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Assessment of Metal Contaminants in River Kubanni Zaria, Nigeria

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Abstract: This study examines the levels of concentration of metal pollutants in river Kubanni and the health implications of these metal contaminants. The main sources of data for the study were sediments from long profile of the river and WHO guidelines for drinking water that were obtained from relevant literatures and internet. The samples were prepared and Instrumental Nitrogen Activation Analysis (INAA) was adopted in the analysis of the data using Nigerian Research Reactor - 1 (NIRR-1). Twenty nine metal contaminants (Mg, Al, Ca, Ti, V, Mn, Dy, Na, K, As, Br, La, Sm, Yb, U, Sc, Cr, Zn, Fe, Co, Rb, Cs, Ba, Eu, Lu, Hg, Ta, Sb and Th) were identified in the river. The safety levels of the metal contaminants were examined by comparing the obtained values with WHO guidelines for domestic water and it was observed that the river is getting polluted by Al, Mn, As, U, Cr, Fe, Co, Zn, Ba, Na and Sb with severe health implications on the consumers of the river Kubanni water. The levels of concentration of Mg, Ca, Ti, V, Dy, K, Br, La, Sm, Yb, Sc, Hg, Ta, Rb, Cs, Eu, Lu and Th are also high, although there is no WHO standard for comparison, some of these metals are suspected to be harmful to humans when consumed in excess quantity.

Keywords: Carcinogenic, earth elements, human, metal contaminants, pollution, river Kubanni

INTRODUCTION

Environmental pollution is one of the popular subjects of research at present time. Most industrial and municipal wastes end up in rivers, lakes and the sea, therefore the idea of continuous monitoring of water quality receives global attention. Water pollution is the introduction of harmful elements into water bodies. Such harmful elements include toxic elements or undesirable ions and compounds in solution in water and this type of water pollution is called chemical pollution. The release of disease producing bacteria and viruses (pathogens) into the water changes its taste and smell and this is biological pollution (Abegunde *et al*., 1991).

Pollution greatly reduce the quality of water available for most purposes, it is also very dangerous to both man and aquatic organisms. Most researchers in aquatic system have been concerned with the form of contaminants present rather than the amount of potential toxic materials bound up in the water e.g., chemical elements (metals) with low concentration are undoubtedly the most difficult to study because their background levels are always present in the environment making their presence and perturbation on an ecosystem could bring about rapid increase in the rate of synthesis of these chemical eelements (Hankouraou, 1998). The potential impact of chemical elements or metals in water for human consumption cannot be overstressed.

Water supply and incidences of water contamination have been a major concern in all parts of the world. Okafor (1985) is of the view that the type and incidence of water borne disease vary according to the socio-cultural back ground and levels of economic development of a country. It is a common practice in Nigeria today to find hawkers and roadside traders contributing tremendously to the deplorable stage of cleanliness in our environment, especially in cities. Tin cans used for packaging processed food, sweet wrappers, papers and polyethylene bags of the so-calledd “pure water” litter the street. Roadside mechanics also empty their oils and lubricants indiscriminately into open spaces and gutters. Most of these wastes often find their way into drainage gutters and finally end up in rivers and dams. Ademoroti (1988) observed that the discharge of untreated or incompletely treated wastes containing algae, nutrients, non-biodegradable organic, metals and other toxicants will hasten deterioration of receiving water bodies such as rivers, lakes or dams it is therefore very necessary to study the levels of concentration of metal contaminants in our rivers that are used for domestic purposes.

Chemical elements are introduced into aquatic systems as a result of the weathering of soils and rocks from volcanic eruptions and from a variety of human activities involving training, processing, or use of metals or substances that contain metal pollutants. The most common metal pollutants are arsenic, cadmium, chromium, copper, nickel, lead and mercury. There are

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different types of sources of pollutants; point source or localized pollution is where pollutants come from single identifiable sources. The second type of pollutant sources are non-point sources or diffuse pollution where pollutants come from dispersed sources and often difficult to identify sources (Lentech, 2006). The main threats to human wellbeing are associated with lead, arsenic cadmium and mercury pollution (UNEP/DENA Earth Watch, 2006).

