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AN ANALYSIS OF SAFETY LEVEL OF METAL CONTAMINANTS IN RIVER HADEJIA CATCHMENT, KANO REGION, NIGERIA

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ABSTRACT

The aim of this study is to analyze safety level of some metal contaminants in water in River Hadejia. Water samples were collected using manual method (simple grab method). Multiple samples were taken systematically and span for ten months to cover dry and rainy seasons using stratified systematic sampling technique. The parameters considered for laboratory investigation were trace and toxic metals. Atomic Absorption Spectroscopy (AAS) technique was used for analysis of the water samples. Descriptive statistics (Mean) was used on the data to examine the concentrations, comparisons of the data obtained from the study and the standards. The WHO (2011) and NSDWQ (2007) guidelines for drinking water quality were used as standards to compare with the laboratory analyzed values. The findings show that the level of concentration of some metals Mg (3.80mg/l against 0.2mg/l); Cr (0.53mg/l against 0.05mg/l); and Pb (2.53mg/l against 0.01mg/l) were above the WHO (2011) and NSDWQ (2007) standards which indicates that River Hadejia shows evidence of metallic contaminants. The sources of many chemical elements were linked to the geologic formations, weathering processes and anthropogenic activities. It is recommended that there should be continuous periodic water quality assessment of the river because of the dynamic nature of human activities taking place in the watershed, for efficient planning and management of our surface water resources.

Key words: *River, Contaminants, Water samples, AAS, Safety level*

INTRODUCTION

Catchment management aims to decrease the amount of contamination that enters the water resource, thereby reducing the amount of treatment that is required to supply safe and clean water. Catchment management is critical in the execution of WSPs (WHO, 2004). The rapid increase in world population, which has led to increase in developmental activities such as increase in industrial production, increase in agricultural activities and urbanization, there has been an increase in waste generation from industrial, agricultural, and domestic sources. All these wastes end up directly or indirectly in rivers and streams which serve as sources of water supply for communities. When consumed or used, such water can have adverse effects on the health of the community or individual users. This justifies the need for continuous water quality evaluation of our water bodies such as streams, rivers and lakes in order to determine the true nature and quality of the water body and to identify the source region of the pollutants. Pollution of the natural environment by heavy metals is a universal problem because these metals are indestructible and most of them have toxic effects on living organisms, when permissible concentration levels are exceeded (Mmolawa, et al, 2011; Omenesa, 2011; Bichi, et al, 2015). The presence of some toxic metals in our rivers is posing a serious challenge to our society. Though some of such metals occur naturally (as a result of geological processes like weathering, leaching), others occur due to some human activities (like mining, industrial, and agricultural discharges) (Bichi, et al, 2009; Lentech, 2011; Nistha, et al, 2012).

The Hadejia river catchment is the main source of domestic water supply for all the water treatment facilities serving urban Kano and other important towns and villages. The Challawa, Tamburawa I and II, Wudil as well as Hadejia water treatment plants are all located in this basin. It also provides water for irrigation in the Kano River Project (KRP) and Hadejia Valley Irrigation Project where thousands of tons of agricultural produce like rice, wheat, sugarcane, maize and variety of vegetables (tomato, onions, and pepper) are cultivated for the nation at large. Fishing and other water contact activities are also very prominent within this basin. This same basin also houses the functional industrial estates of Sharada (Phases I, II and III), Challawa, and Zaria road industrial areas. All of the industries ranging from tanneries, textiles, chemical and rubber, to food and beverages discharge their effluents into this catchment. The southern part of the Kano metropolitan is also drained by this river basin. With all these human activities within this river basin, it is strongly suspected that effluent discharges, sewage, washed and eroded materials from the upstream watershed are emptied into this catchment which prone the river basin to pollution. Therefore, the need for continuous and routine monitoring for periodic assessment of pollutants, especially chemical contaminants in the entire basin is of paramount importance. Out of all pollutants of water, metals pose the greatest threat to man and the environment because these chemical elements are not only difficult to remove from raw water by conventional treatment processes, they are also carcinogenic (Gower, 1980). This study established some findings that will be useful to land use management in the drainage basin.

