Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.12, 2014

Analysis of Some Ground Water Quality Parameters in the Vicinity of Asbestos Factory in Bauchi Metropolis, Nigeria

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ABSTRACT
It has been established that wherever asbestos factory is sited, health of people of the adjoining settlements is threatened. This study was aimed at determining the physico-chemical characteristic of the ground water in villages around asbestos factory in Bauchi. Water samples were collected from six functional hand dug wells with three replications each. The samples were subjected to physical and chemical analyses as follows: Temperature, pH and Conductivity, were directly measured using a portable multipurpose pH, Temperature and Conductivity field meter. Total Dissolved Solids (TDS) calculated from the Conductivity values obtained. EDTA titration method as described by the American Public Health Association, APHA was used to determine the Hardness of the water samples. Calcium and Magnesium were determined by EDTA titration while Total alkalinity was determined by strong acid titration method. Trace elements – Total Fe, Pb, Cr, Cd, Mn, and Si were determined using Atomic Absorption Spectrophotometer (AAS, Unicom 969) after extraction with Aqua-regia. Result of the analysis revealed that many of the water quality parameters in the study area have exceeded World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) limits. It may be concluded that the Asbestos manufacturing operation has impact on the ground water quality in the two settlements adjoining the factory. It is recommended among others that the houses located very close to factory should be relocated far away from the factory and alternative sources of water be provided to the neighborhoods.
Key words: Evaluation; Groundwater; Quality; Asbestos; Factory

1. INTRODUCTION

Ground water is an important source of water supply with a number of advantages. The water source is commonly free from pathogenic organisms (and therefore need little or no treatment), turbidity and color are generally absent, and its chemical composition is almost stationary. Despite these advantages, however ground water is susceptible to pollution as a result of human activities. The sources of pollution may be municipal sewage, industrial discharges and agricultural activities (Umar, 2009).

Analysis of ground water quality aims primarily at ensuring safe drinking water for the presence and the future. The rapid growth of urban areas and industries further affected the groundwater quality due to over-exploitation of resources and improper waste disposal practices.

Many researchers have shown that wherever asbestos industry is sited there is health threat to the inhabitants and company workers (EPA, 1990). Asbestos fibers are releases into environment through erosion and are carried by wind. Asbestos is released to the environment from both natural and anthropogenic sources and has been detected in indoor and outdoor air, soil and drinking water (ATSDR 2001).

Asbestos are generally made up of fibers bundles such as Chrysotile $Mg_3 Si_2 O_5 (OH)_4$, Crocidolite = $Na_2 (Fe^{2+}$, $Mg)_3 Fe^{3+}{}_2 Si_8O_{22}(OH)_2$, Amosite = $(Fe^{2+})_2 (Fe^{2+}, Mg)_5Si_8O_{22}(OH)_2$ etc. All asbestos fibers are hazardous to human health. High concentrations of asbestos constituent elements such as Fe, Mg, Si, Al, Mn, Ca in ground water is known to cause various health problems (ATSDR, 2001). All metal are soluble to some extent in water and excessive amount of any metals may present health hazard and continuous exposure to elevated level could be deadly (Tebbult, 1983).

The aim of this study was to determine physico-chemical characteristic of the ground water in villages around asbestos factory in Bauchi metropolis

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was carried out at Bigi and Gudum which are small settlements close to the asbestos factory at the southern outskirt of Bauchi metropolis (Figure 1). Bauchi State is situated on Longitude 10018'N and Latitude 9050'E in the North Eastern State of Nigeria has a total land area of 66,510,045 sq km and has borders with Kano Kaduna Plateau Taraba Yobe Jigawa and Gombe States.

