

Seasonal Variation of Heavy Metal Concentration in Surface and Underground Water Samples of Maiganga Coal Mine Area, Gombe State.

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Abstract: This study determined the physicochemical parameters and some heavy metals concentrations in wet and dry season water samples from different sampling points within Maiganga Coal Mine Area of Gombe State. The physicochemical parameters and the heavy metal concentrations were determined using standard methods and atomic absorption spectrophotometry respectively. The results obtained were compared with the limits set by the World Health Organization (WHO, 2011) for water samples. The results obtained are: wet season- pH(2.82-6.88) , temperature (28.4-28.7 °C), conductivity (0.03-2.82 μ s/cm³), TDS (10-1400mg/l), TSS (0.054-0.355mg/l), Pb (1.517-1.56mg/l), Cr (0.066-0.805mg/l), Cd (0.318-0.380mg/l), Ni (0.433-0.541mg/l), Co (0.324-0.883mg/l), Cu (0.007-0.008mg/l), Zn (0.163-0.401mg/l), Fe (0.347-0.822mg/l) and Mn (6.320-6.413mg/l) and dry Season- pH(1.23-7.95) , temperature (28.4-28.7 °C), conductivity (0.13-1.00 μ s/cm³), TDS (70-1000mg/l), TSS (0.071-0.222mg/l), Pb (1.516-1.540mg/l), Cr (0.066-0.101mg/l), Cd (0.332-0.363mg/l), Ni (0.044-0.054mg/l), Co (0.333-0.982mg/l), Cu (0.007-0.011mg/l), Zn (0.153-0.652mg/l), Fe (0.341-0.600mg/l) and Mn (6.330- 6.474mg/l). The results generally revealed low pH, conductivity and TSS, while TDS, Pb and Cd were above the maximum permissible limits set by W.H.O (2011).

Keywords: Heavy Metals, Physicochemical Parameters, Coal Mine, Total Suspended Solid (TSS), Total Dissolved Solids (TDS).

I. Introduction

Mining is simply the extraction of valuable minerals or other geological materials from various parts of the earth crust. It can also be generally defined as the process of extracting useful minerals from the earth crust [5]. The area on the earth surface where mining is taking place is known as mine and the type of mineral being mined will qualify the type of mine in question. For example, gold mine, coal mine e.t.c

Maiganga coal mine as the name indicates is a mine where coal in the mineral is being extracted.

Coal is a fossil fuel formed beneath the earth crust from the decomposition of organic materials that have been subjected to heat and pressure over millions of years[9]. Coal is considered as non-renewable source because it cannot be replenished on a human time frame (United State Environmental Protection Agency, USEPA 2000). The quality of coal is influenced by the type of vegetation from which it originated temperature, pressure and the duration in the formation. The main stages of coal formation include; peat, lignite, subbituminous, bituminous and anthracite [5].

Coal mining is an important anthropogenic activity which is of important economic significant to a nation. The mining activity provides employment to a number of citizens and the coal obtained serves as a source of energy in various ways ranging from domestic to industrial uses[11].

As it is generally the case in life, in the quest to solve problem another unforeseen from problem may be created. The production of millions tons of coal from coal mining activity have help tremendously in sourcing energy for domestic and industrial needs and at the same time generate pollutants to the environment which can be hazardous to plants and animals[10].

It was reported that coal particulate pollution is responsible for shorten life of approximate 1,000,000 lives and death toll of 24,000 lives annually in the globe. In addition to the atmospheric pollution which may be due to the release of various pollutants such as heavy metals that are released directly to the atmosphere and other parts of the environment by mining activities, fly ash, bottom ash and flue-gas desulfurization sludge that may contain toxic substances such as heavy metals are also generated in alarming amounts[11].

The common ailments associated with coal mining, its transportation and usage include: Pneumoconiosis, cardiopulmonary diseases, hypertension, lung and kidney diseases among others. Surface mining is the type of mining method adapted at maiganga coal mine. This mining method is associated with destruction of landscapes, forests, wildlife, top soil, soil erosion and destruction of agricultural lands [8]. Noise and heavy metal pollution are common in coal mine.

Maiganga coal mine is the main source of coal needed for the energy requirement of the Ashaka Cement Company in Gombe State, Nigeria. The coal mine is surrounded by small settlements at its vicinity, hence the need to determined physicochemical parameters and concentration of some heavy metals with the view to ascertain the impact of mining activity on the environment.

