study, wrote the first draft of the manuscript, conducted the field work and drew the spatial map. Author MIO managed the laboratory analyses of the study and provided the Literature review. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i830586
Editor(s):
(1) Dr. Md. Hossain Ali, Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Agricultural University, Bangladesh.
Reviewers:
(1) Adamu Mustapha, Kano State University of Technology, Nigeria.
(2) Sangoremi, Anthony Abidemi, Federal University Otuoke, Nigeria.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55963

Original Research Article

Received 08 February 2020
Accepted 13 April 2020
Published 02 May 2020

ABSTRACT

This research was undertaken to assess the spatial distribution of Nitrate levels in the groundwater withdrawn via boreholes. This was done by sampling functional boreholes in the study area for nitrate levels. Lokoja town was selected for this research and the analysis of nitrate contamination was conducted in September which is usually the peak of the rainy season. Ten (10) water samples were collected from ten (10) different boreholes across Lokoja town and examined for Nitrate contamination. Laboratory analysis was conducted via standard methods for water examination using the Cadmium Reduction Method. Results from the laboratory analysis showed that all the boreholes sampled during the study were contaminated with Nitrate. However, the levels of contamination observed were all below the maximum limit of 50 milligrams per litre (mg/l), prescribed by the Nigerian Standard for Drinking Water Quality (NSDWQ). Nitrate levels observed were low at the northern part of the study area and increased down south. This can be attributed to factors of land use and hydrogeologic features of the place. Annual flooding, the use of inorganic fertilizers and the indiscriminate dumping of waste might be responsible for the high levels of Nitrate observed in Ganaja Village, which is in the southern part of the study area. On a whole, it is

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recommended that further work be carried out to examine Nitrate levels in the groundwater of other flood plains within the country with similar land use patterns. This will help to ascertain the combined influence of waste, the use of inorganic fertilizers and flooded soils on nitrate levels in groundwater reserves. Furthermore, the water in the study area can be utilised if properly subjected to efficient purification methods.

Keywords: Spatial variation; water quality; nitrate; groundwater.

1. INTRODUCTION

Nitrate falls under the group of anions and can be found naturally in the environment. Nitrate can reach groundwater as a consequence of leaching from natural vegetation, agricultural activities, septic tanks and from the oxidation of nitrogenous waste products in human and animal [1]. In recent times, Nitrate loading from the application of Nitrogen fertilizers has become a major challenge in groundwater utilisation. This has generated huge concerns due to the extensive dependence of many nations on groundwater abstraction and the widespread use of nitrogen fertilisers to meet up with the current demands of food production. Nitrates ingested by humans, especially children can lead to methaemoglobinaenia which is a result of the reaction between nitrate and haemoglobin in the red blood cells. During this process the haemoglobin is oxidised to bind oxygen tightly and interferes with oxygen transport which can lead to death [2]. In recent years, Nigeria has experienced an increased level of groundwater utilisation to meet her current water needs.

However, the extensive use of artificial fertilizers to meet up with the current food demands of the growing population has continued to pose serious challenge to groundwater reservoir. Thus, there is a growing body of literature that have linked high level of Nitrate loadings in groundwater reserves to the application of inorganic fertilizers [3,4,5]. This has remained a major health concern owing to the health risks involved with long-term ingestion of water with high levels of Nitrate. Delivering suitable solutions will involve appropriate knowledge of the problem in relation to the environment under study. Which can be achieved conveniently with the provision of these spatial maps. Consequently, there is a growing number of literature on the spatial variation of Nitrates [6,7, 8,9]. However, not much has been done to map out the spatial distribution of Nitrate levels in the groundwater of the study area. Hence, the relevance of this study. This study will map out the spatial variation of Nitrate Levels in the groundwater of Lokoja. This will be very essential in providing fitting solutions to Nitrate loadings in the groundwater in the region.

