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Full Length Research Paper

Physico-chemical characterisation of some ground water supply in a school environment in Ilorin, Nigeria

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The water quality assessment of some ground water supply to a school in Ilorin City was carried out over a year. The concentration of nitrates in the samples were determined using a UV - visible spectrophotometer. The wells located within the student hostels were found to be high in nitrate with concentrations ranging from 7.11 - 8.54 mg/l. This is close to the World Health Organization (WHO) limit of 10 mg/l allowed in drinking water. The concentrations in the boreholes ranged between 0.43 - 1.34 mg/l. The trace metal analysis was carried out using Atomic Absorption Spectrophotometer. Lead (Pb) and cadmium (Cd) concentrations were found to be below detection limit. The concentration of copper (Cu) ranged between 0.017 - 0.065 mg/l, the concentration of magnesium (Mg) ranged between 4.29 - 16.28 mg/l while calcium (Ca) concentration ranged between 26.60-235.60 mg/l. The metal concentrations were all within WHO recommended concentrations in drinking water. A linear regression carried out using the polymath software gave a negative slope.

Key words: Water quality assessment, leaching, UV visible spectrophotometer, polymath software, linear regression.

INTRODUCTION

Groundwater is a precious natural resource used for both domestic and industrial purposes. Apart from water supplied by the utility board, many have dug either boreholes or wells in their homes and industries in order to have adequate supply of water. The boreholes which are considered much safer are not affordable to many. In fact, in many developing countries, the well is sited in many homes because of the inadequate supply of public treated water. Clean, fresh water is essential to man (Spalding and Exner, 1993). Drinking water that is high in nitrate is potentially harmful to man and animal. Nitrate (NO_3) is a naturally occurring form of nitrogen (N) which is very mobile in water. It is essential for plant growth and is often added to soil to improve productivity. Water moving down through soil after rainfall or irrigation carries dissolved nitrate with it to ground water (Jennings and Sneed, 1996). Nitrogen is essential in all living things, but high levels of nitrate- nitrogen in drinking water can be dangerous to health, especially in infants and pregnant women (Bukowski et al., 2001).

The determination of nitrate as nitrogen is an integral part of basic water quality assessment. This is used for background monitoring since the presence is usually an indicator of nutrient status and the degree of organic pollution of the affected water body. The major source of accumulated nitrates and nitrites in water include, breakdown of organic matter through mineralization, hydrolysis and microbial action and nitrogen fixation (Fadiran and Mamba, 2005). Nitrites in drinking water occur as intermediate product of conversion of ammonium ion to nitrate as well as in the nitrification process of ammonia. High levels of nitrate in well water often result from improper well construction, well location, overuse of chemical fertilizers, or improper disposal of human and animal waste (Jennings and Sneed, 1996). Sources of nitrate that can enter a well include fertilizers, septic systems, animal feedlots, industrial waste and food processing waste (Spruill et al., 2001).

Water in shallow wells is closer to the surface and to potential sources of contamination, such as fertilizers and septic systems. In contrast, contamination is less likely to occur in deeper ground-water reservoirs because conta-

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minants have to travel greater depths to reach the water (Mueller et al., 1995).

The short term health effect of having excessive nitrate in drinking water is the occurrence of methemoglobinemia which is a blood disorder caused by having too much nitrate in the human body. This blood disorder has very visible signs and mainly affects infants. In babies less than six months of age, high levels of nitrate in the body will prevent the blood from delivering oxygen effectively to different parts of the body. As a result, the infant may have blueness around the mouth, hands, and feet (hence the name "blue baby syndrome"). Other signs of blue baby syndrome include vomiting and diarrhoea (Nolan et al., 1998). On the long term, excess nitrate has the potential to result in increased starchy deposits and haemorrhaging of the spleen. A potential cancer risk from nitrate in water and food has been reported (US EPA, 2001). Nitrates can react with amines or amides in the body to form nitrosamines which is known to cause cancer. The effects of exposure to nitrates in drinking water on the incidence of birth defects have been evaluated in several epidemiologic studies (Cedergren et al., 2002; Croen et al., 2001, US EPA, 1991). The current standard for nitrates in drinking water is based on retrospective studies and approximates a level that protects infants from methemoglobinemia, but no safety factor is built into the standard. The standards apply only to both public and private water systems. Drinking water source was related to nitrate exposure (that is, private systems water was more likely than community system water to have nitrate levels above the maximum contaminant limit). Animal studies have found adverse reproductive effects resulting from higher doses of nitrate or nitrite (Manassaram et al., 2005). The epidemiologic evidence of a direct exposure-response relationship between drinking water nitrate level and adverse reproductive effect is still not clear. However, some reports have suggested an association between exposure to nitrates in drinking water and spontaneous abortions, intrauterine growth restriction, and various birth defects (Bove et al., 2002). Heating of water with nitrate will only increase its concentration in the water. Mechanical filtration and chemical disinfection will not remove it either. It can only be removed by using treatment processes such as ion exchange and reverse osmosis (USEPA, 2001). Calcium and magnesium are both abundant in soil and rocks and they are both essential to human health. Calcium and magnesium are very common elements. Calcium is the fifth most abundant natural element, and magnesium the eighth. Both elements are present in all natural waters. The most common source of calcium and magnesium in groundwater is through the erosion of rocks, such as limestone and dolomite, and minerals, such as calcite and magnesite (Marque et al., 2003). Magnesium gives undesirable taste to drinking water. Sensitive people may find the taste unpleasant at 100mg/l. The average person finds the taste unpleasant at about 500 mg/l. These levels are well above the magnesium concentrations found in most water. Magnesium in drinking water may have a laxative effect, particularly with magnesium sulphate concentrations above 700mg/l. However, the human body tends to adapt to this laxative effect with time. Calcium may have beneficial effects when ingested. It may block the absorption of heavy metals in the body and is thought to increase bone mass and prevent certain types of cancer. Very high concentrations of calcium may adversely affect the absorption of other essential minerals in the body. Copper forms different compounds when it joins with one or more other chemicals. These may be naturally-occurring or man-made. Most copper compounds found in air, soil and water is strongly attached to dust or embedded in minerals, and cannot easily enter the body. These forms are not likely to affect man's health. Other forms become dissolved in water and are not attached to other particles. In this form, copper is more likely to affect man's health on ingesting in concentration above recommended limits as it is non bio degradable.

