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Investigation of fluoride concentration in water samples from kaltungo and its environs.

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Abstract

Groundwater is one of the most important natural resources. It is difficult and expensive to clean-up when contaminated by either natural or anthropogenic means. Fluorosis is a disease that affects the bone and teeth of humans due to excessive intake of fluoride either through water or food. The present study evaluates the concentration of fluoride in underground water from shallow aquifers around Kaltungo, northeast Nigeria. The result of investigation confirmed high concentration of fluoride in some well and bore hole water samples. The fluoride concentration ranged between 0.35mg/l to 3.17mg/l for bore hole water samples and 0.83mg/l to 3.83mg/l for well water samples as against the recommended value of 1.50mg/l. This is an indication that continuous use of water from this area might have resulted to coloration of the teeth of the residents of the area. High fluoride content in groundwater can be attributed to the continuous water-rock interaction during the process of percolation with fluoride-bearing rocks under arid, low precipitation, and high evapotranspiration conditions. The study has established that the fluoride-rich underground water in the area may have emanated from geochemical processes of dissolution and weathering of the granite aquifers in the area. These findings suggest that the enrichment of the underground water system is geogenic and related to the local geology of the area. It is recommended that people living in the coarse grained porphyritic biotite granite dominated area should discontinue the use of underground water especially well water for domestic and drinking purposes in order to minimize fluorosis. Environmentally friendly techniques such as Phyto-remediation and bio-remediation should be employed to monitor and control fluoride and heavy metal content in the groundwater system.

Keywords: Groundwater, Quality, Fluorosis, Shallow Aquifers, Kaltungo

1. Introduction

According to UNICEF (1999), about 65 million people globally are affected by either skeletal or dental fluorosis. Fluorosis is an abnormal disease of the bone and teeth due to excessive intake of fluoride through water or food. Skeletal fluorosis is a crippling disease with major manifestation of overgrowth or distortion of the bones leading to total deformity of the individual. Dental fluorosis is the damage of the teeth in form of permanent dark-brown coloration. Both skeletal and dental fluorosis are as a result of consumption of water with fluoride concentration greater than 1.5mg/l (NSDWQ, 2007; WHO, 2010) while fluoride content below or equal to 1.5mg/l in water is beneficial in building strong bones and tooth (Ahmad et al 2010). Waters with high levels of fluoride content are mostly found at the foot of high mountains and in areas where the sea has made geological deposits. Long-term ingestion of large amounts of fluoride in the body can lead to potentially severe skeletal problems. The early symptoms of skeletal fluorosis include stiffness and pain in the joints. In severe case, the bone structure may change and ligaments may calcify, with resulting impairment of muscles and pain. Acute high-level exposure to fluoride causes immediate effects of abdominal pain, excessive saliva, nausea and vomiting. Seizures and muscle spasm may also occur (Chae et al, 2007; Aminu and Amadi, 2014). Studies have shown that about 85% of all communicable diseases affecting human being are either water borne or water related. Fluoride in groundwater in primarily derived from decomposition/dissociation and dissolution of fluoride bearing minerals and secondly by the use of fertilizer containing fluoride impurities (Saxena and Ahmed, 2002). Fluoride contamination in groundwater in parts of northern Nigerian may be attributed to lithogenic interference arising from rock-water interaction as well as pro-longed application of phosphatic fertilizer containing fluoride as impurities (Aminu and Amadi, 2014). Amadi et al., (2015) revealed that lithogenic contamination of groundwater depends on climate of the area, pH, flow pattern and frequency, ionic exchange, resident time, chemistry and mineralogy of the rock. High fluoride concentration in groundwater may persist for years, decades, centuries, and can contaminate the food chain (Chidambaram et al., 2003; McAllister et al., 2005; Chae et al, 2007; Dan-Hassan et al., 2012). Minerals in rock that contain fluoride include: fluorite, apatite, fluomica, cryolite, epidote, topaz, phosphorite, tremolite, amphiboles, villaumite and clay (Boyle and Chagnon, 1995). Groundwater in contact with any of these minerals can be enriched with fluoride due to rock weathering and dissolution processes. The chemistry of groundwater is modified as it migrates from one area to another due to exchange of ions in the course of its movement. Rock-water interaction allows fluoride rich minerals in bedrock to decompose resulting in enrichment of fluoride in groundwater (Wenzel and Blum, 1992). Investigations have revealed that most fluoride belt in the world are mostly found at the foot of high mountains and in areas where the sea has made geological deposits, though there are few exceptions to this. The level of concentration of fluoride in groundwater depends on the contact time/water-rock-interaction. Groundwater chemistry is dependent on the mineral composition and lithology through which it migrates as a result of rock-water interaction and the associated resident time (Amadi et al., 2014). This implies that the chemical composition of most groundwater are the imprints of rock-water interaction and other related physicochemical processes and this is true for areas with no know anthropogenic activity. Studies have shown that hydrogeochemical processes such as dissolution, chemical weathering, decomposition, ionic exchange processes and resident time along flow path controls the chemistry of groundwater in shallow aquifers (Olasehinde et al., 2015; Amadi et al., 2015).

