GEOCHEMICAL ANALYSIS OF WATER QUALITY IN THE TILDEN FULANI AREA OF BAUCHI STATE, NIGERIA

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Abstract
The relationship between water quality and mining activities in the Tilden Fulani area of Bauchi State, Nigeria was investigated. Primary data on water samples were abstracted from 56 points made up of old mines, ponds, rivers, streams and hand-dug wells. Samples were analyzed for iron (Fe), copper (Cu), lead (Pb), zinc (Zn) and cadmium (Cd) using the Atomic Absorption Spectro-photometer (AAS). The results obtained showed that Cu and Zn were within limits of general acceptability by the World Health Organization (WHO) standard. Fe, Cd and Pb were found to have had high concentrations above acceptable limits in some wells (Fe 0.05-1.10 ppm; Cd 0.005-0.01ppm and Pb 0.05-1.10 ppm). The implications of the findings were discussed with respect to the geology of the study area. The higher values of toxic metals were attributed to mining and anthropogenic activities in the studied area. The research concludes that stringent measures should be taken to properly treat the water in Tilden Fulani for domestic consumption.

Keywords: *Tilden Fulani, Tin, Mining, Water Quality.*

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INTRODUCTION

Tilden Fulani has geographical co-ordinates of 08° 58'-09° 02' 30" E and 10° 04'-10° 09' N (Fig 1). It is relatively located some 35km east of Jos, along the Jos-Bauchi highway. The climate of the area is characterized by two distinct seasons (wet and dry). The wet season stretches from April to October while the dry season extends from November to March. Total annual rainfall ranges between 800-1100mm, with high concentration in July and August (Abdulkadir, 1993). Mean minimum temperature is rather high (38°C), therefore evapor-transpiration is also high. Relative humidity varies from 25% during the dry season to about 80% during the wet season. The area is characterized by tall grasses and scattered economic trees.

The first tin mining beacon in Nigeria was sited in Tilden Fulani, Toro local government area of Bauchi State. Since then, tin-mining activities were vigorously pursued in the area for over fifty years. The open cast method with its waste water generation and mining deposits were dumped all over the landscape and subsequently washed back into water ways. This study is aimed at assessing the effect of tin mining on the quality of water. The importance of water for the survival of living organisms cannot be over emphasized, yet its supply in time and space is limited. Despite the scarcity of water supply, most of the global water drainage systems have suffered serious quality depletion from human abuse. Samaila (2006) observed that human activities are often accompanied by serious environmental consequences in changing the production of excessive amount of waste, which whether solid, liquid or gaseous, finally find there way into the drainage systems to rapidly deplete water quality in streams, rivers, lagoons, lakes, ponds, drains and underground reservoirs.

The effect of metal ore contamination on the environment and its possible impact on plants, animal and human health was first brought to lime light with the first geochemical survey by Applied Geochemistry Research Group (AGRG) in 1965 in England and Wales. Other geochemical works aimed at identifying mine tailings and waste rock deposit and their environmental pollution effect include Nichol *et al.*, (1970a and b), Adraino (1986), Olade (1987), Ogezi (1989) and Ogezi *et al.*, 1994. All these works tried to identify metal point source and determine the concentration of the various metals in the sampled media. High amount of metal substance will have adverse negative effect on human and environmental system. Water quality is made up of many variables: the choice of the variables however depends on the waste problem, source of the waste water and most importantly the intended use of the water.

Ntonifor and Ajayi (2006) analyzed water contact path and *schistosoma haematobium* infection in some selected communities in Toro local government area. Abdulkadir (1993) undertook a water quality analysis for agricultural purposes in the entire northern part of Bauchi. With the over fifty years of tin mining activities in the Tilden Fulani area of Toro local government area, no attempt has been made to analyzed the geochemical quality of the water in terms of its metal base content especially for human consumption and agricultural purposes.

Outline Geology of the Study Area

Generally, the north central part of Nigeria where Bauchi is located is underlined by Basement Complex rocks of the Precambrian age. Around the study area and the Jos plateau however, thermal uplift has resulted into the intrusion of Younger Granites. These rocks are associated with tin, columbite, monazite, wolfromite and pyrochlore mineralizations. Other rock types in the area include the Migmatite- Gneiss Complex which are made up of quartz, plagioclase (25-30% An), biotite and some Carlsbad-twined orthoclase. They represent the characteristics of a paralkaline gneiss rich in almandine garnet, sub-rounded zircons; some apatite and late phase sillimanite and cordierite. It is highly corundum normative (2.4%) and aluminium saturation index molar ratio equal to $Al_2/Na_2O + CaO$ is greater than 1 (Dada *et al.*, 1993).