2. MATERIALS AND METHODS

Groundwater abstraction in the study area is majorly via had dug wells and a few boreholes sunk by the government and some affluent private homes. However, it is important to note that this study was centred on just boreholes. This is as a result of the need to assess the main aquifer instead of the shallow water table which is easily assessed with the sinking of hand dug wells. As a result, ten (10) functional boreholes were designated within Lokoja town for this research. The selected boreholes were labelled MW-01, MW-02, MW-03, MW-4, MW-5 MW-10 respectively. In addition, the locational details of all the boreholes were also collected and documented. A hand-held Global Positioning System was used to collect data on the longitude and latitude of the selected boreholes. The study area is majorly an administrative town thus land use is majorly residential with a few institutional and agricultural areas. Selected boreholes will be from these areas. The water samples from the selected boreholes were collected using sterilized screw-capped plastic water bottles. The plastic water bottle was rinsed thoroughly with the same water before collection. This was to avoid contamination by any physical, chemical or microbial means. The water samples were eventually taken directly to the Laboratory and analysed for Nitrate levels using standard methods for water examination. This was carried out with the Cadmium Reduction Method. Finally, the GroundWater Spatio-Temporal Data Analysis Tool (GWSDAT) was used to plot the spatial variability of the observed Nitrate levels in the area.

3. RESULTS AND DISCUSSION

Results for the analysis is presented on Table 1 and denotes spatial variation in Nitrate levels observed within the study area, which were all below the maximum limit of 50 milligrams per liter (mg/l), prescribed by the Nigerian Standard for Drinking Water Quality [10].

Table 1. Results of the nitrate levels in the water sampled

Location of borehole	Well name	GPS location		Nitrate (mg/l)
Army Barracks	MW-01	E 243688	N 862926	0.4
Workers Village	MW-02	E 246184	N 863918	1.1
Crusher	MW-03	E 243072	N 867187	0.1
Fellele	MW-04	E 249754	N 868321	0.1
Kogi State Polytechnic	MW-05	E 250651	N 867383	2.9
Ajara Quarters	MW-06	E 251591	N 863541	0.1
GRA	MW-07	E 250671	N 862685	3.0
Adankolo New Layout	MW-08	E 250279	N 861467	7.0
Ganaja Village	MW-09	E 250933	N 856742	10.2
Lokongoma Phase 1	MW-10	E 248950	N 861668	5.4