Aim: This research work was aimed at determination of some physicochemical parameters and heavy metals in surface and underground water samples at maiganga coal mine in the wet and dry seasons, with a view to ascertain variation.

II. Material and Methods

2.1 Study site and sample collection

Maiganga Coal Mine Area is located at Akko Local Government Area of Gombe State, Nigeria. The coal mine is located at latitude 009°N and 12°N and longitude 10°E and 12°E. Samples of water (surface and underground) were collected at various points within the Coal Mine and its vicinity during wet and dry seasons. Twenty eight (28) water samples were collected out of which thirteen (13) samples were collected during the dry season and fifteen (15) collected during the wet season. All the samples were collected in clean sterile plastic containers. Some parameters such as temperature, conductivity and pH were determined in-situ. Water samples were preserved by adding 2ml of 2M nitric acid and stored in 1L plastic sample bottles and labeled. The samples were kept in a refrigerator before the digestion process commenced.

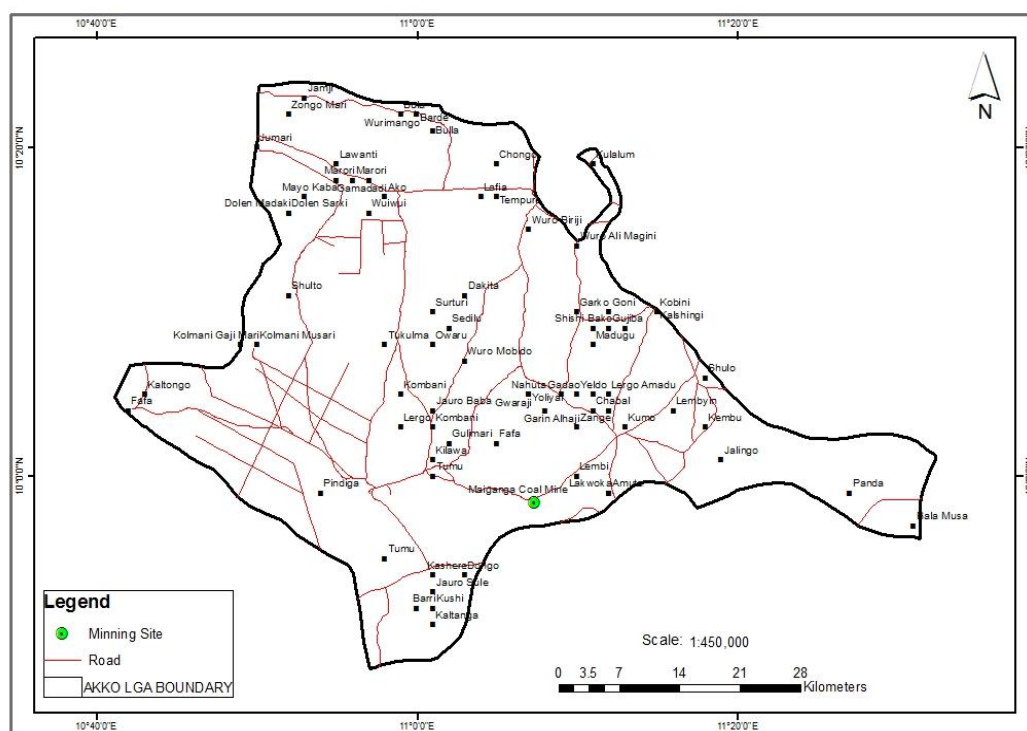


Figure 3.1: Map of Akko LGA, Showing Maiganga Coal Mines

Author: Space Metric Solutions Ltd.

2.2 Determination of Physicochemical Parameters

The pH, temperature and conductivity were determined in-situ using pH meter (pHep pocket size Hanna instrument), thermometer and conductivity meter (model DDS 307) respectively. While total suspended solids (TSS) and total dissolved solids (TDS) were determined using standard methods described by American Public Health Association [2].

