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STATUS OF WATER QUALITY IN THE COAL RICH MUI BASIN ON KITUI COUNTY, KENYA

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ABSTRACT

The Kenyan population is growing at an alarming rate which has led to increase in demand for resources such as energy, food, and infrastructure. The discovery of coal in Mui Basin of Kitui County is so important in the realization of Kenya's blue print vision 2030. Coal is a major source of energy, and is composed of Carbon, Hydrogen, and Oxygen, with lesser amounts of Sulfur and Nitrogen. Despite the high expectation from coal, the extraction of coal and its subsequent use as a fuel source of energy comes with a myriad of challenges which among them are the emissions of sulphur oxides from combustion of sulphur in coal. This study aimed at assessing the physiochemical status of the underground water utilized for domestic purpose in the coal rich Mui basin block D. The results of the minerals content were below detectable limits with only Magnesium being in the range of 4.14-50.18 mg/l. Since coal is a major environmental pollutant from the exploration, mining as well as utilization, this study recommend the application of modern and clean coal technology in order to reduce the emission of poisonous material that pollute the water bodies and the environment in general.

Keywords: mui basin, water quality, coal mining, environment.

INTRODUCTION

Coal is a solid - a sedimentary rock - extracted through surface and underground mining. Coal comes from organic matter subjected to intense heat and pressure for millions of years. According to the U.S. Energy Information Administration (U.S. EIA), total global coal production and consumption in 2009 was about seven billion metric tons with China producing 44 percent of this amount, followed by the United States at 14 percent and India at 8 percent.

The Mui Coal Basin is located 180 km northeast of Nairobi, Kenya and covers an area of 500km^2. Exploration for coal has been conducted by Kenya's Ministry of Energy (MOE) since 1999 and has focused on four blocks, Blocks A, B, C and D, included surface geological mapping, geophysical surveys, exploration drilling, detailed coal quality analyses and resource evaluation. Exploration drilling by the Ministry of Energy has to date been focussed in Block C, where 54 wells have been drilled to depths ranging from 75m to 445m. A further four wells have each been drilled in Blocks A, B and D to confirm the extension of the coal seams into these areas. The Ministry of Energy has reported that exploration drilling has confirmed that six coal seams have been identified (C1 to C6) in the basin. Seam thicknesses varying from 0.3m to 13m have been encountered in 40 of the holes drilled and at depths of between 20m to 320m. Coal quality analyses on 70 samples was subsequently completed with details of the ash, calorific value, volatiles, fixed carbon, sulphur and total organic carbon recorded MoE (Photo of Coal exploration in Mui basin). Mining operation of this "black gold" undoubtedly is anticipated to bring wealth and employment opportunity in the country, but simultaneously it will lead to extensive environmental degradation and disruption of traditional values in the society. Environmental problems associated with coal exploration have already been felt in the Mui basin region's due to the fragile ecosystem. The extraction of coal creates a variety of impacts on the environment before, during and after the mining operations. The extent and nature of impacts can range from minimal to significant depending on a range of factors associated with the exploration, the mining processes as well as post mining management of the affected landscapes.

Figure-1. Coal exploration in Mui Basin (Photo: courtesy of Ministry of Energy, Kenya).

There are several shallow open hand-dug wells as well as boreholes in the vicinity of the exploration site where the local community draw the groundwater for domestic purposes. The quality of water is of upper most importance compared to quantity in any water supply planning and especially for drinking purposes purity is equally important (Walton, 1970). Water resource (rain, river, sea and ground water) are one of the major components of environmental resources that are under threat either from over exploitation or pollution,

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exacerbated by human activities on the earth's surface (Efe, 2001).Generally, water resource problems are of three main types: too little water, two much water and polluted water (Ayoade, J. O, 1988; Adebola, 2001). In most homes in the Mui Basin like in most part of Africa as reported by Efe, *et al*., (2005) valuable man-hours are spent seeking and fetching water, often of doubtful quality, from distant sources.