The aim of this study is to evaluate groundwater sources available to inhabitants of specific locations (this time a school) with inadequate supply of public treated water and hence determine the quality of readily available water source.

MATERIALS AND METHODS

Three boreholes and two wells in the school were investigated. Samples were collected in triplicate on a monthly basis for a period of 12 months. The two wells and one of the bore holes is situated close to the students residence while the other two boreholes are located far from all domestic, laboratory and industrial activities and hence serve as control.

B_1 is located close to one of the female hostels which is located uphill of the septic tanks within the student hostel.

B_2 is far removed from all forms of domestic and industrial activities; it is close to the institution's administrative block.

B_3 is located close to a lecture theatre and far from domestic and laboratory activities.

W_1 is located within a student hostel with the septic tank uphill of it and 23.5 m away. Just 5.0 m away is also a sewage discharge from the hostel that runs from the student's hostel in the direction of the well which is located downhill. This well has no concrete frame work and the water surface is just 5.0 m below ground level.

W_2 is located in one of the student hostels between two septic tanks which are at elevated gradient and a distance of 18.70 and 31.60 m respectively to the well on either side. The well has no concrete frame work and the water surface is 3.60 m below ground level. The measurement of the water surface at just the onset of the rains using metal tape which was lowered until surface of water was contacted.

The samples for trace metal analysis was collected using plastic bags in the case of the wells and transferred into 2 L containers and immediately acidified to keep metals in solution. Samples from the boreholes were collected using manually operated hand pumps. Composites samples were collected for each source. The samples were stored in refrigerators prior to analysis. The choice of Pb, Cu and Cd was influenced by the materials used for the hand pumps which probably have an effect on the water being pumped. The digestion of samples was carried out following standard methods from literature (APHA, 1995). The digested water samples were

Table 1. Concentration of some ions in groundwater supply (mg/l).

Source	NO_3 (mg/l)	Ca (mg/l)	Cd	Cu (mg/l)	Mg (mg/l)	Pb (mg/l)
B1	0.43 - 1.34	16.80 - 26.60	nd	0.037 - 0.046	1.63 - 1.68	nd
B2	0.51 - 0.87	207.80 - 211.80	nd	0.054 - 0.065	8.64 - 9.65	nd
B3	0.46 - 1.02	63.50 - 64.60	nd	0.024 - 0.026	4.29 - 4.38	nd
W1	7.11 - 8.54	230.00 - 235.60	nd	0.031 - 0.040	10.20 - 10.60	nd
W2	7.24 - 7.87	24.60 - 28.30	nd	0.017 - 0.036	6.73 - 6.86	nd

Table 2. Depth of ground water source and nitrate concentration.

