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DETERMINATION OF HEAVY METALS CONCENTRATION IN TUDUN KUKA DAM FOR IRRIGATION PURPOSES AROUND MAIGANGA COAL MINES, AKKO LOCAL GOVERNMENT AREA, GOMBE STATE, NIGERIA

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Abstract

The study examined the concentration of heavy metals in Tudun Kuka dam around Maiganga Coal mining area for irrigation. Water samples were collected using distilled plastic containers from down-stream and up-stream of the only large dam majorly affected by the coal mining activities at the surface of the dam. The collected samples were analyzed for some specific heavy metals (Fe, Mn, Cu, Zn and Al) and the concentration of each metal analyzed was compared with permissible limits as approved by Food and Agricultural Organization (FAO) standard. The results revealed that Iron was detected at both the down-stream (1.74 mg/l) and up-stream (1.91 mg/l) but was above the FAO permissible standard of 0.50 mg/l. This indicates water pollution with Fe. Copper (Cu) was not detected at both down-stream and up-stream in the dam, while the FAO safety limit is 0.01 mg/l. Zinc (Zn) was only detected at the up-stream (0.005 mg/l) of the dam but was below the FAO permissible standard of 0.02 mg/l. This implies that the Zn content has no potentials to cause water contamination. Apart from Fe concentration, which is high, all other considered metals, were either within or far below the FAO permissible limit. This implies that they all constitute no risk of water pollution in the dam and so the water is not objectionable for irrigation at moment.

Keywords: Coal mining, heavy metals, irrigation, permissible limit, Maiganga

1. Introduction

Agricultural production account for the largest water use globally. Irrigation of agricultural lands accounted for 70% of the water used worldwide. In several developing countries, irrigation represents up to 95% of all water uses and plays a great role in food supply and security. Food and Agriculture Organization (FAO,2014) have pointed out that Nigeria is among countries that are unable to meet the food need of its citizens from mainly rain fed agriculture production due to low farm inputs with corresponding increase in population. Therefore, encourages the expansion of food production from rain fed to include large-scale irrigation farming. Irrigation is the deliberate application of controlled quantity of water to land surface for the purpose of crop production at required periods. Irrigation greatly helps in the production of both cash and food crops to satisfy human needs. It also helps to maintain landscapes and vegetate disturbed soils in dry areas and during periods of inadequate rainfall (Rowe *et al*, 1995). Irrigation waters whether derived from springs, diverted from streams, or pumped from wells or dam, contain appreciable quantities of chemical substances in solution that may reduce crop yield and deteriorate soil quality and fertility. Irrigation water always carries substances derived from its natural environment or from the waste products of man activities (domestic and industrial effluents). The chemical constituents of irrigation water can affect plant growth directly through toxicity, deficiency, or indirectly by altering plant availability of nutrients (Ayers and Westcot, 1985; Rowe *et al*., 1995). The issues of water quality have often been neglected because there are quite a number of good quality water supplies (Islam *et al*., 2004). Hydro-chemical study reveals the quality of water that is suitable for drinking, agriculture and industrial uses. Chemical parameters of groundwater play a significant role in assessing water quality, which is suitable for irrigation (Sadashaiah *et al*., 2008). Dam is one of the major sources of water for irrigation farming. The quality of dam water is very important in terms of the productivity, quality and quantity of crops to be produced. Any dam, which is located close to mining site, may be affected by dissolved heavy metals from the mining activities in terms of the water quality need for irrigation.