Geography of the Study Area

The area covered by this study is covered by longitudes and latitudes E 8^{0}07’50.0’’ N 11^{0}32’08.4’’ and E10^{0}01’50.9’’ N 12^{0}26’24.8’’ (which extend up to Jigawa State refer to Table 1 and Figure 1). Urban Kano or Kano metropolis is located between latitudes 11^{0}50’N to 12^{0}2’N and longitudes 8^{0}22’E to 8^{0}40’E. The study covers the long profile of the Hadejia river which covers the southwestern tip of Kano, the western tip near the source of the Challawa system, and the extreme northern tip of Jigawa state. The Hadejia River catchment covers an area of about 32,900 km^{2} (Sobowale *et al*, 2010).

Table 1.0: Geography of the Sampling Points

Sampling Points	Type of Land use/Discharge	Relative Location	Longitude	Latitude	Elevation (m)
KNRS01	Residential	Gyadi-Gyadi behind AKTH	E 8^{O}31’29.0’’	N1 1^{O}57’48.7’’	479
KNRS02		Kumbotso near Works	E 8^{O}30’15.0’’	N1 1^{O}53’01.3’’	454
KNIN01	Industrial	Sharada near Freedom Radio	E 8^{O}30’39.9’’	N1 1^{O}57’34.0’’	466
KNIN02		Challawa behind Cocacola	E 8^{O}28’19.7’’	N1 1^{O}53’08.9’’	449
KNAI01	Agricultural (Irrigated)	KRP near DanHassan, Kura	E 8^{O}31’42.3’’	N1 1^{O}46’24.8’’	430
KNAI01		Hadejia near bridge1	E10^{O}01’50.9’ ’	N12^{O}26’24.8’’	363
KNAC01	Agricultural (Cultivated)	Dukku near Yaryasa	E 8^{O}18’08.6’’	N1 1^{O}20’47.9’’	531
KNAC02		Yakasawa near Ringim	E 9^{O}10’07.4’’	N1 2^{O}07’35.4’’	396
KNAF01	Agricultural (Forested)	Dansoshiya Forest near Dangora	E 8^{O}07’50.0’’	N1 1^{O}32’08.4’’	559
KNAF02		Falgore Game Reserve near Doguwa	E 8^{O}36’55.8’’	N1 1^{O}01’03.9’’	590
KNRW	Raw Water (before treatment)	Raw water intake at Tamburawa (WTP)	E 8^{O}30’44.7’’	N1 1^{O}50’32.6’’	435
KNTW	Treated Water (before distribution	Treated water at Tamburawa (WTP)	E 8030/52.1//	N1 10^{0}50'52.2"	433