2. Materials and Methods

Study Area Description: Kaltungo is a Local Government Area of Gombe State, Nigeria. Its headquarters are in the town of Kaltungo in the west of the area on the A345 highway at 9°48′51″N 11°18′32″E. It has an area of 881 km2 and a population of 149,805 at the 2006 census. The LGA is populated by members of different ethnic affiliations such as the Hausa, Tangale, kanuri and Fulani. The Hausa language is commonly spoken in the area while the religions of Islam and Christianity are widely practiced in the LGA. Kaltungo LGA is home to the Kaltungo Emirate with the area having a number of Chiefdoms such as the Tula chiefdom under it. Notable landmarks in Kaltungo LGA include the General Hospital Kaltungo. This LGA is bounded by Akko LGA to the north; to the east and south by Balanga local government area, to the west by Shongom LGA, and to the north-west by Billiri local government area. A number of animals are reared and sold in Kaltungo LGA and these include camels, cows, and rams. Farming is also an important feature of the economy of Kaltungo LGA with a number of crops such as sorghum, millet, beans, and rice grown in the area. Other important economic activities in Kaltungo LGA include trade, hunting, and crafts making.

Sampling: Sampling stations were selected, taking into account the direction of groundwater flow, direction of prevailing winds and the density of the population within the studied area. Glassware and vessels were treated in 10% (v/v) nitric acid solution for 24 h and were washed with distilled and deionized water. The samples for were collected in polypropylene containers, labeled and immediately few drops of HNO3 (ultrapure grade) to pH < 2

were added to prevent loss of metals, bacterial and fungal growth and then stored in a refrigerator. The samples were stored on ice in cooler boxes and transported to the laboratory immediately after sampling was completed.
Fluoride concentration was determined using Hana Hatch 83300 Multi-parameter Spectrophotometer.

3. Results and Discussion

The results of the laboratory analyses are summarized in Table 1.

Table 1: Results of the laboratory analyses

Location	BW	WW
Kalogari	0.63	1.1
Termana	0.83	1.42
Poshere	0.43	1.06
Ture	1.24	2.63
Ladur	NA	1.93
Gelengu	1.13	NA
Lambu	1.7	2.5
Okra	1.35	1.51
Lapadang	1.27	2.74
Sabon Layi	1.44	1.93
Popandi	1.54	2.28
Baganje	0.37	0.83
Sabon Kasuwa	1.53	1.83
Awak	3.17	3.83
Kalarin	0.35	1.27

The fluoride concentration ranged between 0.35mg/l to 3.17mg/l for bore hole water samples and 0.83mg/l to 3.83mg/l for well water samples. These values imply that the fluoride concentration in groundwater in most locations exceeds the permissible limit of 1.5mg/l. Since there was no known industry in the area that could have discharged fluoride rich-effluent into the soil or surface water, high fluoride concentration in groundwater of an area may be attributed to weathering and dissolution of rocks as well as irrigation processes which also accelerates weathering of rocks (Murthy et al, 2003; Amadi et al, 2015). Fluoride when consumed in inadequate quantities (<0.5 mg/l) causes health problems like dental caries, lack of formation of dental enamel and deficiency of mineralization of bones, especially among children (Fluhler et al, 1982). Also, fluoride when consumed in excess (>1.5 mg/l), it leads to several health complications such as skeletal and or dental fluorosis (Deshmukh et al, 1995). Being a cumulative bone seeking mineral, the resultant skeletal and dental changes/ metabolic processes are progressively affected negatively. Fluoride is a typical lithophile element under terrestrial conditions and studies have revealed their association with granitic rocks. It is a major constituent in silicate rocks especially those of late magmatic stages typified in apatite, Fluorspar, Cryolite and Fluorapatite as well as villiaumite and syenites (Aminu and Amadi, 2015). According to Omueti (1977), the fixation of the bulk of fluoride as complex hydroxy-silicates and hydroxyalumino-silicates, in which the hydroxyl ions (OH) are largely replaced by fluoride are common in amphiboles and minerals of the mica family (biotite and muscovite). Fluoride in the groundwater are derives from the weathering and subsequent leaching of fluoride bearing minerals in rocks and soils. A substantial amount of this fluoride is retained in subsoil horizons, where it complexes with Aluminum that is associated with phyllosilicates (Vaish and Vaish, 2002). The concentration of fluoride in most of the location were observed to be higher than the recommended maximum permissible limit of 1.5mg/l (NSDWQ, 2007; WHO, 2010).

4. Conclusion and Recommendation

The concentration of fluoride around Kaltungo was investigated in the study and its presence is no longer in doubt. The quality of groundwater depends on the nature of surface run-offs, weathered products and mineralogical composition of the underlying rocks. The geology of an area has a strong influence on the chemistry of groundwater. The natural processes of weathering and dissolution may be responsible for release of fluoride bearing minerals. People living in the granite dominated region should discontinue the use of groundwater from the area for domestic and drinking purposes in order to avert the problem of fluorosis in the near future. It is suggested that Phyto-remediation, bio-monitoring, bio-mining and bio-remediation techniques be employed to monitor, control and manage the high fluoride content and heavy metal contamination in the groundwater system at this early stage

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