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Elemental Analysis of Sub-Bituminous and Bituminous Coal

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Abstract

Two samples (A and B) of sub-bituminous and bituminous coal deposits respectively from Ute community in South-West Nigeria were analysed for Mg, As,Cd, Hg, Zn, Mn, Se, Pb,Cs, Fe, Ca and Co. pH and Conductivity were also measured from the two diluted sub-bituminous and bituminous samples. This is with interest to know the harzadous level of the elements before exposure to the surface in tailings. The levels of Hg (19.74 ppm and 14.67 ppm), As (1.3 ppm and 3.4 ppm) and Pb (21.15 ppm and 21.44 ppm) in the two samples A and B respectively gave indication of potential pollution deposit whose mining residues can result to pollution in the water intake by plant and animal. The respective (samples A and B) pH levels of 2.37 and 2.48 of diluted sub-bituminous and bituminous coal show that the deposits are acidic and if leached into river, ground water or soil can pose health harzard to the ecosystem.

Keywords: Bituminous coal, contamination, concentration, heavy metals, environment

1.0 Introduction

Coal is a stratified combustible accumulation of carbonaceous organic material derived from compaction of plant remains mixed with variable amount of inorganic materials. The various grades of coal are peat, lignite, sub-bituminous, bituminous, anthracite and graphite in increasing order of hardness (Dapples, 1942). Coal also contains many trace elements such as arsenic, mercury, lead, nickel, iron etc such contaminants can be released in effluent mine waters to the environment during exploitation. In the tropics, rainfall and resulting run-off enable release of pollutants such as metals from coal mine waste to nearby farmlands and rivers unlike in temperate countries where coal mining is done, low temperature permafrost has been identified as a factor reducing element recycling (Welker *et al.*, 2000; Elberling, 2001).

The production of coal is likely to increase in future due to shift in global demands for coal and the abundance of coal (Finkelman *et al.*, 2002). The high future demand for coal will result in the release of acid mine drainage from coal mine waste rock since it contains sulphide minerals. The likely significant result will be extensive plant damage and the absence of plants (Holmes *et al.*, 2003; Banks, 1996). Ute is a community within South-Western part of Nigeria with records of large bituminous coal deposit yet to be tapped industrially.

The study of Coal is important due to its various industrial uses like production of electricity, heat generation, and raw materials for organic and inorganic chemicals. It is used for making paint, to fuel rail transport, for making hydrocarbon fuels, for road construction, as energy fuel in cement, for brick producing factories and foundries. It is also used as raw materials for the production of tyres, polymers and batteries.

The importance of this research is to determine the level of elemental impurities in the coal raw materials whose accumulation in soil can cause environmental problems and also to sensitize potential miners to guide against polluting the environment during their extraction processes.

2.0 Methodology

Two representative samples (A and B) of coal naturally exposed at the surface at cocoa, palm tree, kolanut and rubber mixed farmlands in Ute town were collected in nylon. Sample A is the sub-bituminous coal; wet semi-solid and brownish black in colour. Sample B is bituminous; hard and black coloured; formed in solid layers deep down where

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it extends more in surface area. 5g of each sample was oven dried at 105^oC and later ground to powder and sieved in 2mm mesh size. 2g from the ground samples were put into digestion flask followed by the addition of 20 ml of concentrated H_2SO_4. The flask was later placed inside a 1.007 digester (Tectactor) and digested at 60^oC for 3 hours until homogeneous solution was obtained (Kane, 1989). The samples were cooled, filtered and make up to 100ml in a volumetric flask. The filtered diluted samples were analyzed for lead, cadmium, arsenic, cobalt, magnesium, mercury, zinc, manganese, selenium, chromium, iron and calcium with Alpha 4 Series Atomic Absorption Spectrometer at Obafemi Awolowo University.

For the pH and conductivity, 2g of both samples were weighed into 100 ml beaker, followed by addition of 20 ml of distilled water. The pH and conductivity of the samples were measured with the Mettler Toledo (MC126) pH and conductivity meter.

3.0 Result and Discussion

Tables 1 shows the various metal concentrations in ppm, the conductivities and pH data. The Rank correlation coefficient was derived from the equation

$$\rho_{x,y} = \frac{Cov(x,y)}{\sigma_x \sigma_y}$$

where $-1 \leq \rho_{x,y} \leq 1$ is the correlation coefficient

$$\mathrm{Cov(x,y)} = \frac{1}{\mathrm{n}}\sum_{i=1}^{n}(x_i - \mu_x)(y_i - \mu_y)$$

where x and y are the sub-bituminous and bituminous coal data, σ_x and σ_y are standard deviations of sub-bituminous and bituminous coals respectively.