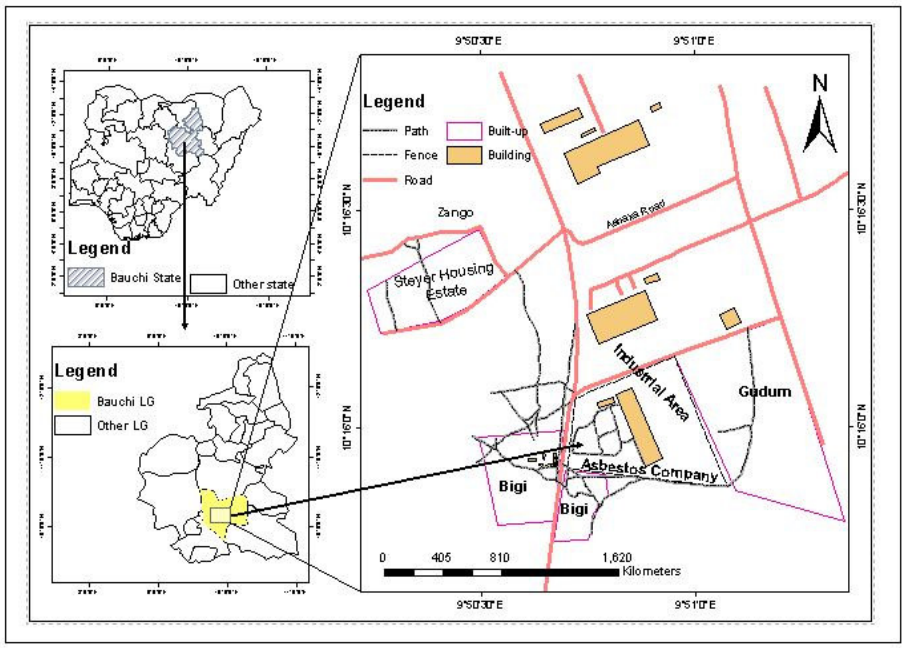

Figure 1: Nigeria showing Bauchi State, and Bauchi State showing Bauchi Local Government Area and location of study site

2.2 Sampling Techniques

Water samples were collected randomly from various hand dug wells within Bigi and Gudum villages situated in the vicinity of the asbestos factory. Eighteen (18) water samples were collected from six (6) functional hand dug wells. Sterilized plastic containers were used for collecting the water. This was done carefully to avoid contact between the containers and walls of the well, thus avoiding contamination of samples. Well labeled sterile bottles were used to collect the water sample, and were tightly closed immediately. The samples where transported at low temperature ($4^{O}C$) to the laboratory for physicochemical analysis.

2.3 Laboratory Analysis

Temperature, pH and Conductivity, were directly measured using a portable multipurpose pH, Temperature and conductivity field meter. Total Dissolved Solids (TDS) calculated from the conductivity values obtained. Alkalinity was done by titrating 100 ml of the samples with 0.02 M HCl solution using methyl orange as indicator and chloride by titrating 100 ml of the samples with a standard solution of 0.0257 M $AgNO_3$ solution using 1.00 ml solution of 5.00% $K_2Cr_2O_4$ as indicator (AOAC, 1984) EDTA titration method as described by the American Public Health Association, APHA (1992) was used to determine the hardness of the water samples. Calcium and Magnesium were determined by EDTA titration. Heavy metals – Total iron, Lead, Chromium, Cadmium, Silicate and Mn were determined using Atomic absorption Spectrophotometer (AAS, Unicom 969) after extraction with Aqua-regia.

2.4 **Statistical analysis of analytical data**

Simple descriptive statistics (Means and Standard Deviations) using SPSS software was use to interpret the data generated in the course of the investigation.

3.0 RESULT AND DISCUSSION

Distance between water source and Asbestos factory

The approximate distances between the asbestos factory and the ground water sources (hand dug wells) distributed in the two adjoining villages (Bigi and Gudum) are as shown in Table 1.

Table 1. Distances between asbestos factory and hand dug wells in Bigi and Gudum, Bauchi metropolis.