The problem of water pollution as a result of dumping chemicals into rivers and lakes has reached a hazardous level especially in developing countries. Several chemicals and organic wastes are drained into our water ways indiscriminately. The Kubanni River also suffers from these effluents. Chemical elements are known to be carcinogenic and fatal. Metals are generally dangerous to living organisms especially man because of their bioaccumulation nature. They accumulate in living things any time they are taken up and stored faster than they are metabolized. Increased technology has lead to rapid industrialization and by implication increased pollution in the environment and thereby exposes man to environmental risk. Ezekanagha (1999) is of the view that the Lagos environment and its inhabitants run the risk of been poisoned in the short or long term by metals such as nickel, cadmium, manganese and copper which are discharged as effluents in to the environment mostly by the numerous small-scale industries which hardly treat their wastes.

The rate of increase in level of concentrations of metal contaminants in domestic water is highly worrisome. Butu (2002) reported the presence of lead, chromium and cobalt in significant concentration above WHO permissible limit in the Galma River. He is of the view that the levels of concentration of these metals are on gradual increase compared to the previoust studies due to land use and other anthropogenic activities in the basin. Since the Kubanni basin has similar characteristics with the Galma, it is therefore necessary to assess the levels of the metal contaminants in the Kubanni water way periodically to ascertain the health implication of the metals.

The study area: The study area is the Kubanni River in Zaria, Kaduna state Nigeria. The Kubanni River takes its source from the Kampagi Hills in Shika near Zaria. It flows in a Southeast direction of Ahmadu Bello University. The Kubanni river flows Southwards in a total length of 21 km into river Galma (Lat 11° 59.77”N 11° 08” 29.77N and longitude 07° 34”0.59-0.84”E-07° 41’ 59.84”E). The Kubanni catchment area belongs to the Northeastern part of Kaduna river basin which borders the Chad basin. It is located within the Central High Plains of Northern Nigeria Savanna region at approximately 670 m above sea level (Yusuf, 1992).

The Kubanni river flows through several research institutions such as Ahmadu Bello University Teaching Hospital, (ABUTH), College of Agriculture Samaru, Centre for Energy Research and Technology (CERT) and Nigeria College of Aviation Technology as well as several rural and urban settlements such as Zango, Palladan, Kwangila, GRA, PZ, Tudun Jukun and Tudun Wada. The Kubanni catchment area lies within the tropical wet and dry climatic zone characterized by strong seasonality and temperature distribution. The study area experiences an average of six to seven raining months from Mar/April to October/November and five to six dry mmonths usually from November to March. The geology of the area is composed mainly of fine grain gneisses and migmatite with some coarse-grained granitic outcrops in few places. The depth of weathering is irregular but thorough, the depth ranges from 10 m to deep pockets occasionally extending to about 60 m (WAPDECO, 1991).

Generally the soil of the Kubanni basin is classified as leached ferruginous tropical soil developed on ragolith rich in fine grain quartz and oligoclass. The basin soil is shallow and often less than 1 m deep and usually underlain Kubanni by lateritic formations. The Kubanni River is one of the main tributaries of Galma River; it has its headwaters from Kampagi Hills and flows into the Galma River near Tudun Wada Zaria. The River is a seasonal stream flowing at full capacity during the raining season with little surface water along stretches of the river channel in the dry season. The Kubanni basin lies in natural zone known as the northern guinea savanna. The zone is characterized by savanna vegetation but cultivation, bush burning and grazing activities have greatly modified the natural vegetation cover and composition. The entire vegetation and soils of the study area have been under great anthropogenic influences. The present day land use has been categorized into “gari” (urban) and rural land use.