Coal mining has been linked to severe drinking water contamination in many coal mining regions. In the state of Orissa, India, communities' drinking water was contaminated as a result of coal mining and processing activities. Women are particularly at risk for adverse health effects resulting from exposure to this contaminated water, as they are responsible for many household activities that involve contact with water, such as collecting the water, washing clothes and utensils, and bathing children (Murthy and Patra, 2006). According to Mielke *et al*. (2010), water-related impacts of fossil-fuel extraction and refining in a given region are a function of multiple factors, including the amount and type of fossil fuel produced, the extraction methods used, physical and geological conditions, and regulatory requirements (In some cases, social conditions such as political stability also influence the links between water and energy. When drinking water is contaminated, communities have three basic choices: (1) find an alternative source of water, (2) treat water before drinking it, or (3) drink contaminated water and risk adverse health outcomes. Often, alternative water sources can be much more expensive; for example, in Kenya, a litre of drinking water is in the range of one US$ (market price, 2012), while in the United States bottled water can be thousands of times more expensive than tap water or may require travelling long distances at a high energy cost as reported by Gleick and Cooley (2009).

The growing recognition of the serious risks of underground water contamination due to coal exploration raises new questions. The water bodies of the Mui basin area are the greatest victims of the coal exploration and later mining. Studies on the impact of coal exploration on water bodies are lacking in literatures, especially shallow well and borehole water quality assessment which is usually neglected because of the general belief that it is pure through the natural purification process (Efe, 2002).

Nevertheless, no information has been documented in the literature on Physico-chemical and cationic characteristics of water in the Mui Basin, which are very vital as water quality monitoring parameters due to their instability. Significant variations in physico-chemical parameters in water affect the quality of a water resource and thus the livelihood of the community utilizing the water. Hence, it is necessary to obtain information on the physicochemical characteristics of water resources in the coal rich Mui basin prior to the initiation of the mining process in order to monitor the water quality. Therefore, this study aimed at analyzing the physicochemical characteristics of water quality from shallow open hand-dug wells and boreholes in the Mui Basin of Kitui County.

EXPERIMENTAL

Materials

The study was conducted in the coal rich Mui basin on the Eastern part of Kitui County, Kenya located on latitude 1° 08' 26'' S and longitude 38° 12' 58'' E. A survey was embarked upon to collect water samples in the study area from shallow open wells and boreholes. The sampling points 01, 02, 04, 06, 08, 09 were chosen due to their proximity to the exploration wells drilled by the MoE, while 03 and 05 were chosen as a control since they are located away from the zone. Twenty seven (27) plastic buckets were used to collect the well and borehole water samples. The buckets were thoroughly washed and sterilized to avoid extraneous contamination of the samples. The open-well and borehole water samples were transferred to the plastic containers. 2.5 litres of water samples were collected from each sampling station for subsequent analysis. The water samples were transported to the laboratory in Marina 35S cooler (Indonesia) and stored in a refrigerator at 4^{o}C to avoid sample loss through evaporation and subsequent concentration of the different parametric indices analyzed.

Mapping of the location of the selected shallow wells as well the bore holes was carried out by use od GARMIN™ eTrex Legend HCx, a high-sensitivity GPS navigator. The pH, electrical conductivity (ms), Resistance (Ohms-Ω), Total dissolved solids (TDS, g/l) and Salinity (ppt) were determined using SANXIN® Model SX751, (China) while the cationic composition were determined according to standard methods in an Atomic Absorption Spectrophotometer PPG-990 (UK).

Data analysis

To maintain quality assurance, triplicate determinations were made and the data presented as the mean.

RESULTS AND DISCUSSIONS

The results of the GPS locations and some physicochemical parameters and selected priority metals (cations) in shallow open hand-dug wells and borehole water resources in the study area are presented in Tables 1, 2 and 3, respectively.

Table-1. Show the GPS locations of the sampled water resources.