Mining however, poses major threats and hazards that can degrade the natural environment (water, soil, air). Mining operation alter a site's water quality, thereby affecting the ecological balance, natural landscapes, agricultural land, forest, plantation and vegetation as well as the economic food and trees crops (Buba, Essoka and Musa, 2019). The impact of mining activities on terrestrial and aquatic environment are mostly associated with change in hydro geological system, hydrological transformation of soil and surface flows, contamination of soil and surface water, reservoirs, as well as pollution of the atmospheres (Aigbedion and Iyayi, 2007). Waste rocks generated from coal mining often constitute source of heavy metals pollution, while tailing pond or piles may give rise to pollution of water bodies (Adekoya *et al.*, 2003). Runoff from coal mines can transport dissolved heavy metals, notably, copper, lead, zinc, manganese, mercury, molybdenum among others, into ground and surface water bodies and some of the metals are dangerous to human health and can lead to other health related issues such as typhoid fever, salmonellosis, cholera, dysentery (Arogunjo, 2007).

Mining activities involve the blasting of rocks, which result to the release of large quantities of heavy metals, dust particles and other products into the environment including water bodies. Metals are regarded as one of the major sources of water and soil pollution. These metals among others , include: Cu, Ni, Cd, Zn, Cr, and Pb (Yee, 2012). There are some metals like As, Cd, Hg, Pb that are not essential for plants growth, because they do not perform any physiological function in plants. Others are like Cu, Cu, Fe, Mn, Mg, Ni and Zn, which are essential elements required for normal growth and metabolism in plants. These elements can easily cause poisoning when their concentration is greater than the optimal values. Intake of some heavy metals by plants and gradual accumulation along the food chain is a threat to human and animal health. The absorption of plants by its roots is one of the main ways of entrance of heavy metals in the food chain (Li, 2015). Similarly, in the same study area Adamu, (2019) pointed out the health implications of heavy metals accumulation in plants and emphases that heavy metals toxicity can result in; damaged or reduced mental and nervous function, lower energy levels, damaged the blood, kidneys, lungs, liver, and other vital organs. The study also, reveals the presence of Cr, Pb, Ni, Zn, and Cd heavy metals considered in maize plants leaves obtained from farms around Maiganga village, at 20 meters downstream and 1 km up-stream (Adamu, 2019).

Considering the amount of heavy metals discharged from the coal mining activities to soil and the dam around the mines constitute a major source of Tudun Kuka dam water pollution and can pose a great danger to man if consumed through food chain via irrigation. Hence, the need to determine the concentration of heavy metals in Tudun Kuka dam for irrigation purposes.

2. Materials and Methods

2.1 Study area

The study area is Tudun Kuka dam located at Tudun Kuka settlement in Maiganga village, Akko Local Government Area, Gombe State. It is located between longitude $09^0 59^1$ N and $11\ 09^1$ N and latitude of 11^0 8E and $11^0 9^1$ E. Maiganga covers a land area of about 48.16 km^2 (Fig.1), bounded to the South by Blliri and to the West by Kumo towns, which is the Headquarters of Akko Local Government Area (Buba, Essoka and Musa, 2019). Maiganga lies within the Tropical Continental type of climate. It has both wet and dry seasons. Rainfall ranges from 850 mm to 100 mm every year. Temperature in the study area is relatively high for most part of the year (Oruoye, Musa and Ahmed, 2016). The mean maximum temperature is 37 ^{0}C from March to October, but reduces to 21^0C in December to February. Tangale, Jukun, Tula, Hausa and Fulani dominate the people in Maiganga. Maiganga has a population of about 3,520 according to 2006 National Population Commission census and projected using 3% growth rate to have 39,881.6 people in 2017. The major economic activities of the people among others are peasant farming with the cultivation of crops like maize, millet, rice, beans, sorghum, soya beans, ground nut, and guinea corn, among others, Also there is the practice of small scale open grazing because Maiganga coal mining activities has affected the natural vegetation cover around the environment in the study area (Buba, Essoka and Musa, 2019). The study area Maiganga

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coalmine is the major source of water pollution at Tudun Kuka dam. The coalmine was established in 2006. Full scale operations was in 2007 and in 2008 it started providing fuel coal to Ashaka cement factory at Bajoga. It has an estimated 4.5 million tons of coal to be mined to serve the factory for about the next 25 years and has about 2 million-coal reserve for future exploitation. Now, coal mining at Maiganga is done at industrial and large scale; which has the tendency to affect the environment; water, soil/land and air, with potential health hazard to humanity (Buba, Essoka and Musa, 2019).