MATERIALS AND METHODS

Primary and secondary data were used for this study. The primary data were sediments from four distinctive sections along the long profile of river Kubanni Zaria, Nigeria. The sediments samples for this study were collected from 1 January to 4 October 2008. The secondary sources of data used were the WHO guidelines for domestic water, WHO (2008) and materials from other relevant literatures and internet.

The sediment samples were obtained at each sampling points along the river Kubanni, they were prepared in the laboratory and finally analyzed. The Certified reference materials IAEA-SL-3 (sediment) was used to determine the calibration factors for all the elements. The Instrumental Nitrogen Activation Analysis (INAA) technique was adopted in the analysis of the data using Nigeria Research Reactor -1 (NIRR-1). The Nigeria Research Reactor-1 is Miniature Neutron Source Reactor (MNSR); it is a low power nuclear reactor which has high enriched uranium as fuel, light water as moderator and beryllium as a reflector.

To analyze the data, two irradiation schemes were adopted based on the half life of the product radionuclide, For elements leading to short-lived activation product they were irradiated in the outer channel B4, where the spectrum is soft. For elements leading to long-lived activation products samples were irradiated for six hours in the inner irradiation channel. Following the short lived irradiation regime the first counting was done for 10 min after a waiting time of 2-5 min. The second round of counting was carried out for 10 min after a waiting period of 3-4 h. In the long irradiation regime the first round of counting was carried out for 30 min after a waiting time of 4-5 days. The second counting was performed for 60 min after a cooling period of 10-15 days. Finally, the identification of gamma-ray of product radio nuclides through their energies and qualitative analysis of their concentrations were obtained by using the gamma-ray spectrum analysis soft ware, WINSPAN 2004.

RESULTS AND DISCUSSION

In order to examine the safety levels of the metal contaminants that are identified in river Kubanni, the mean value of each of the metals that were found in the entire river was compared with WHO guidelines for drinking water as shown in Table 1. The table shows that there are no existing guidelines for Mg, Ca, Ti, V, Dy, K, Br, La, Sm, Yb, Sc, Rb, Cs, Eu, Lu, Hg, Ta and Th. The existing WHO (2008) guideline for Al is 0.2 ppm and mean concentration of Al in the river is 4000 ppm, the permitted standard for Ca is 0.5 ppm and river Kubanni has 247.75 ppm, the standard for Na is 200ppm and the concentration in the stream is 2100 ppm. The guideline for As is 0.01 ppm and the value in the river is 2.02 ppm, The level of concentration of U in the river is 5.49 ppm against the 1.4 ppm WHO standard, Cr concentration in the river is 24.6 against 0.05 ppm WHO standard, Fe level of concentration in the stream is 16500 against 0.3 ppm WHO standard, Co is 4.17 against 0.05 ppm WHO standard, Zn is 103.66 against 5.0 ppm WHO guideline. Ba level of concentration in the river is 402.06 against 0.3 ppm WHO standard and Sb is 1.36 against 0.005 ppm permitted by WHO standard.

Table 1: Comparisons of the observed values of levels of concentration of metals in river Kubanni with the World Health Organization (WHO) standard/guideline

Element/metal		Mean value (PPM)	Who standard (PPM)
Magnesium	Mg	2800	NG
Aluminium	Al	4000	0.2
Calcium	Ca	4200	NG
Titanium	Ti	2900	NG
Vanadium	V	35.35	NG
Manganese	Mn	247.75	0.5
Dysprosium	Dy	6.34	NG
Sodium	Na	2100	200
Potassium	K	19900	NG
Arsenic	As	2.02	0.01
Bromine	Br	0.99	NG
Lanthanium	La	37.51	NG
Samarium	Sm	29.64	NG
Yittarbium	Yb	5.86	NG
Uranium	U	5.49	1.4
Scandium	Sc	3.64	NG
Chromium	Cr	24.64	0.05
Iron	Fe	16500	0.3
Cobalt	Co	4.17	0.05
Zinc	Zn	103.66	5.0
Rubidium	Rb	121.72	NG
Caesium	Cs	3.71	NG
Barium	Ba	402.06	0.3
Europium	Eu	0.83	NG
Lutetium	Lu	0.68	NG
Hafnium	Hf	18.88	NG
Tantalum	Ta	2.06	NG
Antiniony	Sb	1.36	0.005
Thorium	Th	21.44	NG