S/N	Well Identity	Location	Approx. distance from the factory
1	A	Bigi	50m
2	B	Bigi	47m
3	C	Bigi	53m
4	D	Gudum	250m
5	E	Gudum	80m
6	F	Bigi	34m

As shown in Table 1, wells D and E situated at Gudum had the longest distance from the asbestos factory. The shortest distance was that recorded between the factory and Well F at Bigi. In general all the ground water

sources considered for this investigation at Bigi were closer to the factory compared to those collected from Gudum. Thus the impacts of the factory on water sources could be higher at Bigi than Gudum.

Physico-chemical Parameters

The mean values of physico-chemical parameters of the ground water obtained from the various hand dug wells are as shown on Table 2.

Table 2. Mean (±SD) physico-chemical parameters of ground water quality obtained from two settlements in the vicinity of asbestos factory in Bauchi.

S/N		**Parameters**	**Bigi**	**Gudum**	**NSDWQ**	**WHO**
1.	1	Temperature (^oC)	32.31(0.18)	32.2(0.10)	Ambient	25
2.	2	pH	7.12(0.28)	7.00(0.21)	6.5-8.5	6.5-9.5
3.	3	Electrical Conductivity (µS/cm)	482.83(181.30)	550.16(159.02)	1000	1000
4.	4	Total Dissolved Solids (mg/L)	216.33(72.18)	250.83(82.53)	500	1000
5.	6	Total Alkalinity, as ($CaCO_3$)mg/L	8.95(4.82)	14.68(5.02)	100	NA
6.	7	Hardness, as ($CaCO_3$)mg/L	168.33(62.58)	170.66(48.82)	150	200
7.	8	Magnesium, Mg^{2+}(mg/L)	0.58(0.22)	0.61(0.43)	0.20	NA
8.	9	Calcium, Ca^{2+}(mg/L)	3.43(2.87)	1.84(1.21)	75	50
9.	10	Silicon, Si mg/L	85.33(28.37)	3.14(0.10)	NA	NA
10.	11	Manganese,Mn^{2+}(mg/L)	0.70(0.74)	0.20(0.13)	0.2	0.1
11.	12	Sodium Na^+ (mg/L)	7.87(4.30)	7.57(2.97)	200	200
12.	13	Iron Fe^{2+} (mg/L)	3.85(4.12)	4.14(4.98)	0.3	0.3
13.	14	Lead Pb^{2+} (mg/L)	0.39(0.23)	0.57(0.08)	0.01	0.01
14.	15	Chromium, Cr^{+6}(mg/l)	0.10(0.07)	0.05(0.01)	0.05	0.05
15.	16	Cadmium	0.01(0.004)	0.01(0.009)	0.003	0.01

pH

The mean pH values in water samples obtained from Bigi and Gudum villages were 7.12 and 7.00 respectively. Thus the water obtained from Gudum is neutral (neither acidic no alkaline), while that of Bigi is slightly alkaline. Compared to the standards of 6.5 – 8.5 and 6.5 – 8.5 given by NSDWQ and WHO respectively, it may be concluded that the pH of the water from all the two villages falls within the acceptable limits for drinking.

Temperature

The mean value of Temperature in water samples obtained at Bigi was 32.31^0C, while that of Gudum was 32.20^0C. The difference in the mean temperatures in water obtained from the two villages is not much. This may be due to the fact that water temperature is normally influenced by the ambient temperature. Since the sampling points are not far apart, no significant variation is expected in the mean water temperatures obtained from the two villages. Hence the temperature values of water at the study sites are virtually the same. No specified limit for water temperature is recommended by both NSDWQ and WHO. However, potable water in general terms has low temperature which is necessary for its palatability and wholesomeness.

Electrical Conductivity

The average conductivity values in water samples obtained from the hand dug wells in Bigi and Gudum were 482.83µS/cm and 550.16µS/cm respectively. A relatively high mean value of conductivity was therefore recorded in water sample obtained at Gudum compared to what was recorded in samples from Bigi. The NSDWQ and WHO recommends a value of 1000 µS/cm for conductivity in water meant for drinking. Thus the conductivity values of water obtained from the two villages in the vicinity of the asbestos factory falls within the limits set by both the Nigerian regulatory agency as well as that of WHO.