MATERIALS AND METHODS

Collection of samples

Water samples from streams, hand-dug wells and abandoned mines were collected (Fig. 1). Polyethylene bottles were used because they eliminate the risk of contamination by metals dissolved from the walls of the container. The containers were rinsed out at the sample site with water to be collected. The samples were acidified with concentrated HNO_3 at 1% level to the volume of water collected at sample site to prevent the precipitation of hydrous Fe oxides and at the same time the growth of micro organisms. pH and Eh were determined at the sampling sites. In all 56 water samples were collected for analysis.

The analyses were performed using the Atomic Absorption Spectrophotometer (AAS), Buck Scientific 210, VGP system model. The reading of the AAS was adjusted to zero with distilled water. Absorption with distilled water was compared with absorption solution; this in turn was compared with known concentration of standard solutions.

RESULTS AND DISCUSSION

The results obtained are shown in Table 1. Water sustains life activities and is been consumed directly into the biological systems of both humans and animals, its pollution study is highly imperative. For instance, elements like lead, copper, zinc and cadmium when consumed by human beings may lead to the formation of particularly stable bonds in some enzymes. This chemical affinity is the basis of metal toxicity in man.

Mining activities can produce a variety of anthropogenic substances to the environment, depending on a number of factors as materials being mined, milling process being adopted. Also mining methods adopted affects the water regimes. In open cast mining method which is commonly practiced in the area, surface water source are altered resulting to artificial dams from the excavated areas. Several of such dams do exist in this area. The so-called dams are being used for domestic activities and livestock consumption but do not cause hazards immediately because of the level of contamination by mine waste is very slow. Due to awareness worldwide with regards to water pollution problems, standards for drinking water were developed based on toxicity of numerous substances, which are commonly detected in drinking water. The United States Environmental Protection Agency (USEPA), European Union (EU), Canadian Government and World Health Organization (WHO) developed their drinking water standards (Table 2).

However, it is a well known fact that mineral elements are necessary for life (Buss and Robertson, 1976; Ipinmoroti and Oshodi, 1993; Adeyeye *et al.*, 2000; Aremu and Inajoh, 1997). Copper and zinc are essential metals and play an important role in enzyme activity (NAS, 1997). Copper and zinc in the water samples analyzed were found to be within the permissible limits of WHO, EU, USEPA and Canadian government standards. The metalliferrous ions were also within the WHO, EU and USEPA standards (Fe, 0.10 1.00 ppm; Pb, 0.05 110 ppm; Cd, 0.005 0.01 ppm) except for iron, cadmium and lead which were observed to have high concentration values above the mentioned standards in some areas.

Iron occurs mostly in the ferric state but it is absorbed in the ferrous state. It plays an important role in the oxidative processes of respiration in living organism (Adeyeye, 1997). Iron is reported to be very important for normal functioning of the central nervous system (Vyas and Chandra, 1984). It also facilitates the oxidation of carbohydrates, proteins and fats (Bender, 1992). The concentration values of iron in the samples of WS10 and WS51 (Table 1) were 1.25ppm and 2.23ppm, respectively higher than WHO, EU and USEPA standard values. It was observed that WS10 is a stream close to a mine, therefore high concentration of iron at this location might be due to ferromagnesian nature of the rocks, which are exposed and highly weathered thereby librating Fe^{2+} and Fe^{3+} ions into the solutions.

Lead is toxic even at low concentrations and has no known function in biochemical processes. Sources of lead include storage batteries, ammunition and type of metal, cable sheaths, solder, pigments and anti-knock

Table 2: World Health Organization (WHO) Standard for Drinking Water

ELEMENTS	LIMIT OF GENERAL ACCEPTABILITY	MAXIMUM PERMISSBLE LEVEL	UNDESIRABLE EFFECTS AT HIGHER LEVEL
Iron (Fe)	0.1	1.0	Stains and Taste
Lead (Pb)	0.05	0.10	Severe and permanent brain damage
Cadmium (Cd)	0.005	0.01	Toxic
Zinc (Zn)	0.1	5	Bitter taste, gastro intestinal problems and opalescence of alkaline water
Copper (Cu)	0.05	1.5	Taste and liver damage