Source: Bichi, A. A. 2016

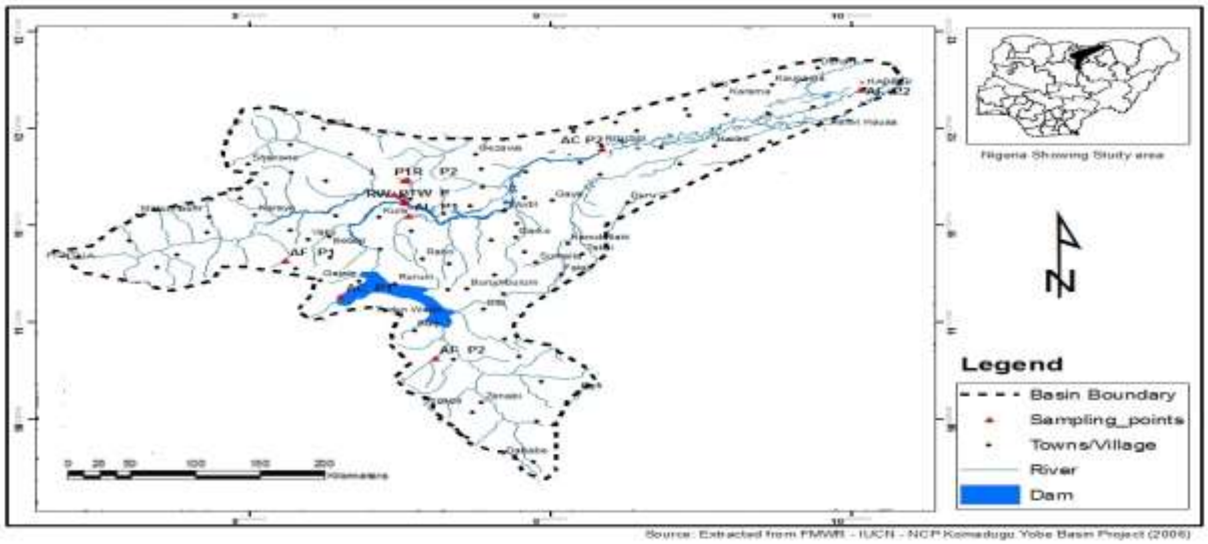

Fig. 1.0: Map of the study area showing sampling points

MATERIALS AND METHODS

A preliminary survey was conducted in order to get acquainted with the study area, with a view of selecting the sampling points. Various land-use activities were identified before deciding on where to obtain the samples. ST 2276 GPS was used to determine the absolute location as well as the elevation of each point above sea level. Various anthropogenic (land-use) activities were identified before deciding on where to obtain the samples. From the field study, major land use types in the study area were identified as the ways through which man tampers with the quality of water resources especially in urban areas. Twelve sampling points were selected using stratified systematic sampling frame based on Land use variation along the long profile of River Hadejia and their spatial location is shown in Table 1 and Figure 1. The sampling period was divided into dry and wet season.

Water Quality Criteria:

One very important aspect of water quality considered for laboratory investigation is chemical contaminants. This is because trace elements (metals) are potentially toxic and disastrous when present in water even in minute concentration. They are not easily detected and removed by the traditional water treatment facilities, the selected parameters were selected due to their health implication. Atomic Absorption Spectroscopy (AAS) technique was used for the analysis of the water samples. The choice of the AAS method for the quantitative determination of heavy metals in the water samples is because it is sensitive, specific, simple and relatively inexpensive.

Samples Handling and Treatment:

The water samples were collected throughout the sampling period using manual method (simple grab method). Multiple samples were obtained using stratified systematic sampling technique for about eleven months based on difference in human (land-use) activities. Precaution taken during sampling to minimize any external contamination of the samples with metals. This is very important for trace metal analysis as there are many metal containing materials (e.g. dust, car exhaust particles, rust) on the field and laboratory that may contaminate samples (Ajai *et al.*, 2011). The sample bottles (plastic made) were washed with detergent; cleaned and rinsed with distilled water. At the sampling sites, the bottles were rinsed twice with the water to be collected as sample thoroughly, and each bottle was dipped in to the river and the sample collected from below the surface water. The standard procedure of sample description and identification as prescribed in MARLAP, (2004) were used.

Laboratory Techniques and Data Analysis

The Atomic Absorption Spectroscopy (AAS) technique was used to determine the level of concentrations of the selected chemical elements in the water. The Multi-User Science Research Laboratory (MUSRL) Ahmadu Bello University, Zaria was used for the AAS analytical technique. The AAS analyses the concentration of elements in a liquid sample based on energy absorbed from certain wavelengths of light (usually 190 to 900 nm). The principle of AAS is that determinant atoms in a non-emitting ground state will absorb light of a characteristic resonance wavelength. The extent of absorption will increase as the number of atoms increases. The light source is selected so that it emits only the atomic spectrum of the chosen elements. Hollow- cathode lamps (HCLs) are usually employed; the light emitted by the lamp is modulated, either by operating the lamp on a pulsed power supply or by using a mechanical chopper prior to entry of the beam into the atom cell. The choice of the AAS method for the quantitative determination of heavy metals in the water samples is because it is sensitive, specific, simple and relatively inexpensive.

To assess the safety levels of these metals by comparing their concentration with the WHO (2011) and NSDWQ (2007) permissible limits for drinking water. To achieve this objective, the results obtained through laboratory analysis were compared with the Standard Guidelines by WHO and NSDWQ for drinking water. The comparison was used to examine the safety level of the river (within or outside the set limit).

RESULTS AND DISCUSSION

The results obtained from laboratory analysis using AAS were compared with the Standard Guidelines by WHO and NSDWQ for drinking water. The comparison determined the safety level of the river (within or outside the set limit). The mean value of each metal that was found in the river was compared with the standard guideline values of WHO (2011) and NSDWQ (2007). Using AAS technique, the Table 2.0 shows the comparison of the mean value of the 11 elements with the WHO (2011) and NSDWQ (2007) guidelines.

Table 2.0 shows that there are no established standard (WHO) guidelines for some metals like Mg, Ca, Mn and Zn, and there are also no established NSDWQ (2007) guidelines for Ca, and Co. The table shows that the levels of concentration of Mg, Cr, Fe, Cd and Pb are above the permissible limits set by both WHO (2011) and NSDWQ (2007) standard guidelines for drinking water. Mn mean concentration is within the acceptable limit of WHO (2011) but outside the NSDWQ (2007) standard guidelines. The mean concentration of Zn and Ni in the surface water of Hadejia river are within the WHO (2011) standard guidelines; Co mean concentration is 0.00 mg/l though there is no established WHO (2011) and NSDWQ (2007) standard guidelines for Co. This indicates that River Hadejia is fast becoming polluted with these contaminants that are outside the permissible standard guidelines of both WHO (2011) and NSDWQ (2007). Also, Ca do not have established WHO (2011) and NSDWQ (2007) standard guidelines as well. The presence of these metals above the permissible standard guideline limits in the surface water of Hadejia river will lead to negative consequences on both human beings and the environment.

