IOSR Journal of Engineering (IOSRJEN)
e-ISSN: 2250-3021, **p**-ISSN: 2278-8719
Vol. 3, Issue 8 (August. 2013), ||V3|| PP 01-09

Heavy Metal Pollution in Surface and Ground Waters Used for Irrigation along River Tatsawarki in the Kano, Nigeria

Bichi, M. H., Bello, U. F.
[1,2]Department of Civil Engineering, Bayero University, Kano-Nigeria.

Abstract: The Tatsawarki River, which is one of the major tributaries of the Kano River, receives all domestic and industrial waste waters from the southern part of Kano metropolis. The river, with no natural flow in the dry season, is extensively used for, irrigation, fishing and domestic water supply. Surface water samples were collected from three different points along the river and ground water samples were collected from three irrigation areas along the river. Control samples were collected from locations away from the river. The samples were analyzed for physic-chemical parameters (Temperature, pH, TDS, Turbidity, Electrical conductivity, Hardness, Nitrates, and Nitrites) and heavy metals (Pb, Cr, Co, Cd, Zn, Cu, Fe and Mn). The results show that the water is generally unfit for irrigation as the physic-chemical parameters reveal higher values than the WHO guideline values for irrigation water quality as well as the values obtained in the control samples. The concentrations of the heavy metals in the irrigation water were also found to be higher than the FAO guideline values with the exception of Fe and Pb which were found to be below the FAO guideline values. All irrigation water samples were also found to have higher metals level in comparison with the levels obtained in control sample with the exception of Pb. It is recommended that the standards for different end uses be reviewed in order to recognize the variation in risks and benefits; and a more realistic, gradual and strategic implementation of the standards should be ensured with achievable targets set. Effective market-based incentives to reduce pollution, such as the 'polluter pays' principle, or grants, subsidies and tax credits for environmentally friendly behavior should also be encouraged.

***Keywords*:** *Ground water, Heavy metals, Industrial pollution, Irrigation, Surface water,*

I. INTRODUCTION

Industrialization is considered vital to the nation's socio-economic development as well as to its political standing in the international community. While development aims at bringing about positive change in human life, uncontrolled consumption of natural resources both in developed and developing countries have inadvertently led to environmental degradation, pollution, incurable diseases, poverty, social conflicts (Osibanjo, 2009). The impairment of water quality due to the introduction of pollutants is a problem of industrial cities around the world. The uncontrolled releases of waste effluents to large water bodies have negatively affected both water quality and aquatic life (Udosen, 2006; Dan'azumi & Bichi, 2010a, b).

Heavy metals are major pollutants in water bodies because of industrial and municipal waste discharges into the environment without proper treatment. To a small extent these heavy metals find their way into human bodies via food, drinking water and air. These metallic chemical elements are toxic or poisonous at low concentration. However, at higher concentration they can lead to poisoning as a result of bioaccumulation in the human body. Aikman (1983) has reported that high concentrations of heavy metals in irrigation water can result in death of crops, interfere with uptake of other essential nutrients, or form objectionable deposits on fruits and render the edible portion of plants toxic to human and grazing animals.

In Nigeria, improper disposal of untreated industrial wastes has resulted in colored, murky, odorous and unwholesome surface waters, fish kills and a loss of recreational amenities. A significant proportion of the population still relies on these polluted surface and ground waters for drinking, irrigation, fishing and other domestic uses. According to one World Bank report (1990), advisors warn that water contamination has the second highest potential for future negative impacts on GDP and in Nigeria alone, higher incidences of water-related diseases cost the country an estimated US $1 billion annually through increased health costs and lost productivity, and put 40 million people at risk. In greater Kano, waste water treatment facilities are virtually non-existent, such that poor people, including those who engage in urban farming practices to make a living, cannot afford defensive sanitary practices. Local surface water is of vital importance, and the shallow ground water supplies found in fadama depressions where much of the peri-urban agriculture takes place, are highly polluted with urban and industrial contaminants (Binns et al, 2003).