**Source: Field and laboratory analysis*

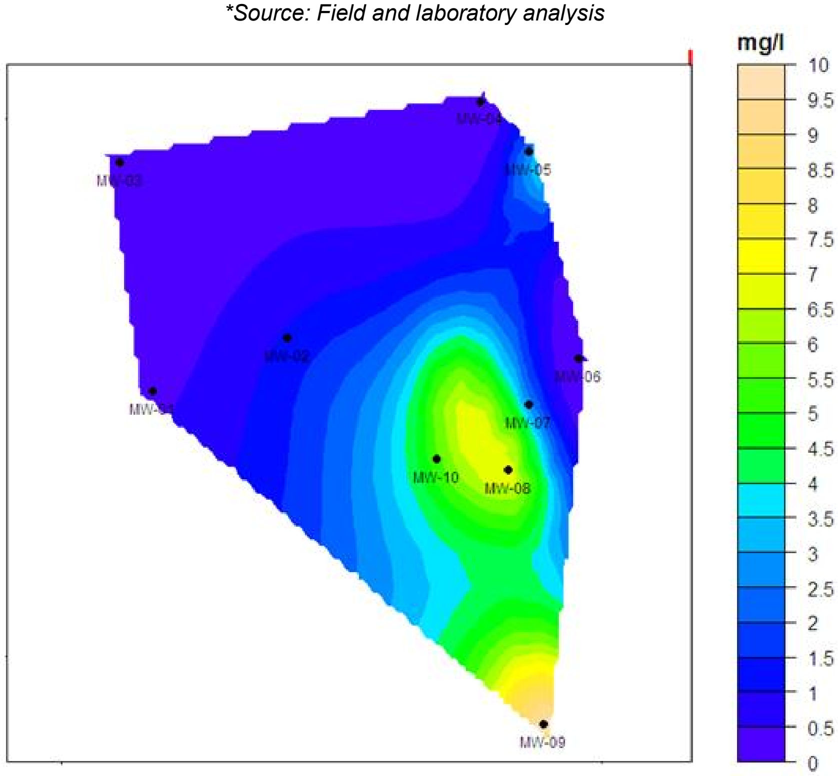

Fig. 1. Spatial variation of nitrate levels in the groundwater drawn from selected boreholes in Lokoja

According to the study, the levels of Nitrate were observed to be low at the northern part of the study area and increased down south as shown in Fig. 1. This could be as a result of the hydrogeologic features of the place and the cumulative loading of Nitrates into groundwater reserves via the application of fertilizers. It is important to note that the highest value of Nitrate was recorded in Ganaja village (MW-09) which is located on the flood plain of River Niger and is usually flooded every year. Moreover, this area over the years had been used for some level of agricultural activities. However, in recent years have experienced rapid population growth due the growth of new settlements. Consequently, some of the agricultural lands in Ganaja village have been converted for residential use.

The consequence of this is that cultivation over the years may have already introduced high nitrate loading to the groundwater through the solubilizing of excess nitrogen from the applied fertilizers, which is mobilised into groundwater reserves via infiltration of the flooded water, resulting in Nitrate contamination in groundwater observed. This could be responsible for the high nitrate levels in the groundwater of Ganaja village. Taking into consideration the fact that the impact of land use in the study area has been cumulative over the years.

Furthermore, the hydrogeologic characteristics of Ganaja village may have also exacerbated the mobility of Nitrate into groundwater reserves. Ganaja is located on the flood plain of River Niger and is usually flooded every year. Consequently, this could result in the solubilizing of excess nitrogen from the applied fertilizers, which is mobilised into groundwater reserves via infiltration of the flooded water, resulting in Nitrate contamination in groundwater observed. This has also been observed in a number of studies [11-14]. Moreover, the problem of floods in Ganaja is further exacerbated by the presence of dumps which leads to the complete subsuming of a number of dumps and septic systems (in the area) below the water table. As a result, leachate from these sanitary facilities are incorporated freely into the water table without any form of barrier or natural filtering. In a similar way, the boreholes located in Adankolo new layout (MW-8) and Lokongoma Phase 1 (MW-10) which is located at a very close proximity to River Meme, both had high levels of nitrate. Yearly floods at the height of the rainy season could also lead to the subsuming of sanitary facilities in the elevated water table. Consequently, this could introduce nitrates into groundwater reserve in the area. Thus, they are a number of studies that have shown the impact of waste as a contributing factor to the presence of nitrates in groundwater [9,15].

4. CONCLUSION

The study indicates that all the boreholes examined in the course of this research work were contaminated with Nitrate. However, the levels of contamination observed were all below the maximum limit of 50 milligrams per liter (mg/l), prescribed by the Nigerian Standard for Drinking Water Quality. Nitrate levels observed were low at the northern part of the study area and increased down south. This can be attributed to factors of Land use and the hydrogeologic features of the place. Yearly flooding , the use of inorganic fertilizers and the indiscriminate dumping of waste might be responsible for the high levels of Nitrate observed in Ganaja Village, which is in the southern part of the study area. On a whole, it is recommended that further work be carried out to examine Nitrate levels in the groundwater of other flood plains within the country with similar land use patterns. This will help to ascertain the combined influence of waste, the use of inorganic fertilizers and flooded soils on nitrate levels in groundwater reserves. Furthermore, the water in the study area can be consumed if properly subjected to efficient purification methods.

ACKNOWLEDGEMENTS

This research was fully funded by the authors with no external funding.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/55963