Site code	GPS Reading
01	1□ 07.434, S, 38□ 13. 120 E
02	1□ 07.321 S 38□ 13. 059 E
03	1□.01.865, S 38□ 10. 236 E
04	1□ 07.127, S 38□ 11.968 E
05	1□ 05.232, S 38□ 11.077 E
06	1□ 06.394, S 38□ 11.953 E
07	1□ 07.088, S 38□ 13.153 E
08	1□ 07.311 S 38□ 13. 091 E
09	-

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Table-2. Physico-chemical parameters of Shallow open-hand-dug well water.

Site	pH	Conductivity (μS/cm)	Resistance (Ohms-Ω)	TDS (mg/l)	Salinity (ppt)	Magnesium (mg/l)
01	7.32	1700.1	142	635.3	3.53	41.15
02	7.76	2017.6	56.7	834.9	9.24	38.32
03	7.76	1945.9	205	593.5	2.40	4.14
06	7.75	1700.8	95.8	679.64	5.34	43.36
08	7.85	1700.2	58.3	814.5	8.97	44.19
09	7.90	1600.8	146	765.1	3.41	40.91
EPA Std	6.5-8.5	NS	-	500	-	-

NS=No standard,

Table-3. Physico-chemical parameters of borehole water.

Site	pH	Conductivity (ms)	Resistance (Ohms-Ω)	TDS (mg/l)	Salinity (ppt)	Magnesium (mg/l)
04	7.58	3500.0	28.6	2333.9	19.8	
05	8.02	3700.3	26.8	2637.0	20.7	50.18
07	7.90	2000.2	49.5	2517.3	10.7	47.51
EPA Std	6.5-8.5	NS	-	500	-	-

NS=No standard,

The data revealed that the maximum and minimum pH values in the sampled water resources from all the sampling sites were alkaline with the pH range from 7.32-8.02. These values are acceptable as per guidelines suggested by W.H.O, 2003. The pH value above 7.0 shows the alkaline nature of water due to excess of carbonate and bicarbonates ion. The results of pH are in the range of 6.8-8.4 as reported in literature by Sushma Jain and Monika Agarwal (2012). The pH values for water resources in coal mining zones has been reported to be acidic in nature with a range of 2.31-4.01, these results suggest the water has not been affected by the exploration process. Conductivity is the measure of the capacity of a solution to conduct electric current (Sumarlin Swer1 and O. P. Singh, 2004) and is a rapid measure of the total dissolved solids present in ionic form. In this study, the conductivity was high in the borehole water as compared to the shallow wells within the range of 1600.8-3700.3 micro siemens/cm at 25°C. These values are way beyond the limit in drinking water prescribed as 1400 micro siemens/cm (WH, 2003) the high conductivity recorded in the samples, may be attributed to high salinity and high mineral content of the sampling point. The measure of total dissolved solids (TDS) is a good indicator of the mineralized character of the water. Ground water having less than 500 mg/L of total dissolved solids is generally satisfactory for domestic and industrial use according to the set standard by WHO (2003) and EPA (2002) while ground water having greater than 1000 mg/L of total dissolved solids is generally unsatisfactory for these uses. High total dissolved solids are often indicative of other characteristics such as hardness. TDS values varied from 635-2637.0 with the highest TDS being recorded in the borehole water, all samples exceed the permissible limit of TDS. Desirable limit for TDS is 500 mg/l and maximum limit is 2000 mg/l prescribed for drinking purpose according to Avash Maruthi *et al*., (2004). Drinking water is the likely dietary component to provide magnesium since water is a regular dietary constituent and magnesium is up to 30% more bioavailable in water. Minimum standard of at least 25 milligrams of magnesium per liter of water has been recommended in drinking water. The Magnesium ($Mg^{2+)}$) concentration in the water samples varied from 4.14-50.18 mg/l. These values were within the acceptable range with only the shallow well 03 having the lowest concentration. Industrial development in East Africa requires power and the coal in the region can drive the agenda and transform the EAC into an industrial giant. Harnessing of coal deposits in Mui basin provide an alternative source of energy to hydro power, which is not guaranteed because of drought resulting from climate change. Many natural factors can affect ground-water quality; however, the primary factors include the source and chemical composition of recharge water, the litho logical and hydrological properties of the geologic unit, the various chemical processes occurring within the geologic unit, and the amount of time the water has remained in contact with the geologic unit (residence time). All of these factors can affect the type and quantities of dissolved constituents in ground water. The most abundant dissolved constituents measured are the

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major ions, which can be both positively charged (cations) and negatively charged (anions).