Dike et al (2004) have observed that rapid increase in populations coupled with other factors such as urbanization, rapid industrial development, mining, agriculture etc result in huge accumulation of wastes and pollutants which end up in water bodies such as rivers, streams and lakes thereby polluting them. Heavy metals are also present in virtually every area of modern consumerism as such it is very difficult for anyone to avoid exposure to any of the harmful heavy metals that are so prevalent in our environment. Heavy metals toxicity represent an uncommon, yet clinically significant medical condition, if unrecognized or inappropriately treated, heavy metal toxicity can result in significant morbidity and mortality (Ferner, 2001). This paper examines the level of pollution in the surface and ground waters that are used for irrigation of crops along the highly polluted Tatsawarki River in the Kano River basin.

II. MATERIALS AND METHODS

2.1 The Project Area

Kano is the centre of Nigeria's tanning industry, and is home to 70 percent of the country's tanneries (World Bank, 1995). The waste bi-products from these tanneries have high concentrations of the heavy metals chromium and cadmium, and a 1989 study, which monitored the activities of 15 tanneries in Kano, found that in all cases permissible limits for effluent discharge were violated, with the exception of pH and temperature (World Bank, 1995). Osae-Addo (1992) adds that not only do down-stream fish and crops become heavily contaminated by heavy metals, but human health is further threatened in urban and peri-urban Kano, because over 60 percent of local people depend on rivers and groundwater aquifers in the area for water. The Kano River basin is the main source of water supply to the metropolitan Kano with a population of over 3 million people. Two of the major industrial areas of Kano, Sharada and Challawa, are also situated within this basin.

River Tatswarki and its tributary, the River Salantan (Fig. 1), are the main drains of the southern part of Kano, with no natural flow in the dry season. The river receive the entire waste water from sharada phase 1 industrial area, as well as waste water from the residential areas of Tarauni, Gandun Albasa, Gyadi-gyadi, Na'ibawa and Kumbotso (Bichi and Anyata, 1999).

2.2 Water Sampling

Surface water samples were collected at three different points along River Tatsawarki. Sample S1: at the beginning of the project area; Sample S2: before its confluence with the waste water channel from Tamburawa water works, and Sample S3: before its confluence with River Challawa (Fig. 2). For ground water sampling, the irrigation area was divided in to four zones (Table 1), with zone ZD being located away from the river to serve as the control.

Sample collection was done using the standard procedure described by the Department of waters affairs and forestry Pretoria (SA) DWAF (1992) in order to achieve an optimal level of success in sample collection. The following parameters were recorded at the site of collection: name of sample, zone and time and date of collection, place of collection and pH.

Two litres (2L) polyethylene bottles after being thoroughly washed with detergent ,rinsed with water and then distilled water and then soaked in 5% HNO_3 for 24 hours were used for collection of the river water and irrigation water samples from tube wells along the banks of the river. The samples are preserved using 1-2 ml of concentrated HNO_3 in order to get a required pH of 2.2 to 2.8. Ice packs were used to keep the samples cool and refrigerated in order to stabilize the metal before analyzing.