The summary statistics of the pH, conductivities and metal concentrations from the two major sampling sites is presented in Table 1. The derived rank correlation coefficient 0.999324, shows that both samples are similar; the difference can be due to the level of compaction or solidification. The elevated levels (in ppm) of Hg (19.74 and 14.67), As (1.3 and 3.4) and Pb (21.15 and 21.44) in the two samples gave enough signal that the residues of the mining if exposed to the environment can result to pollution in the water intake by plant and man. The allowable level of Mercury and Lead in the drinking water by WHO standard (WHO, 2004) is 0.001ppm and 0.05 ppm respectively. The pH from both sites indicated that the bituminous coal are acidic. Consequently, the minerals in these samples can react with underground water and soil if leached into groundwater or if exposed to soil thereby contaminating the environment. Run-off activities during raining season may contribute to severe impact into agricultural land and non-acidic plants will not do well in such environment. The conductivities are extremely low ranging between 2.25x10^{-3} to 2.90x10^{-3} S/cm. Metals concentration (see Table 1 and Figures 1 to 3) vary from the two samples. Iron (Fe) and Calcium (Ca) recorded the highest (349.20 mg/kg (ppm)) and lowest (0.06mg/kg) metal content respectively. Three of the metals (Hg, Pb and Fe) recorded elevated concentrations above 10.0mg/kg. Two of these metals (Hg and Pb) are very important environmental pollutants which are of serious health concern. A critical look at Table 1 and Figures 1 to 3 show that apart from Mg, Hg and Se, all the other metals were recorded at higher concentrations in sample B than sample A. Considering the places of occurrence of sample A and B, close to plants and river, the elevated metal contents and acidic level in the bitminous and sub-bituminous coal if not properly mined can cause damage to plant, animal and aquatic

Table1: Summary of Physico-Chemical Characteristics

Samples	pH	Conductivity (x10^{-3})S/m	Mg	As	Cd	Hg	Zn	Mn	Se	Pb	Cs	Fe	Ca	Co
A	2.48 ±0.00	2.25±0.001	1.110 ±0.10	1.300 ±0.01	6.270 ±0.24	19.740 ±2.14	1.079 ±0.04	3.495 ±0.11	9.076 ±1.25	21.150 ±2.42	0.120 ±0.01	278.800 ±14.24	0.060 ±0.01	0.120 ±0.02
B	2.37 ±0.00	2.90±0.001	0.630 ±0.11	3.400 ±0.41	7.471 ±0.32	14.670 ±1.21	2.096 ±0.24	4.099 ±1.01	4.045 ±0.41	21.440 ±2.62	0.260 ±0.11	349.200 ±12.01	0.070 ±0.01	0.320 ±0.01
WHO* Standard	6.5-9.0	20±0.00	NA	0.011	0.003	0.006	3.000	0.400	0.010	0.010	NA	0.300	NA	NA

NA: Not available *: WHO(2004) ±: Standard deviation lives in the river. Sustainable mining with this and other prior impact assessments and environmental monitoring can reduce the leaching and contamination of the environment.

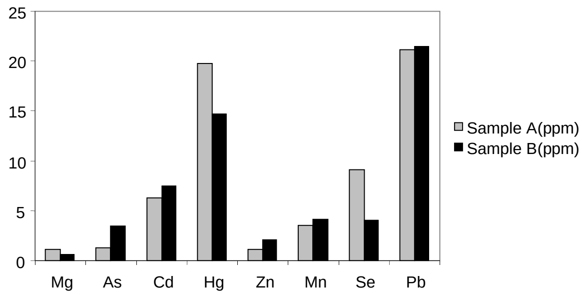

Figure 1: Concentrations of 8 Metals in Sub-Bituminous and Bituminous Coal

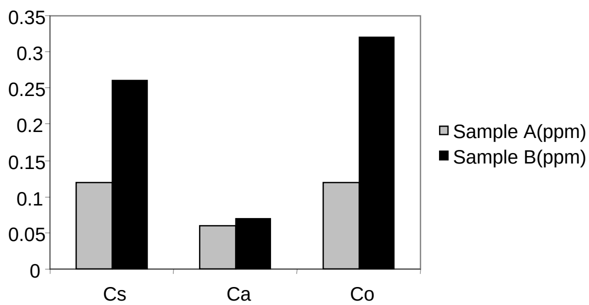

Figure 2: Caesium, Calcium and Cobalt Metal concentrations in Sub-Bituminous and Bituminous Coal

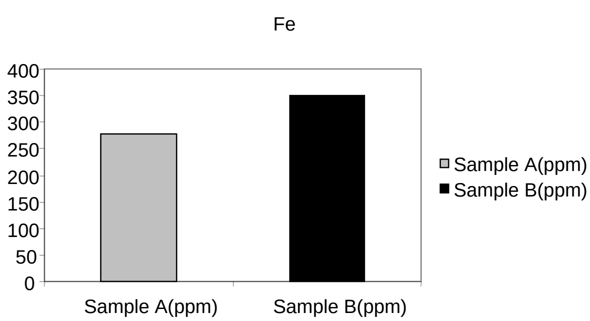

Figure 3: Iron concentration in Sub-Bituminous and Bituminous Coal

4.0 Conclusion and Recommendation

Two samples of bituminous and sub-bituminous coal were analysed with AAS to determine concentrations of eleven metals and Mettler Toledo (MC126) pH meter for the level of acidity. The sub-bituminous coal has higher level of Mg, Se and Hg than the bituminuos coal. The bituminous coal was found to contain higher level of As, Cd, Zn, Mn, Cs, Fe, Ca and Co than the sub-bituminium coal. The two samples have high levels of Hg, As and Pb, harzadous metals that should not be allowed to leach into the groundwater and soil if careful environmental sustainable mining is to be implemented.

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