Total Hardness

The mean value of Total Hardness obtained at Bigi village was 168.33mg/L and that of Gudum village was 170.66mg/L. Thus a very little and insignificant variation exist in the mean value of Total hardness recorded at Gudum and Bigi. Total hardness is mostly contributed by dissolved Calcium and Magnesium ions in water. It should be noted however that the mean values of total hardness in underground water from all the two villages have exceeded the limit recommended by NSDWQ although it falls within the value stipulated by WHO. The high value of total hardness in the water samples may not be unconnected with the activities of the asbestos factory which produces materials containing calcium and magnesium as byproducts of their operations. Waste materials deposited around the factory may contains excess amount of these materials thus raising their concentrations and contributing to the hardness of the water in the shallow hand dug wells around the factory.

Total Dissolve Solid

The mean value of Total Dissolve Solid obtained at Bigi village was 216.33mg/L while that obtained at Gudum

village was 250.83mg/L. Compared to the threshold limits of 500mg/L and 1000mg/L recommended by NSDWQ and WHO respectively, it may be concluded that the water samples from the hand dug well have satisfied the requirement of the regulatory authorities as far as total dissolved solids are concerned.

Iron

The mean values of Iron in water samples obtained from the hand dug wells at Bigi and Gudum villages were 3.85mg/L and 4.14mg/L respectively. Thus higher values were recorded in water samples obtained from Gudum than Bigi. Both WHO and NSDWQ recommends a value of 0.3mg/L for Fe in drinking water and almost all wells have values above this limit. Dissolved Iron, though not harmful to human health, does have adverse impact on some aesthetic quality of potable water e.g. taste, color and sometime odour. Most underground water sources in Nigeria have dissolved Fe, however the excess concentration far above the threshold limit in well water samples obtained from the two villages may not be unconnected with the activities of the asbestos factory because Fe is one of the elements found naturally in some asbestos fibre.

Magnesium

The average level of magnesium ion in hand dug water at Bigi village was 0.58mg/L while that of Gudum was 0.61mg/L). The mean value of magnesium in water obtained at Gudum village was therefore relatively higher than that of Bigi village though the difference was not much.

Compared to the threshold limits recommended by NSDWQ and WHO, the water samples collected from all the villages contained excess amount of Mg. The excess concentration of Mg in water obtained from the villages may be due to the activities of the asbestos factory since the it is one of the elements found naturally in certain kind of asbestos particularly Chrysotile.

Also, the presence of high amount of Mg might be responsible for the hardness recorded in the water samples obtained from all the two villages.

Sodium

The mean Na values obtained in hand dug underground water samples at Bigi and Gudum villages were 7.87mg/L and 7.57mg/L respectively. These values are far below the limit of 200mg/L set by the Nigerian regulatory body (NSDWQ). Excess of sodium in drinking-water can cause hypertension; in addition concentrations in excess of 200 mg/l may give rise to unacceptable taste

Calcium

The mean value of Ca water samples obtained at Bigi village was 3.43mg/L, while that of obtained Gudum village was 1.87mg/L. Thus higher values of Ca were recorded in samples collected at Bigi village than Gudum. The relatively higher values recorded in water obtained from wells at Bigi village may be due to their proximity to the asbestos factory than Gudum. All the values recorded were however far below the threshold limits of 75mg/L and 50mg/L recommended by NSDWQ and WHO respectively.

Manganese

The mean value of Mn in water collected from hand dug wells in Bigi village was 0.70mg/L while that of Gudum was 0.20mg/L. The result shows that the manganese level in the entire ground water sources exceed maximum permissible limit of either 0.20mg/L or 0.1mg/L recommended Nigerian standard (NSDWQ) and WHO. Excess level of this element in the ground water source especially at Bigi village (which is in close proximity) may be due to the impact of the asbestos factory around the area. High level of manganese in drinking water has the possibility of causing Neurological disorder.