2.3 Digestion of Samples

Water samples were digested by measuring 100ml of well-mixed water sample using 100ml measuring cylinder into a 250ml beaker followed by addition of 2ml concentrated HNO₃ and 5 ml of concentrated HCl. The sample was covered with a watch glass and heated on a hot plate at 90°-95°C until the volume was reduced to 15-20 ml. The beaker was then removed and allowed to cool. The inner part of the watch glass which was in contact with the beaker content was carefully washed into the beaker with distilled water and the resultant solution was into a volumetric flask (100ml) and made up to the mark [1]. This process was repeated for all the water samples. The digested samples were stored in plastic sample bottles and labeled.

2.3.1 Heavy Metal Determination

The digested samples obtained in 2.3 were analyzed for heavy metals of interest using atomic absorption spectrophotometer (AAS).

III. Results and Discussion

The results of physicochemical parameters and heavy metals concentrations in surface and underground water samples in both wet and dry seasons are presented in table 1-8.

Table 1.Physicochemical Parameters of Wet SeasonSurface Water Samples

Sample Code	pH	Temperature	Conductivity $\mu\text{s/cm}$	TSS mg/l	TDS mg/l
SR1	2.82	28.6	2.82	1400	0.267
SR2	6.01	28.6	0.03	10	0.109
SR3	6.75	28.6	0.74	370	0.082
SR4	6.36	28.7	2.52	1260	0.176
SR5	3.09	28.6	0.21	100	0.252
SR6	6.88	28.5	0.35	170	0.271
SR7	6.74	28.5	0.34	170	0.193
SR8	6.35	28.6	0.29	150	0.355
X \pm S	5.63 \pm 1.67	28.4 \pm 0.06	0.91 \pm 1.11	453 \pm 551	0.21 \pm 0.09

Table 2.Physicochemical Parameters of Wet SeasonUnderground Water Samples

Sample Code	pH	Temperature	Conductivity $\mu\text{s/cm}$	TSS mg/l	TDS mg/l
UR1	4.08	28.4	0.63	310	0.279
UR2	3.33	28.5	0.55	270	0.136
UR3	6.17	28.5	0.15	70	0.054
UR4	5.35	28.6	0.08	40	0.121
UR5	6.14	28.6	0.06	30	0.163
UR6	5.99	28.5	0.23	110	0.292
UR7	6.29	28.5	0.66	330	0.073
X \pm S	5.34 \pm 1.17	28.5 \pm 0.07	0.34 \pm 0.27	165 \pm 132	0.16 \pm 0.09

Table 3.Physicochemical Parameters of Dry SeasonSurface Water Samples

Sample Code	pH	Temperature	Conductivity $\mu\text{s/cm}$	TSS mg/l	TDS mg/l
SD1	1.33	28.5	1.00	1000	0.071
SD2	1.47	28.6	1.00	1000	0.426
SD3	7.95	28.6	0.40	200	0.222
SD4	1.44	28.6	1.00	1000	0.091
SD5	1.52	28.7	1.00	1000	0.059
SD6	7.52	28.4	0.41	210	0.125
SD7	3.57	28.6	0.24	120	0.169
SD8	1.41	28.7	1.00	1000	0.100
X \pm S	3.28 \pm 2.85	28.5 \pm 0.10	0.76 \pm 0.34	691 \pm 426	0.16 \pm 0.12

Table 4.Physicochemical Parameters of Dry SeasonUnderground Water Samples

Sample Code	pH	Temperature	Conductivity $\mu\text{s/cm}$	TSS mg/l	TDS mg/l
UD1	1.23	28.6	1.00	1000	0.147
UD2	6.93	28.6	0.24	120	1.143
UD3	6.97	28.6	0.16	80	0.280
UD4	5.92	28.6	0.13	70	0.295
UD5	6.84	28.6	0.52	260	0.130
X \pm S	5.58 \pm 2.47	28.6 \pm 0.00	0.41 \pm 0.36	306 \pm 395	0.40 \pm 0.42

Table 5.Concentration of Heavy Metals (mg/l) of Wet Season Surface Water Samples

Sample Code	Pb	Cd	Co	Fe	Mn	Cr
SR1	1.555	0.321	0.811	0.565	6.444	0.092
SR2	1.527	0.357	0.450	0.782	6.402	0.074
SR3	1.526	0.355	0.505	0.373	6.415	0.069
SR4	1.546	0.324	0.306	0.386	6.461	0.069
SR5	1.520	0.380	0.883	0.355	6.389	0.084
SR6	1.526	0.380	0.333	0.539	6.356	0.101
SR7	1.524	0.380	0.324	0.386	6.330	0.094
SR8	1.519	0.350	0.559	0.347	6.345	0.065
X \pm S	1.53 \pm 0.01	0.35 \pm 0.02	0.52 \pm 0.22	0.47 \pm 0.15	6.40 \pm 0.05	0.08 \pm 0.01