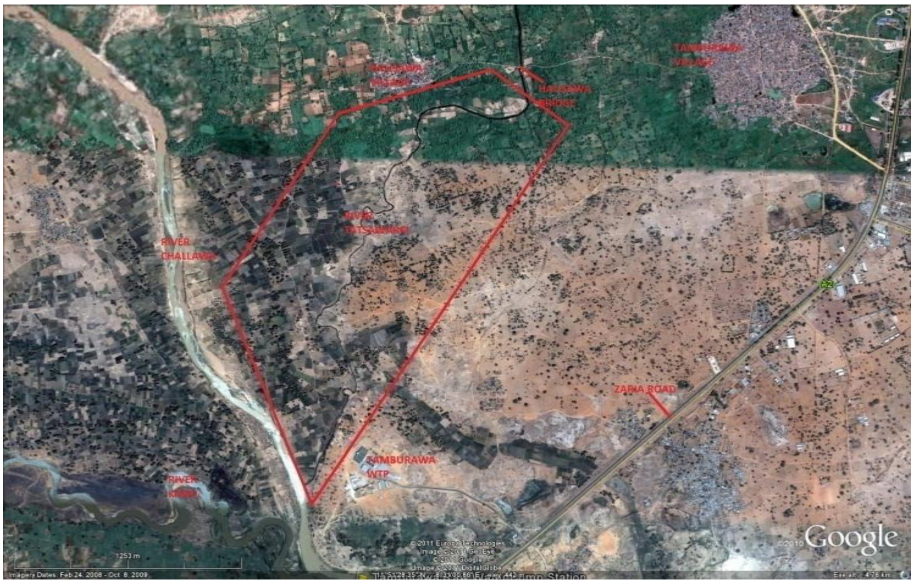

Figure 1: Map of the Project Area (Google, 2011)

Figure 2: Location of Sampling Points

Table 1: Ground Water Sampling Points

ZONE	LOCATION	LABEL
ZA	Tsafe irrigated farmlands	G3
ZB	Gidan kwanso irrigated farmlands	G2
ZC	Magami irrigated farmlands	G1
ZD	Kwarin Matage as control	Control

2.3 Physico-chemical analysis

The physic-chemical parameters investigated are pH, temperature, turbidity, Total Dissolved Solids (TDS), Electrical Conductivity, hardness, Alkalinity, Nitrates and Nitrites. The analysis was carried out using the Standard methods (AWWA, 1990).

2.4 Analysis of Heavy Metals

2.4.1 Pre-treatment of Samples

The open-beaker digestion (OBD) method was employed using HNO_3 as described by Dike et al (2004) for the chemical analysis of water samples. 50ml of the water samples was measured into a beaker and 10ml HNO_3 was added. The beaker and the content were placed on a hot plate and digested until the brown fumes of HNO_3 escaped. The heating continued until the content reduced to 10ml; the content was then washed into a 50ml volumetric flask and made up to the mark. The digest obtained was subjected to determination of the metals.

2.4.2 Determination of Heavy Metals

The analysis/measurements of heavy metal concentration were carried out with an Atomic Absorption Spectrophotometer (AAS). All concentrations were determined using the absorbance made with air-acetylene flame. Eight working solutions were prepared from the stock solutions for each of the metals by successive serial dilution and each of the standard solutions was then aspirated into the flame of AAS and the absorbance recorded in each case. A plot of the concentration against the corresponding absorbance gives the calibration curve of each metals. The samples, after aspirated into the flame and the absorbance obtained were then extrapolated from the calibration plot to obtain the corresponding concentration.

III. RESULTS

The results of the analysis of the physic-chemical parameters for the surface water samples are presented in Table 2 and those for ground water samples in Table 3. The WHO guidelines for irrigation water quality and the FAO (1992) criteria for irrigation waters are included in Tables 2 & 3 and 5& 6 respectively for comparison. The results for sampling points located away from the polluted rivers are also included and these serve as controls.

Table 2: Results of Physico-chemical Parameters for Surface Waters used for Irrigation

S/No	Parameters	WHO Guideline for irrigation water	Control Sample	S1	S2	S3
1	Temperature(˚C)	30	27.60	27.10	26.90	25.60
2	Turbidity (NTU)	25	0.00	932	701	538
3	Suspended Solids (mg/l)	30	1.00	781	478	164
4	Total Dissolved Solids (mg/l)	>320	1087	1508	1496	1580
5	pH	6 - 9	6.71	8.07	7.89	7.76
6	Conductivity(µS/cm)	2250	2550	2850	2590	3030
7	Alkalinity (mg $CaCO_3$/l)	-	75.00	1120	942	305
8	Hardness (mg/l)	-	98.76	225.36	183.63	103.25
9	Calcium (mg/l)	-	33.35	73.54	36.58	28.84
10	Magnesium (mg/l)	0.20	4.93	10.41	8.32	6.35
11	Chloride	140.0	64.16	303.99	101.10	128.31
12	Nitrates (mg/l)	0.2	0.15	0.00	0.06	0.09
13	Sulphates (mg/l)	250.0	44.0	248.0	73.0	102.0
14	Sulphides (mg/l)	-	0.01	2.80	0.74	0.36