Total Alkanity

The alkalinity in water is mainly due to the presence of bicarbonates. It is a measure of the capacity of the water to neutralize acids and it reflects its so-called buffer capacity. The mean Total Alkalinity value of water samples obtained at Bigi and Gudum villages were 8.95mg/L and 14.68mg/L respectively. The level of alkalinity in the water samples collected from all the two villages falls within the limit of 100mg/L given by NSDWQ.

Silicate

Silicate is an important component of asbestos fibre. The mean value of Silicate (85.33mg/L) obtained at Bigi, much higher than 3.14mg/L obtained in samples collected at Gudum. No specific figure is available as recommended limit by either WHO or NSDWQ for Silicate. However, the higher values of silicate in water samples obtained from Bigi than those recorded in Gudum is an indication of the possible impacts of the asbestos factory on the ground water quality. The well water at Bigi contained much higher value of silicate because it is closer to the factory, whose products and in consequence its waste material contains the silicate.

Heavy metals

The mean Pb content in water obtained from Bigi village was 0.39mg/L while that of Gudum village was 0.57mg/L. The mean content in water obtained from all the two villages in the vicinity of the asbestos factory exceeds the limit of 0.01mg/L given by NSDWQ and WHO. The mean total concentration of Cr in water collected from hand dug wells at Bigi (0.10mg/L) is above the limit of 0.05mg/L recommended by NSDWQ. The level of this metal in water obtained at Gudum (0.05mg/L) however did not exceed the recommended limit. The mean Cd content in water (0.01mg/L) obtained from all the two villages have exceeded the limit of

0.005mg/L recommended by the Nigerian regulatory authority.
The excess concentration of these metals in water could be as a result of asbestos fibre and dust spread by wind which in turn percolate into the soil to reach the water table. Other possibilities are the products of combustion of fossil fuel, leakages of oil and disposal of spent oil in close proximity. Also since Pb, Cr and Cd are component of solvent based paints used in the asbestos manufacture; improper disposal of wastes containing these metals could possibly affect the ground water quality.

4.0 CONCLUSION AND RECOMMENDATIONS

The ground water in the study area is not good enough for drinking because quite a number of the physical and chemical parameters analyzed have exceeded the limits recommended by regulatory authorities. This investigation also revealed that the asbestos factory has more impacts on the ground water at Bigi than Gudun probably because Bigi is much closer to the factory.
The degradation of ground water quality in the two villages under consideration may be linked to the activities of the asbestos. It should be noted however that certain natural phenomena in and around the aquifers could also result in water quality falling below that required for drinking purposes. These natural phenomena could be chemical (e.g. acid/base reaction, dissolution of particles, precipitation of minerals and other chemical ion exchange); Biological (e.g. microbial die off and growth) or even geological (e.g. weathering of rocks). Ground water therefore may naturally contain specific ions and toxic elements in quantities that are harmful to health not necessarily as a result of industrial establishment. It is therefore very important to carry out extensive investigation on geology of the industrial area and the actual types of asbestos raw materials used and their products in Bauchi in term of their chemical compositions before drawing conclusion on their impacts ground water quality in the adjoining villages.
Be that as it may, the following recommendations were made.

a) The houses located very close to the factory and the hand dug wells which are the major sources of water in the villages, should be relocated away from the factory being the possible source of contamination.
b) The government should supply safe water for drinking and domestic uses through pipe lines networking throughout the villages as a substitute to ground water.
c) Water development should go hand in hand with water quality consideration. Periodical analysis of water quality of the environment should be made and be compared with previous value to check the cumulative impact the factory has on the environment.
d) Further studies need to be carried out to evaluate the possible impact of the asbestos factory on air quality.
e) To avoid polluting environment and contaminating ground water, the Federal Ministry of Environment and BASEPA should be monitoring and reviewing the factories EIA and ensure implementation of pollution abatement act.
f) The public at large should be educated on the possible impact associated with living close to industrial site and its consequence.

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