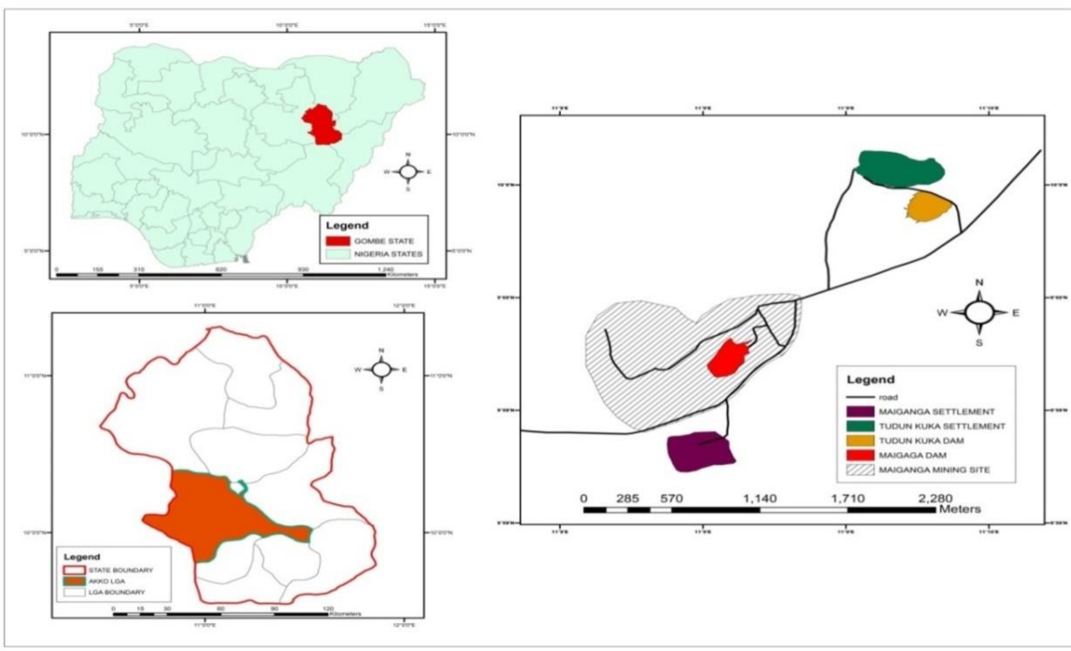

Fig. 1: Map of the Study Area
Source: Google Earth/ArcGIS analysis, 2019.

The plastic containers for collection of the water samples were thoroughly washed and sterilized to avoid contamination. The sterilized plastic containers were rinsed severally before collecting the water sample in the containers. Then 3 mls nitric acid were added into each collected water sample to avoid biochemical reaction that may likely occur before laboratory analysis. Each water sample was labeled for laboratory analysis. At the point of water sampling, the points at which water samples were collected in the dam were geo-referenced using a hand held

Geographical Positioning System (GPS). The water samples were taken to the laboratory for the determination of the considered heavy metals; Iron, Manganese, Copper, Zinc and Aluminum (Fe, Mn, Cu, Zn and Al) using standard analytical procedures for analysis. This was done at Federal Ministry of Water Resources, Department of Water Quality Control and Sanitation, National Water Quality Reference Laboratory Gombe, Gombe State. Each value of the considered heavy metals examined was compared with the permissible limits according to Food and Agricultural Organization (FAO, 2014) standards.

3. Results and Discussion

3.1 Concentration of Heavy Metals investigated examined in Tudun Kuka Dam reservoir

This section present the values of each heavy metal considered for the study for two sampled locations alongside with the FAO permissible limit Standard.