Table 6.Concentration of Heavy Metals (mg/l) of Wet Season Underground Water Samples

Sample Code	Pb	Cd	Co	Fe	Mn	Cr
UR1	1.517	0.371	0.324	0.408	6.366	0.082
UR2	1.526	0.359	0.640	0.551	6.316	0.066
UR3	1.517	0.346	0.342	0.347	6.377	0.087
UR4	1.524	0.359	0.468	0.410	6.370	0.097
UR5	1.523	0.380	0.387	0.633	6.385	0.805
UR6	1.521	0.318	0.360	0.822	6.320	0.077
UR7	1.538	0.351	0.342	0.363	6.413	0.079
X±S	1.52±0.01	0.35±0.02	0.41±0.11	0.50±0.17	6.36±0.03	0.18±0.27

Table 7.Concentration of Heavy Metals (mg/l) of Dry Season Surface Water Samples

Sample Code	Pb	Cd	Co	Fe	Mn	Cr
SD1	1.520	0.344	0.982	0.367	6.472	0.066
SD2	1.516	0.385	0.279	0.353	6.398	0.071
SD3	1.519	0.368	0.396	0.396	6.339	0.069
SD4	1.563	0.330	0.604	0.380	6.429	0.069
SD5	1.530	0.353	0.387	0.433	6.413	0.101
SD6	1.526	0.348	0.658	0.341	6.453	0.081
SD7	1.516	0.360	0.550	0.359	6.347	0.075
SD8	1.539	0.342	0.387	0.359	6.474	0.083
X±S	1.53±0.16	0.35±0.02	0.53±0.22	0.37±0.03	6.42±0.05	0.08±0.01

Table 8.Concentration of Heavy Metals (mg/l) of Dry Season Underground Water Samples

Sample Code	Pb	Cd	Co	Fe	Mn	Cr
UD1	1.530	0.355	0.559	0.357	6.385	0.085
UD2	1.535	0.363	0.802	0.600	6.329	0.075
UD3	1.527	0.332	0.333	0.437	6.427	0.097
UD4	1.520	0.345	0.459	0.425	6.390	0.097
UD5	1.523	0.347	0.378	0.347	6.413	0.069
X±S	1.53±0.01	0.35±0.00	0.51±0.17	0.43±0.09	6.39±0.03	0.08±0.01

III. Discussion

The pH values for surface and underground water samples for both wet and dry seasons did not show any significant difference. The pH values were generally below the standard value set by W.H.O (2011) of 6.5-8.5. This shows that the water samples were within the acidic range. This observation was in agreement with the value reported by Tijjani *et al.*, (2014) and Matthew *et al.*, (2012).

The mean temperatures of surface water samples for both wet and dry seasons were 28.5 °C (table 1) and 28.5 °C (table 3) while that of underground water samples for wet and dry seasons were 28.5 °C (table 2) and 28.6 °C (table 4) respectively. Temperature range was similar and no significant difference between the surface and underground water samples for wet and dry seasons which might be due to the geographical location of Gombe State.

The mean conductivity measurement obtained from surface water samples for both wet and dry season were 0.912 µs/cm³ (table 1) and 0.756 µs/cm³ (table 3) while that of underground water samples for wet and dry seasons were 0.337µs/cm³ (table 2) and 0.41 µs/cm³ (table 4) respectively. The maximum permissible limit for electrical conductivity in water according to the W.H.O is 250µs/cm³, however the conductivity of all the samples were within the permissible limit.

The average mean values obtained for total dissolved solids in surface water samples for both wet and dry seasons were 453.7mg/l (table 1) and 691.2mg/l (table 3) while that of underground water samples for wet and dry seasons were 165.7mg/l (table 2) and 306mg/l (table 4) respectively. This indicates that all water samples were below the maximum permissible limit of 1000mg/l. Total dissolved solids contains small amounts of organic matter that can be easily dissolved in water.