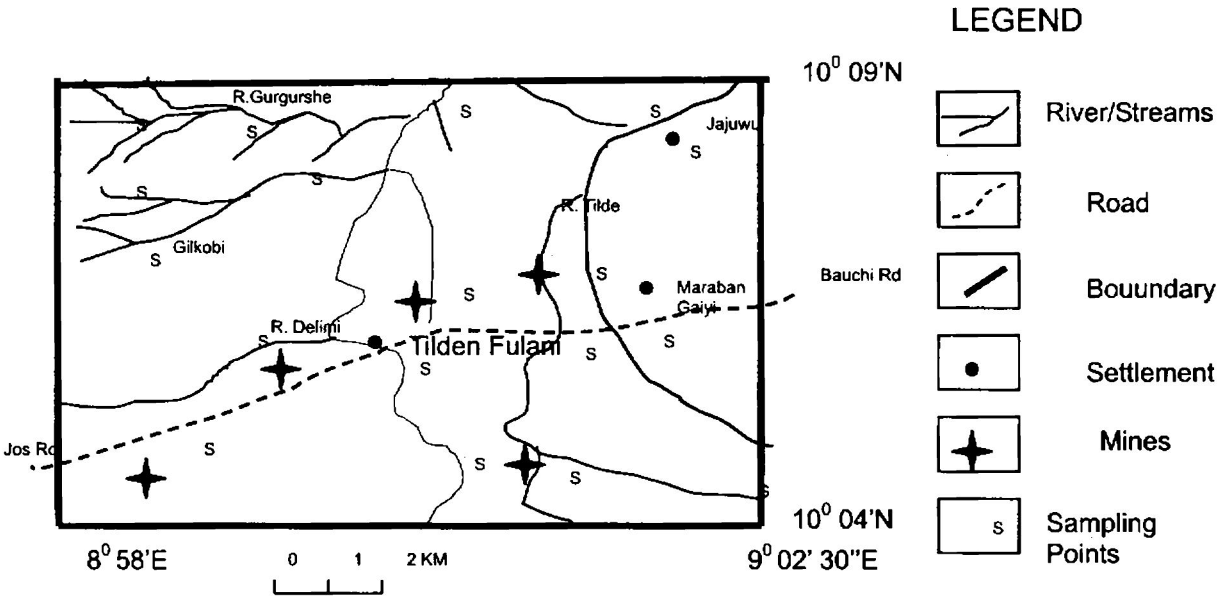

Fig. 1: Location Map of the study area showing sampling location

compounds in petrol (Crosby, 1977). The onset of lead pollution of surface waters in Nigeria has been reported (Mombershora *et al.* 1983), the major source being the use of leaded gasoline Osibanjo and Ajayi, 1980). Lead is known to inhibit active transport mechanisms involving ATP, to depress the activity of the enzyme cholinesterase, to suppress cellular oxidation-reduction reactions and to inhibit protein synthesis (Waldron and Stofen, 1974; Adeyeye *et al.*, 1996). Table 1 depicts that lead concentration values higher than WHO standard value were detected in the water samples from 30 locations (Table 1). Higher concentration values might be linked to the primary mineralization of cassitterite in the Younger Granites that are weathered and transported mechanically for a long distance. According to United State Agency for Toxic Substances and Diseases Registry (ATSDR, 1993), arsenic, lead and mercury top the priority list of hazardous substances. Lead does not dissolve, but water, air and sunlight change its mineral and compounds. Lead sticks to soil particles and enters underground water or drinking water only if the water is acid or soft and from the results obtained (Table 1), most samples showed acidity with pH ranged from 6.80 7.77. Exposure to lead takes place through drinking water, breathing polluted air or dust, and eating contaminated food, for example food grown on soil with lead content. Lead is toxic even at very low levels of exposure. Even the lowest doses can impair the nervous system and affect feotus, infants and young children, resulting in lowering of IQ (UN, 1998). In the US (USEPA, 2000), lead required in air should not exceed 1.5mgm^3 and the amount in the drinking water is limited to 15mgL^1 (ATSDR, 1993).