NG: No Guideline; WHO (2008) and Fieldwork (2008)

The result of the analysis therefore shows that river Kubanni is becoming increasingly contaminated by metal pollutants with dire consequences on the consumers of its water on the long run. Some metals such Mg, Fe, Ca and Zn are essential micro nutrients, they are essential to life in the right concentrations, but in excess they chemicals can be poisonous. Al in drinking water above WHO standard can constitute some complications such as Alzheimer's disease and head trauma (Niefor *et al*., 1995). Chronic exposure to excessive Mn level can lead to a variety of psychiatric and motor disturbance termed manganism (Wikipedia, 2010). WHO (2008) reports that consumption of elevated levels of as through drinking water is casually related to development of cancer at several sites in the human body.

IPCS (2001) is of the view that long term exposure to As in drinking water is usually related to the increase risk of cancer in the skin, lungs, bladder and kidney as well as other skin changes such as hyperkeratosis and pigmentation changes.

Argonne National Laboratory Evs (2005) reports that elevated intake of U results to life time cancer and finally death. It is a radioactive element that occurs naturally in low concentrations in the geologic formation, surface and ground water. Chromium often accumulates in aquatic life adding to the danger of eating fish that many have been exposed to high level of Cr. Lentech (2006) observes that low exposure to Cr can irritate the skin and cause ulceration and that long term exposure can cause kidney and liver damage and damage to circulatory system. Fe is known to be essential to humans but high concentration in domestic water may cause turbidity or stain on plumbing fixture, laundry and cooking utensils, it may also impact objectionable taste or color to foods and drinks but has little direct and adverse health implications on humans (Zhang, 1993).

Co is a natural earth element present in trace amount in the soil. MOE (2001) reports that the toxicity of Co is low compare to other metals in the soil, however exposure to very high levels of Co can be carcinogenic to humans because the metal accumulates into human muscles or under skin, Zn is a dietary mineral for human and animals, however overdoses above WHO guideline may negatively influence human and animal health, Zn toxicity may cause nausea, vomiting, dizziness, colic fever and diarrhea (Lentech, 2006). Excessive intake of Ba is known to have gastrointestinal discomfort in humans (Francis and Forsyth, 2010). Exposure to high levels of Sb for short time may cause nausea, vomiting and diarrhea and exposure for long time is suspected to be carcinogenic for humans (Lentech, 2009). Commercially, Na is the most important of all alkaline metals; it is abundant in the earth crust. Na is necessary for human, but overdose can damage kidney and increase chance of high blood pressure.

There are no WHO guidelines on some of the metal contaminants that are present in the river, probably because of the impossibility of these metals to reach dangerous concentration levels in water due to their insolubility or scarcity before, however there are evidences to show that they could be toxic to human when consumed in excess quantity in water constantly (Lentech, 2009). Mg has no evidence of any systemic poisoning although persistent over indulgence in taking Mg can lead to muscles weakness, lethargy and confusion (Lentech, 2009). Ca occurs in water naturally, Ca compounds such as calcium phosphide is very toxic to aquatic organisms (Lentech, 2009). Elemental Ti and Titanium dioxide is of low order of toxicity, however excessive exposure in human may result in slight changes in the lungs (Lentech, 2009).