Table 2.0: Comparison of Mean Concentration (mg/l) of Metals in the surface water in the Hadejia river obtained from AAS technique with the WHO (2011) and NSDWQ (2007)

Location	Mean (mg/l)										
	Mg	Ca	Mn	Cr	Fe	Co	Zn	Cd	Ni	Pb	Cu
Challawa	7.22	79.62	0.38	4.09	2.14	0.00	0.23	1.02	0.00	3.89	0.03
Dansoshiya	3.45	5.64	1.71	0.11	7.11	0.00	0.04	0.79	0.01	2.84	0.01
Dukku	2.55	5.34	0.12	0.67	4.42	0.00	0.02	1.22	0.00	13.30	0.01
Falgore	3.35	6.62	1.07	0.12	3.22	0.01	0.01	1.35	0.00	1.60	0.01
Gyadi-Gyadi	5.10	22.22	0.25	0.20	1.28	0.00	0.05	0.73	0.01	2.00	0.00
Hadejia	2.70	3.02	0.04	0.14	4.98	0.01	0.01	0.88	0.00	0.52	0.01
KRP (D/Hsn)	2.55	3.93	0.13	0.14	2.96	0.01	0.01	1.07	0.00	0.83	0.01
Kumbotso	3.44	14.78	0.18	0.14	2.01	0.00	0.06	1.27	0.01	0.90	0.01
Raw water	2.38	2.28	0.16	0.10	5.20	0.00	0.02	1.17	0.00	0.55	0.01
Sharada	7.71	40.59	0.18	0.37	1.29	0.01	0.05	0.51	0.07	2.97	0.05
Treated water	1.71	32.78	0.04	0.10	0.34	0.00	0.23	1.33	0.00	0.49	0.01
Yakasawa	3.42	1.44	0.14	0.15	4.48	0.00	0.02	0.71	0.00	0.51	0.01
Total Mean	3.80	18.19	0.37	0.53	3.29	0.00	0.06	1.00	0.01	2.53	0.01
NSDWQ Standard	0.2	NG	0.2	0.05	0.3	NG	3.0	0.003	0.02	0.01	1.0
WHO Standard	NG	NG	NG	0.05	0.3	NG	NG	0.003	0.07	0.01	2.0

Source: Fieldwork, 2013; WHO (2011) and NSDWQ (2007) NG = No Guideline

Implication of Metal Contaminants on the Quality of Water in River Hadejia, Kano Region:

From the results of the AAS analytical technique, the chemical contaminants exceeding the established local and international standard guidelines for domestic uses have been determined. The Human health implications of each chemical contaminant and the concentration level is presented as follows:

Magnesium (Mg): From Table 2.0, the total mean concentration of Mg in the Hadejia river is 3.80 mg/l, while the recommended permissible limit is 0.2 mg/l by NSDWQ (2007). This shows there is serious Mg pollution in the River Hadejia. Concentrations above the permissible limits, may pose some problems of health concern. Lentech (2009) asserts that though there is no evidence that magnesium produces any systemic poisoning, persistent over indulgence in taking Mg may lead to muscles weakness, lethargy and confusion.

Calcium (Ca): From the Table 2.0, the mean concentration of Ca in the Hadejia river is 18.19 mg/l. There is no established standard guideline both WHO (2011) and NSDWQ (2007) probably because it is not of health concern at levels found in drinking water. Calcium is to known to have a positive health value. It is one of the constituent of metals needed for strong bone formation.

Manganese (Mn): From the Table 2.0, the mean concentration of Mn in River Hadejia is 0.37 mg/l which indicate manganese pollution. According to the NSDWQ (2007) standard guideline, it should not exceed 0.2 mg/l, but there is no guideline in WHO (2011), and major reason for not establishing a guideline value could be that it is not of health concern at levels found in drinking water, but according to our National standard guideline NSDWQ (2007) it has health impact of leading to Neurological disorder when the standard guideline limit is exceeded. This shows that there is Mn pollution in River Hadejia catchment. According to Duffus (1980) excessive concentrations of Mn is toxic. It causes cramps, tremors and hallucinations, manganic pneumonia and renal degeneration.