Cadmium is highly toxic and has been implicated in some cases of poisoning through food (Aremu *et al.*, 2005). Minute quantities of cadmium are suspected of being responsible for adverse changes in arteries of human kidneys. Sources of cadmium are food. It includes those that occur naturally in the geosphere as well as those caused by human activity (John, 1972). Cadmium may enter water as a result of industrial discharges or deterioration of galvanized pipe (Fleisher, 1974). In the present study cadmium was observed to have had anomalous concentration values in WS33, WS55 and WS56 locations. The reason might be due to mining and anthropogenic activities in the area via application of fertilizers such as super phosphates which are known to contain between 1.5 2.1mg/100g sample of cadmium because people in the area are predominantly farmers.

Conclusions

It can be deduced from the above discussion that these three elements (Fe, Iron, Lead and Cadmium) may form a potential source of contamination in the area; though, at the moment the water resources used by the Tilden Fulani and environs residents may be regarded to be safe.

Three important activities that were observed to have taken place in the recent years in the area were land degradation, deforestation and soil erosion. Mining in the area is by opencast, and the ores are washed and separated from the waste rock, which is subsequently dumped into heaps as tailings. Mining has left behind dredged out and contaminates streams, disturbed vegetation and littered landscape, open trenches and gaping, pits filled with water. For instance Deriko mine, one can easily identify the scars remaining from the 1920s 1980s large-scale mining. Large number of miners put much pressure in the environment in terms of energy resources, thus large quantity of trees were felt down either for firewood or as timber for supporting roofs of their houses. This causes deforestation and soil erosion.

Finally, it would be recommended that water used for consumption should be treated prior to use, to reduce level of contamination, mining laws should be enforced by the relevant government agencies to restore physical land degradation being noticed in the area by reclaiming the mines using the waste rock once mining is over and planting of deep rooted plants.

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0.09	0.04	0.04	0.21	0.01
0.05	0.06	0.06	0.54	0.00
0.04	0.04	0.01	0.08	0.00
0.03	0.09	0.03	0.25	0.00
0.03	0.06	0.01	0.04	0.00
0.22	0.08	0.03	0.51	0.00
0.06	0.05	0.03	0.94	0.01
0.09	0.05	0.01	0.35	0.01
0.05	0.01	0.01	1.25	0.00
0.20	0.02	0.01	0.14	0.00
0.08	0.04	0.02	0.93	0.01
0.01	0.04	0.02	0.23	0.01
0.19	0.04	0.01	0.18	0.00
0.25	0.05	0.01	0.54	0.00
0.37	0.02	0.04	0.20	0.01
0.12	0.04	0.04	0.22	0.00
0.09	0.03	0.02	0.15	0.01
0.18	0.05	0.03	0.12	0.00
0.05	0.03	0.01	0.12	0.00
0.29	0.03	0.05	0.52	0.00
0.19	0.05	0.03	0.14	0.00
0.11	0.05	0.03	0.19	0.00
0.14	0.04	0.06	0.17	0.00
0.19	0.03	0.03	0.20	0.00
0.27	0.06	0.02	0.17	0.00
0.10	0.02	0.03	0.08	0.00
0.08	0.05	0.03	0.09	0.00
0.21	0.02	0.03	0.24	0.00
0.03	0.02	0.04	0.13	0.00
0.04	0.05	0.03	0.30	0.00
0.11	0.06	0.01	0.51	0.00
0.16	0.05	0.11	0.78	0.00
0.06	0.06	0.08	0.14	0.00
0.31	0.02	0.04	0.26	0.00
0.17	0.06	0.06	0.10	0.00
0.12	0.05	0.06	0.07	0.00
0.12	0.03	0.04	0.08	0.00
0.17	0.02	0.05	0.15	0.01
0.22	0.04	0.07	0.19	0.00
0.11	0.04	0.07	0.10	0.00
0.14	0.06	0.05	0.08	0.00
0.01	0.02	0.05	0.15	0.01
0.05	0.02	0.06	0.05	0.00
0.00	0.02	0.02	0.19	0.00
0.01	0.07	0.02	0.14	0.00
0.23	0.03	0.02	0.21	0.00
0.12	0.01	0.04	0.15	0.00
0.02	0.02	0.09	0.09	0.01
0.07	0.03	0.07	2.23	0.01
0.18	0.03	0.03	0.32	0.00
0.10	0.04	0.02	0.18	0.01
0.03	0.07	0.05	0.13	0.00
0.09	0.06	0.05	0.24	0.00
0.17	0.06	0.40	0.07	0.01
0.05	0.03	0.30	0.07	0.01

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