Dy is a rare earth metal which is not found in naturale as free elemint, but in mixture with other minerals. The level of concentration of Dy is high in the stream but there is no WHO standard for comparison. Dy nitrates are mildly toxic but high levels of concentration of Dy could be fatal to human (Webster Online Dictionary, 2006). K is an essential mineral nutrient in human nutrition, but individuals suffering from kidney diseases may suffer adverse health effects from consuming large quantity of dietary K (Wikipedia, 2010). Acu-Cell Nutrition (2012) reports that low intake of Br could lead to seizures, insomnia, agitation, irritability and hyperthyroidism and high dose could lead to drowsiness, fatigue, nausea, vomiting, ace, skin, rash, blurred vision, dizziness, mania, pancreatitis, coma, hallucination, increased thirst, hunger, urination, poor memory and hypothyroidism. La also has no WHO guideline for comparison. It is one of the rare earth elements but over dose could be harmful to humans (Yongxing *et al*., 2000). Samarium is not free in nature, but like other rare earth elements samarium compounds are of low toxicity, when ingested only 0.05% of samarium is absorbed into the bloodstream and the remainder is excreted (Wikipedia, 2012).

Silber (2010) is of the view that Yb compounds are known to cause skin and eye irritation and may be carcinogenic. Scandium has no biological role, it is not toxic, although it is suggested that its compounds in excess levels might be carcinogenic (Lentech, 2009). Rb is particularly not harmful to humans because once it is taken in the body its ions are rapidly excreted in sweat and urine (Senthilingan, 2010). Cesium compound can cause hyper irritability and spans, although the metal is not commonly found in nature (Wikipedia, 2010). Eu has no biological importance but its salts could be mildly toxic by ingestion, its toxicity has not been fully establishment (Lentech, 2009). Lutetium is also known to be mildly toxic, although its insoluble salts are non toxic (Lentech, 2009). Hf has high levels of concentration in river Kubanni but there is no WHO standard for comparison and there has been no established effect of this metal on humans (Lentech, 2009).

Ta was discovered by Anders Ekerberg in 1802, Ta is said to be irritating to mucous membranes, upper respiratory track and also cause eyes and skin irritation when injected (Lentech, 2009). Th is known to be harmful to human because it is a radioactive element and can cause bone cancer in humans after many years of exposure in large quantity (Lentech, 2009). This metal has considerable level of concentration in river Kubanni.

CONCLUSION

The study has looked at the level of contamination of river Kubanni and it is observed that the river is getting polluted with twenty nine metal pollutants in various levels of concentration. The chemical pollutants

identified in the stream are Mg, Al, Ca, Ti, V, Mn, Dy, Na, K, As, Br, La, Sm, Yb, U, Sc, Cr, Ba, Eu, Lu, H8, Fe, Co, Zn, Rb, Cs, T, Sb and Th. It is observed that the levels of concentration of Al, Mn, As, U Cr, Fe, Co, Zn, Na, Ba and Sb are high above acceptable limits for safe drinking water, meaning that the river is becoming polluted with these metals, while Mg, C, Ti, V, Dy, K, Br, La, Sm, Yb, Sc, Rb, Cs, Eu, Lu, Hg, Ta and Th also have high levels of concentration, although there are no WHO guidelines, however some of these metals are known to have some toxic effects to human when consumed in excess levels over a long period. Most metals are known to be carcinogenic to humans because of their bioaccumulation characteristics.

RECOMMENDATIONS

To protect the Kubanni River and other water resources meant for human consumption from contamination by chemical pollutants, this study makes the following recommendations:

- Fluvial geomorphologic routing techniques should be used for upslope tracing of the metal contaminants. This will enable the Researchers to identify the sources of the chemical pollutants entering the river and check them immediately.
- The indiscriminate discharge of refuse which litter the built up area of the Kubanni and other catchment areas be discouraged by the Government because most of these substances in the dumps. An acceptable method of sanitary land fill should be introduced.
- The unhealthy practices such as discharging of engine oil, petrol, used batteries, used bulbs; grease, training and salon effluents into public drains which finally end up into the rivers should be discouraged. Government should rather organize collection system of waste lubricant which can be recycled if possible.
- Government should provide necessary vehicles for regular evacuation of all refuse dumps that are commonly seen in our cities.
- The use of toxic chemicals for farming should be controlled.

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