Chromium (Cr): From the Table 2.0, the mean Cr concentration is 0.53 mg/l which indicates that there is serious chromium pollution in the River Hadejia catchment. All the sampling points (various land use points) recorded values far above the permissible limits for both WHO (2011) and NSDWQ (2007), which is 0.05 mg/l. According to Duffus (1980), chromates are soluble and toxic in water, and may cause various diseases such as lung cancer, irritation to eyes, nose, and throat. Chronic exposure may lead to liver and kidney damage. A characteristic effect on human beings is the appearance of perforations in the nasal septum. At the cell level it appear that hexavalent chromium (Cr^{6+} the most toxic) may cause chromosome abnormalities. According to Hughes (2005) the respiratory system is the major route of chromium absorption. A common renal symptom associated with the ingestion of chromium is acute tubular necrosis (ATN); Cr is recognized as a contact allergen and carcinogen (cancer of the lung) .

Iron (Fe): From Table 2.0, the mean concentration of Fe in River Hadejia is 3.29 mg/l, this clearly shows that there exist iron pollution throughout the river catchment. The standard guidelines for both WHO (2011) and NSDWQ (2007) for Fe is 0.3 mg/l. Though it is an essential micronutrient in trace quantities for most organisms, but ingestion in excessive amounts may result in inhibition of activity of many enzymes. In some forms, it can react with sulphide in the presence of water to produce sulphuric acid thereby increasing the acidity of the water and decrease the oxygen content of the water. In excess concentration, it may lead to liver and cardiovascular damage; if inhaled, silicosis-like symptoms (Hughes, 2005).

Cobalt (Co): From Table 2.0, the mean concentration of Co in the River Hadejia is 0.00 mg/l, this shows that the concentration is low compared to other metals in the river. There is no established standard guideline of both WHO (2011) and NSDWQ (2007) probably because it is not of health concern at levels found in drinking water. Its toxicity is quite low compared to other metals in the river, however exposure to very high concentration can be carcinogenic to human because the metal can accumulate into the human muscles or under the skin (Butu and Bichi, 2013); it may be associated with polycythemia and cardiomyopathy (Hughes, 2005).

Zinc (Zn): From Table 2.0, it can be observed that there is no Zinc pollution in River Hadejia since the mean concentration is 0.06 mg/l which is very low value compared to the permissible limit as according to NSDWQ (2007) of 3.0 mg/l. According to the WHO (2011), though Zn may affect acceptability of drinking water, the major reason for not establishing a standard guideline is that it is not of health concern. Zn is generally considered as a less hazardous element, but its toxicity may be enhanced by the presence as impurity of some toxic metals like arsenic, lead, cadmium and antimony. Due to its toxic effects at certain concentrations, it is not recommended to store food in zinc or galvanized containers but acceptable for drinking water. This is because acidic foods can dissolve enough zinc to cause poisoning. The risk of Zn poisoning is minimize because it appears to be lost along food chains, unlike methyl-mercury or cadmium, for example which accumulate (Duffus, 1980).

Cadmium (Cd): From Table 2.0, the mean concentration of cadmium in River Hadejia is 1.00 mg/l this shows a serious cadmium contamination in the river. Both WHO (2011) and NSDWQ (2007) standard guidelines for Cadmium in drinking water are 0.003 mg/l. It is highly toxic even at low concentration, and can create mutations in the organisms Emre *et al.*, (2013). According to Lentech (2011); WHO (2011) and NSDWQ (2007) cadmium pollution present a very serious health hazards to human and may lead to damage to the kidney. Cd toxicity associated with acute respiratory exposure may include pulmonary edema (accumulation of fluid in the lungs), whereas ingested Cd may result in nausea, vomiting and abdominal pain (Hughes, 2005). Other associated health effects include psychological disorder, reproductive failure and possibly even infertility, diarrhea, stomach pains and severe vomiting among others.

Nickel (Ni): According to the Standards set by the WHO (2011) and NSDWQ (2007) the standard guidelines is 0.07 mg/land 0.02 mg/l respectively. From Table 2.0, there is no nickel pollution in the River Hadejia since the mean concentration of Ni in the river is only 0.01mg/l. In concentrations above the standard guidelines, Ni may cause ailments like heart failure, asthma/bronchitis/other respiratory disorders, birth defects and cancer (Lentech, 2009).