Iron (Fe): The results show that Iron was detected in both downstream (1.70 mg/l) and up-stream (1.91 mg/l) of the dam as could be seen in Table 1. However, the concentrations of Fe at both sampling locations were above the permissible/safety limit of 0.50 mg/l approved by FAO. The water is not safe for irrigation now because it indicates contamination by Fe. Some metals are carcinogenic in nature, heavy metals are generally non-biodegradable and if detected and consumed in high quantity can lead to health threat (Isirimah, 2000, Essoka *et al.*, 2006 and Essoka and Umaru, 2006).

Table 1: Concentration of heavy metals in Kudun-kuka Dam compared with FAO permissible standards for irrigation inthe Study Area

Parameters (mg/l)	Downstream		Upstream		FAO Standard limits
	Results	**Remark**	**Results**	**Remark**	
Manganese	0.94	BP	0.15	BP	0.20
Iron	1.74	AP	1.91	AP	0.50
Copper	0.00	BP	0.00	BP	0.01
Aluminium (Al)	0.14	BP	0.011	BP	0.20
Zinc	0.00	BP	0.005	BP	0.02

Source: Field survey and laboratory Analysis (2019).
NB: (AP = Above Permissible and BP = below permissible)

Manganese (Mn): Result in Table 1 shows that Manganese was detected in both the two sampling locations of the downstream (0.094 mg/l) and up-stream (0.15 mg/l) of the dam. Though, the concentration of Manganese in the two sampling locations was ere below the FAO permissible/safety limit of (0.20 mg/l). Since none of the sampled locations at the dam has Manganese concentration above the FAO safety limit, the water is permissible and considered good for irrigation at the moment (Essoka *et al*., 2006).

Copper (Cu): Copper was not detected in the two sampling locations in the dam; though, the FAO permissible/safety limit is 0.01 mg/l. Since none of the sampling locations had concentration of copper, the water could be safe and free from the effect of copper. Shahbaz (2015) observed that high copper content in water can affect crop production and can cause different diseases to man if consumed through food chain. Hence the water is safe and permissible for irrigation at moment.

Zinc (Zn): From results in Table 1, Zinc was only detected at the up-stream (0.005 mg/l) of the dam. The concentration of Zinc detected was below the permissible standard as approved by Food and Agricultural Organization safety limit of 0.02 mg/l. The result shows that concentration of Zinc even at the up-stream is not objectionable for irrigation and would not pose any health implication. Essoka and Umaru (2006) observed that excess of this metal if consumed through food chain can cause health implications in human.

Aluminium (Al): The result in Table 1 shows that Aluminum was detected in both the down-stream (0.14 mg/l) and up-stream (0.11 mg/l) of the dam. However, the concentration of Aluminum in the sampling locations was below the permissible/safety limit of 0.20 mg/l by Food and Agricultural Organization. Since none of the two sampled locations has Aluminum concentration above the recommended safety limit, the dam water would not be objectionable for irrigation purpose at moment.

Conclusion

Findings of the study indicate the presence of heavy metals in the study area. the result show that only the concentration of Iron was above permissible standard in the two sampled locations within the dam. Copper was not detected in the sampled locations. The concentrations of Manganese (Mn) and Aluminum (Al) were both below the permissible limit in the considered sampled locations. However, Zinc (Zn) was only detected at the up-stream (0.005 mg/l) of the sampled locations and it was below the FAO recommended safety limit of 0.02 mg/l, possible built-up may occur in future at the downstream of the dam. Therefore, Iron is the only heavy metal likely to stand the risk of water pollution in the dam due to the coal mining activities of Maiganga. This is because the values of Iron at downstream (1.74 mg/l) and up-stream (1.91 mg/l) were both above FAO safety limit of 0.50 mg/l.

Recommendations

Based on the results of the findings of the study, here are some suggestions, which include the need for regular monitoring of water quality analysis in the dam for 3-5 years in other to determine possible pollution of the dam water by heavy metals from the coalmines. Moreover, it is important and very necessary to have a follow-up water quality assessment of Iron concentration levels at the two sampling locations.

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