Source	Height (m)	Average nitrate concentration (ppm)
B1	47.7	0.89
B2	48.6	0.69
B3	49.2	0.74
W1	15.2	7.83
W2	15.2	7.56

B1: Borehole beside the female hostel.
B2: Borehole beside the administrative block.
B3: Borehole beside the Engineering Faculty.
W1: Well within Lagos female hostel.
W2: Well within Lagos male hostel.

subjected to AAS analysis. NO_3 in the water sample was determined following standard methods of preparation from literature and using the Aqua mate UV - visible spectrophotometer at a wavelength of 425 nm. Ca and Mg in the water samples were determined using EDTA titration (Malati, 1999)

RESULTS AND DISCUSSION

The Polymath software was employed to carry out a linear regression on the result and the model and result of the analysis are as shown in the Appendix. Concentrations of the various ions investigated are shown in Table 1. Table 2 shows the variation of the concentration of the nitrate with the depth of the ground water source. A study of the table shows that, the concentrations are much higher in the wells as compared to the boreholes. This is confirmed in Figure 1 which is a polymath plot of the data collected. The negative slope indicates that there is a decrease in nitrate concentration with depth of the groundwater source. Calcium in drinking water may have some beneficial effects but at very high levels this can have negative health effects. Magnesium in drinking water can have a laxative effect and can also affect the taste of water and both are major contributors to water hardness. The result shows that highest concentration of both Ca and Mg can be found in W1 closely followed by B2 which are within 500 m of each other. They are however within the acceptable values for drinking water. The US Environmental Protection Agency (USEPA) has set an enforcement standard called the Maximum contaminant level (MCL) for nitrate as 10 ppm. The agency also required that water supply be analysed at least once a year to find out if nitrate is present in concentration above 50% of the MCL. If this is found to be so, the system is expected to be monitored every three months. The high concentrations of nitrate in the water from the wells investigated makes it necessary to routinely carry out analysis of these wells to determine the influx of nitrate into the wells with time. This is because, it is expected that, if at any point, the nitrate concentration exceeded 10 mg/l, there might be a need to provide an alternative drinking water supply so as prevent serious risks to public health (USEPA, 1991).

From this study, the concentration of nitrate ranged from a minimum of 0.43 mg/l in one of the hostels to a maximum of 8.54 mg/l in a well located within another hostel. From this result, it is expected that the shallow wells in this area be monitored closely especially since it is obvious that the source is from the location of the septic tanks which are still very much in use.

A proper casting of these wells is to be done so as to reduce the ease with which materials are leached into the