S1 – Samples collected at point A (upstream)
S2 – Samples collected at point B (midstream)
S3 – Samples collected at point C (downstream)

Table 3: Results of Physico-chemical Parameters for Ground Waters used for Irrigation

S/No	Parameters	WHO Guideline for irrigation water	Control Sample	G1	G2	G3
1	Temperature(˚C)	30	27.60	27.40	27.50	27.40
2	Turbidity (NTU)	25	0.42	1.20	33.00	247.00
3	Suspended Solids (mg/l)	30	1.00	2.00	30.00	227
4	Total Dissolved Solids (mg/l)	>320	1087	1563	1716	1053
5	pH	6 - 9	6.71	6.20	6.58	6.32
6	Conductivity(µs/cm)	2250	2550	2680	3520	2240
7	Alkalinity (mg $CaCO_3$/l)	-	75.00	315	725	490
8	Hardness (mg/l)	-	98.76	799.08	343.42	219.97
9	Calcium (mg/l)	-	33.35	286.78	110.67	69.39
10	Magnesium (mg/l)	0.2	4.93	17.52	13.47	11.28
11	Chloride	140.0	64.16	645.49	676.09	377.03
12	Nitrates (mg/l)	0.20	0.15	0.17	0.08	0.00
13	Sulphates (mg/l)	250.0	44.0	240.0	55.0	12.0
14	Sulphides (mg/l)	-	0.01	0.00	0.01	0.02

G1 – Samples collected at Magami Irrigated farmlands
G2 – Samples collected at Gidan-kwanso irrigated farmlands
G3 – Samples collected at Tsafe irrigated farmlands

Table 4: Water Classification in Terms of Hardness

Hardness classification	**Total hardness (mg/l CaCO □)**
Soft	Less than 50
Reasonably soft	50 to 100
Slightly hard	100 to 150
Reasonably hard	150 to 250
Hard	250 to 350
Very hard	More than 350

Source: Schutte (2006)

Table 5: Results of Heavy Metals in Surface Waters used for Irrigation

S/No	Parameters	FAO Guideline for irrigation water	Control Sample	S1	S2	S3	Aver-age
1	Chromium (mg/l)	0.1	0.8	8.8	8.5	9.1	8.8
2	Copper (mg/l)	0.2	1.2	4.7	4.7	5.3	4.9
3	Cadmium (mg/l)	0.01	4.1	17.0	12.2	12.0	13.7
4	Zinc (mg/l)	2.0	2.0	11.4	10.3	9.6	10.4
5	Cobalt (mg/l)	0.05	0.5	1.9	1.8	1.9	1.9
6	Iron (mg/l)	5.0	1.0	0.7	0.9	1.5	1.0
7	Lead (mg/l)	5.0	1.9	1.4	1.1	1.4	1.3
8	Manganese (mg/l)	0.2	0.9	2.5	3.2	3.5	3.1

S1 – Samples collected at point A (upstream)
S2 – Samples collected at point B (midstream)
S3 – Samples collected at point C (downstream)