CONCLUSIONS

The quality of ground water varies from place to place and the location of the water source from the coals block. Water, is a precious natural resource and very vital for life of all organisms. Clean water is critical to the health, economic and social well-being, and quality of life. Change in the water quality affects not only the human beings but also a variety of flora and fauna of the area. This makes the life sustaining water become a life threatening substance that affects living organisms at different levels. Very little has been written about the water-quality implications of coal exploration, mining and use in the Mui Basin of Kitui County in Kenya. Contamination of water, due to coal extraction and processing has been reported in other parts of the globe. This contamination of water has significant implications for ecosystems and for communities that depend on the water to support their livelihood. A holistic analysis of the status and geohydrological impact assessment of the entire water resources in the Mui basin and the neighbouring water bodies' needs to be carried out to protect the community within the coal rich zone.

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REFERENCES

Avash Maruthi and S. Rama Krishna Rao. 2004. Asian Journal of Chemistry. 16, 1, 122.

Ayoade J. O. 1988. Tropical Hydrology and Water Resources. London and Basingstoke, Macmillan. Adebola K. D. 2001. Groundwater Quality in Ilorin Township: An Environmental Review. African Journal of Environmental Studies. 2(2): 4-6.

Efe S I., Ogban F E., Horsfall M Jnr. and Akporhonor E E. 2005. Seasonal Variations of Physico-chemical Characteristics in Water Resources Quality in Western Niger Delta Region, Nigeria. Journal of Applied Sciences and Environmental Management. 9(1): 191-195.

Efe S. T. 2002. Urban Warming in Nigerian cities. The case of Warri metropolis. African Journal of Environmental Studies. 2(2): 6.

EPA. 1996. U.S Environmental Protection Agency, Safe Drinking Water Act Amendment. EPA 810S-96-001.

Gleick P.H. and Cooley H.S. 2009. Energy implications of bottled water. Environmental Research Letters 4. doi:10.1088/1748-9326/4/1/014009.

Mielke E., Anadon L.D. and Narayanamurti V. 2010. Water Consumption of Energy Resource Extraction, Processing, and Conversion: A Review of the Literature for Estimates of Water Intensity of Energy-Resource Extraction, Processing to Fuels, and Conversion to Electricity. Energy echnology Innovation Policy Discussion Paper No. 2010-15. Cambridge, Massachusetts: Belfer Center for Science and International Affairs, Harvard Kennedy School, Harvard University.

Murthy A. and Patra H.S. 2006. Ecological, Socio-Economic and Health Impact Assessment Due to Coal Mining - A Case Study of Talabira Coal Mines in Orissa. Orissa, India: Vasundhara.

Sumarlin Swer1 and O. P. Singh. 2004. Proceedings of the National Seminar on Environmental Engineering with special emphasis on Mining Environment, NSEEME, 19-20, March; Indra N. Sinha, Mrinal K. Ghose and Gurdeep Singh (Eds.). Indian School of Mines, Dhanbad - 826 004.

Sushma Jain and Monika Agarwal. 2012. Study on physico-chemical characteristics of ground water of various villages around Raisar. Journal of Chemical, Biological and Physical Sciences. 2(3): 1551-1555.

Tatawat - Singh Chandel. 2008. Quality of ground water of Jaipur city and its suitability for domestic and irrigation purpose. Applied ecology and environmental research. 6(2): 79-88.

Walton W.C. 1970. Ground water resources evolution, New York, Mc Graw Hill Book Co.

World Health Organization. 2003a. Water Sanitation and Health. Arsenic in Drinking water. www. who. int/water sanitation and health /dwq/arsenic/en.