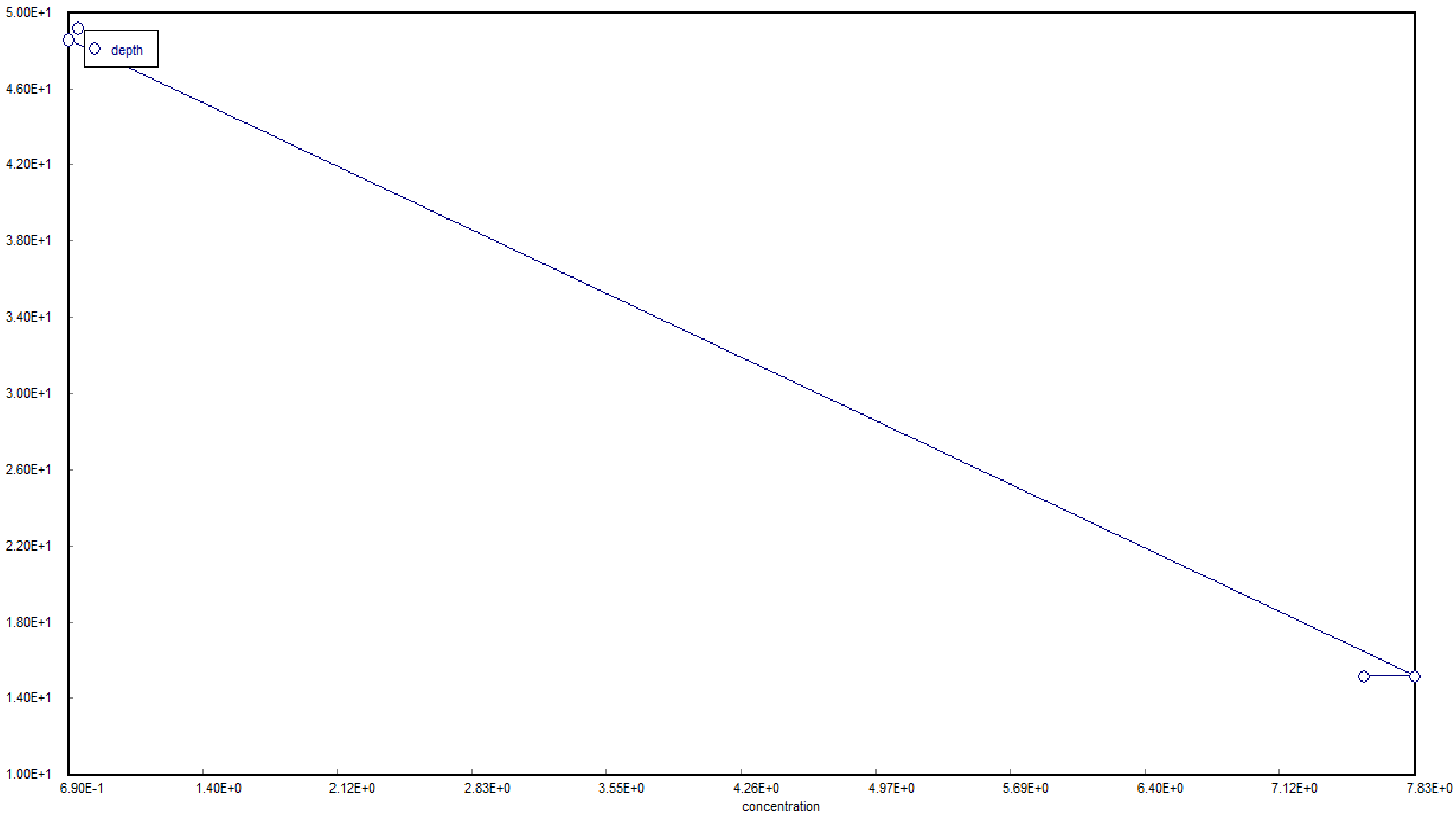

Figure 1. A plot of the depth (m) against concentration (ppm).

ground water. With the wells located downstream of the septic tanks, it is almost inevitable that there will be seepage into the well at such a short distance between them. In view of this, there is a need for the hostel managers to alert the students on the hazard involved in drinking such water which would be good for laundry purposes and cleaning of toilets and floors.

This is especially necessary in the female hostel since the presence of nitrate in high concentration has been established to adversely affect pregnant women and babies. While the hostel is not a breeding ground, it is not uncommon to find a few of the students that are pregnant.

From the results of the trace metal analysis carried out, it is safe to conclude that the material used for the manual pumps installed, and used in the boreholes does not negatively affect the quality of the water discharged through them.

REFERENCES

APHA (American Public Health Association) (1995). Standard methods for the examination of water and wastewater. 17th ed., American Public Health Association, Washington DC.

Bove F, Shim Y, Zeitz P (2002), Drinking water contaminants and adverse pregnancy outcomes: a review. Environ. Health Perspect. Suppl. 110(1): 61-74.

Bukowski J, Somers G, Bryanton J (2001). Agricultural contamination of groundwater as a possible risk factor for growth restriction or prematurity. J. Occup. Environ. Med. 43: 377.

Cedergren MI, Selbing AJ, Lofman O, Kallen BA (2002). Chlorination by-products and nitrate in drinking water and risk for congenital cardiac defects. Environ. Res. 89: 124-130.

Croen LA, Todoroff K, Shaw GM (2001). Maternal exposure to nitrate from drinking water and diet and risk for neural tube defects. Am. J. Epidemiol. 153: 325-331.

Fadiran AO, Mamba SM (2005). Analysis of nitrates and nitrites in some water and factory effluent samples from some cities in Swaziland. Bull. Chem. Soc. Ethopia, 19(1): 35-44

Jennings GD Sneed RE (1996). Nitrate in drinking water, North Carolina Cooperative Extension Service, Publication Number: AG pp. 473-474.

Malati MA (1999). Experimental Inorganic/Physical Chemistry, Horwood Publishing, Chichester, England. pp. 58-60.

Manassaram DM, Backer LC, Moll DM (2005). A review of nitrates in drinking water: maternal exposure and adverse reproductive and developmental outcomes, J. Am. Vet. Med. Assoc. 131: p. 226.

Marque S, Jacqmin-Gadda H, Dartigues JF, Commenges D (2003) Cardiovascular mortality and calcium and magnesiumbin drinking water; an ecological study in elderly people, Eur. J. Epidemiol. 18(4): 305-309.

Mueller DK, Hamilton PA, Helsel DR, Hitt KJ, Ruddy BC (1995). Nutrients in Ground Water and Surface Water of the United States-An Analysis of Data Through 1992, U.S. Geol. Survey Water Resour. Invest. Rep. 95: 4031.

Nolan BT, Ruddy BC, Hitt KJ, Hesel DR (1998). A national look at nitrate contamination of ground water, Water Conditioning and Purification, 39(12): 76-79

Spalding R, Exner ME (1993). Occurrence of Nitrate in Groundwater-A Review, J. Environ. Qual. 22: 392-402.

Spruill TB, Showers WJ, Howe SS (2001). Application of Classification -Tree methods to identify Nitrate Sources in ground water, Technical report on Ground Water Quality, US Geological survey, 3916 Sunset Ridge Road, Raleigh, NC 27607

USEPA (2001). National primary drinking water standards. EPA 816-F-01-007. USEPA, Washington, DC.

USEPA (1991). Ground Water and Drinking Water. Consumer Fact Sheet on Nitrate /Nitrites. www.epa.gov/safewater