Lead (Pb): From Table 2.0, it can be observed that the mean concentration of Pb in surface water of River Hadejia of 2.53mg/l shows a serious lead pollution. This is because the standard guidelines for both WHO (2011) and NSDWQ (2007) for Pb is 0.01mg/l were highly exceeded. Its greatest risks arise from the emissions associated with human use of the metal and its derivatives. Most of the lead is taken up by red blood cells and circulated throughout the body where it may concentrate initially in the liver and kidneys (Duffus, 1980). It may then be redistributed to the bones, teeth, and brain. Anaemia, abdominal pain, nausea, vomiting, degeneration of tissues in the central nervous system (especially in children) are major symptoms of lead poisoning. In children, Pb encephalopathy (disease of the brain) may result in loss of appetite, ataxia, coma, and death (Hughes, 2005).

Copper (Cu): From Table 2.0, it can also be observed that the mean concentration value of Cu in River Hadejia is 0.01mg/l which shows no Cu pollution in the Hadejia River catchment. The standard guidelines of both WHO (2011) and NSDWQ (2007) of Cu is 2.0mg/l and 1.0mg/l respectively. Brain damage in higher animals is known to be associated with copper poisoning (Duffus, 1980). Its presence may also cause staining of laundry and sanitary wares.

Arsenic (As): From Table 2.0 As mean value in the sediment of River Hadejia is 1.20 mg/l, also this toxic metal occur in all sampling points in concentrations above the permissible limits of 0.01 mg/l WHO (2011); and 0.2 mg/l NSDWQ (2007). Arsenic is poisonous causing a host lot of diseases like dermatitis, bronchitis, vomiting, abdominal pain, and cancer. According to Hughes (2005) acute As toxicity leads to anorexia, hepatomegaly, possible cardiovascular failure, and death.

Thorium (Th): From Table 2.0, Th mean value in River Hadejia is 11.05 mg/l. Release of large amount of Th into the environment, especially domestic water may be harmful because the metal is radioactive and can cause bone cancer in humans many years after the exposure has taken place (Lentech, 2009).

The presence of these metals (both essential and toxic metals) in concentrations above the permissible limit may pose serious negative challenges and negative health effects on the water users of this river catchment. The prevalence of some ailments like high blood pressure, and cancer may be connected to this negative consequences. metals are unique as toxicants since they are neither created nor destroyed by organisms, plants or animals because as chemical elements they cannot be degraded beyond their elemental states (Hughes, 2005).

CONCLUSION

The Water Safety Plan (WSP), an approach launched in the third edition of the WHO Guidelines for drinking-water quality (WHO, 2004): states that "The most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. This provision can be extended to irrigation and other water uses which are tied to the river. The River Hadejia catchment is one of the largest cultivated (both rain fed and irrigated) perennial agricultural area in the country (Chiroma , et al 2012). From the findings, it was observed that the general quality of water in River Hadejia is good, since most of the tested metals did not fall outside the limits of the permissible recommended guidelines set by the World Health Organization (WHO, 2011), and the National Standards for Drinking Water Quality (NSDWQ, 2007) for drinking water, however continuous loading of this important waterway with these metals may lead to high level of pollution in near future since there is some form of pollution of the waterway by the various land use activities within the catchment area. this indicate there is no serious problem of health concern in the river catchment.

Many organizations and governments especially in developed nations where severe chemical pollution from several land use activities (especially industrial) have caused deaths, deformations and other health hazards have made several recommendations to safeguard public health. These range from planning, policy formulation and enforcement, to management of water resources watersheds. The above is a general recommendation. But for the peculiar nature of pollutants generation and nonchalant attitude of residents of some parts of Kano region to the sanitary ethics, the following suggestions are recommended:

i. There should be continuous periodic water quality assessment of the river because of the dynamic nature of human activities taking place in the watershed, for efficient planning and management of our surface water resources.
ii. The use of mass media for propagating environmental education with emphasis on impacts of indiscriminate waste discharge on water quality, public health and the environment should be introduced in this drainage basin.
iii. Since industrial land use activity is discovered as the second major source region of the pollutants (with tannery and textile industries as major contributors), the chemicals employed in many stages of tannery and textile processing may be known, but some bye- products are formed, and there are many complex auxillaries used with unknown detailed composition, hence the need for continuous research to further understand these interactions.
iv. It is important that government and other relevant agencies should take appropriate measures to protect the quality of the water resources in the area so as to improve public health.

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