The average mean values obtained for total suspended solids in surface water samples for both wet and dry seasons were 0.213mg/l (table 1) and 0.157mg/l (table 3) while that of underground water samples for wet and dry seasons were 0.159mg/l (table 2) and 0.399mg/l (table 4) respectively. This indicates that TSS in all water samples were below the maximum permissible limit of 20mg/l. High concentrations of total suspended solid decrease the effectiveness of drinking water.

Heavy metals constitute important group of environmentally hazardous substances which are toxic in large doses. Lead is a general metabolic poison and enzyme inhibitor which causes mental retardation and can damage nervous connections and cause blood and brain disorder [4]. The mean concentration of lead in surface water samples for wet and dry seasons were 1.530mg/l (table 5) and 1.528mg/l (table 7) respectively while that of underground water for both wet and dry seasons was 1.523mg/l (table 6) and 1.527mg/l (table 8). This indicates that the concentration of lead in all samples are above the maximum permissible limit of 0.015mg/l, this result is

of great concern because lead is a cumulative poison and a possible human carcinogen which accumulates in soft tissues and bone overtime [4].

The mean concentration of chromium in surface water samples for both wet and dry seasons were 0.081mg/l (table 5) and 0.076mg/l (table7) while that of underground water for wet and dry seasons were 0.184mg/l (table 6) and 0.083mg/l (table 8) respectively. This result indicates that the concentration of chromium in underground water sample for wet season was slightly above the maximum permissible limit of 0.1mg/l while the mean concentration was below the maximum permissible limit in the surface water samples for both wet and dry seasons. Chromium is also essential for organisms as a micronutrient in traces from fat and carbohydrate metabolism, it is also harmful in its lower oxidation state (III), chromium and chromates are potential carcinogen [6]. Chromium in water is generally found in the hexavalent form which is highly toxic and in higher concentrations to be carcinogenic [7].

The mean concentration of cobalt in surface water samples during for wet and dry seasons were 0.521mg/l (table 5) and 0.530mg/l (table7) while that of underground water for wet and dry seasons were 0.409mg/l (table 6) and 0.508mg/l (table 8). This indicates that the concentration of cobalt in both surface and underground water for wet and dry seasons were below the maximum permissible limit of 0.005mg/l. Cobalt is beneficial for humans because it is part of vitamin B₁₂, essential for human health. It is used to treat anemia in pregnant women as it stimulates the production of red blood cells, too much concentration of cobalt may damage human health [6].

Cadmium had a mean concentration of 0.354mg/l (table 5) and 0.353mg/l (table 7) in surface water samples for both wet and dry seasons while 0.354mg/l (table 6), 0.349mg/l (table 8) in underground water samples for wet and dry seasons. This indicates that the concentration of cadmium in all samples were above the maximum permissible limit of 0.005mg/l. Cadmium is considered as one of the important pollutants, it is extremely toxic even in low concentration and will bio-accumulate in organisms, it has a long biological half-life in the human body, long term exposure induces renal damage [3].

The mean concentration of iron in surface water samples for both wet and dry seasons were 0.466mg/l (table 5) and 0.373mg/l (table7) and that of underground water for wet and dry seasons were 0.504mg/l (table 6) and 0.427mg/l (table 8). This also shows that the concentration of iron was above the maximum permissible limit of 0.3mg/l in both surface and underground water samples. Excess amount of iron impacts a bitter taste and causes hypertension; it also causes rapid increase in pulse rate, coagulation of blood in blood vessels. Iron is discharged from natural geological sources, industrial wastes, and domestic discharge and also from byproducts [6].

The mean concentration of manganese in surface water samples for both wet and dry seasons were 6.392 mg/l (table 5) and 6.415mg/l (table7) and that of underground water for wet and dry seasons were 6.363mg/l (table 6) and 6.391mg/l (table 8). This indicates that the concentration of manganese in both surface and underground water samples for wet and dry season were above the maximum permissible limit of 0.05mg/l.

IV. Conclusion

Except for cobalt and pH, the concentrations of heavy metals analyzed in all the samples were above the maximum permissible limit set by W.H.O (2011) which did not show any significant variation between the seasons. All other physicochemical parameters were also below the standard set by W.H.O (2006) and do not show any significant variation between the wet and dry seasons.

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