Table 6: Results of Heavy Metals in Ground Waters used for Irrigation

S/No	Parameters	WHO Guideline for irrigation water	Control Sample	G1	G2	G3	Aver-age
1	Chromium (mg/l)	0.1	0.8	4.0	4.0	2.0	3.3
2	Copper (mg/l)	0.2	1.2	1.3	1.3	2.7	1.8
3	Cadmium (mg/l)	0.01	4.1	9.0	8.0	15.0	10.7
4	Zinc (mg/l)	2.0	2.0	5.0	5.5	6.8	5.8
5	Cobalt (mg/l)	0.05	0.5	1.0	1.0	0.8	0.9
6	Iron (mg/l)	5.0	1.0	2.0	1.0	1.5	1.5
7	Lead (mg/l)	5.0	1.9	1.4	1.0	1.9	1.4
8	Manganese (mg/l)	0.2	0.9	5.0	2.5	3.0	3.5

G1 – Samples collected at Magami Irrigated farmlands
G2 – Samples collected at Gidan-kwanso irrigated farmlands
G3 – Samples collected at Tsafe irrigated farmlands

IV. DISCUSSIONS

4.1 Physico-Chemical Parameters

4.1.1 Sulphates

The irrigation water exhibits sulphates in concentrations within the WHO guidelines for irrigation water of 250mg/l, with the surface water showing a higher value of 248mg/l at point A (beginning of the research area), 73mg/l at point B (midway into the research area just before the waste water channel from Tamburawa water works) and 102mg/l at point C (before the confluence with river Challawa) showing a contribution of sulphates from the new Tamburawa water works, the groundwater shows a value of 240mg/l at Magami irrigated farmlands, 55mg/l at Gidan-kwanso and 12mg/l at Tsafe irrigated farmlands. All values obtained show higher values than that obtained in the control irrigation water (Tables 2 and 3).

4.1.2 Nitrates

The nitrates concentrations obtained were found to be within the set guidelines of 0.2mg/l, the groundwater shows a higher nitrates concentration of 0.17mg/l at Magami irrigated farmlands, 0.08mg/l at Gidan-kwanso irrigated farmlands and no nitrates were found in groundwater used in Tsafe irrigated farmlands (Table 3). The surface water exhibits no nitrates at point A, 0.06mg/l at point B and 0.09mg/l of nitrates at point C. While the control sample exhibits a nitrates concentration of 0.15mg/l (Table 2).

4.1.3 Sulphides

The sulphides in the irrigation water showed higher concentrations in the surface water as it exhibits a concentration of 2.8mg/l at point A, 0.74mg/l at B and 0.36mg/l at point C (Table 2). The groundwater exhibits no suphides at Magami irrigated farmlands, 0.01mg/l at Gidan-kwanso and 0.02mg/l at Tsafe farmlands, while the control irrigation water exhibits 0.01mg/l of sulphides (Table 3).

4.1.4 Chlorides

The chloride concentration obtained in most of the irrigation water samples were higher than the WHO guideline value of 140mg/l, with the groundwater exhibiting much higher concentrations of 645.49mg/l at Magami farmlands, 676.09mg/l at Gidan-kwanso and 377.03mg/l at Tsafe irrigated farmlands. The surface water shows a value of 303.99mg/l at point A, 101.1mg/l at B and 128mg/l at point C, while the control sample has a concentration of 64.16mg/l (Tables 2 and 3).

4.1.5 Magnesium

The magnesium content of both surface and groundwater used as irrigation water in the research area were found to be higher than the guideline value of 0.2mg/l, with the groundwater exhibiting higher values than the surface water which indicates the presence of magnesium naturally in the soils. The concentrations obtained were also higher than that obtained in the control irrigation water though it was also higher than the guideline value of 0.2mg/l (Tables 2 and 3).

4.1.6 Calcium

The concentration of calcium in the groundwater samples were higher than the concentration obtained in the surface water samples, with both concentrations higher than the value obtained in the control sample of 33.35mg/l with the exception of surface water at point C having a value of 28.84mg/l. The high concentration obtained in the groundwater can also be attributed to the calcium bearing rock/soil in the irrigated farmlands (Tables 2 and 3).

4.1.7 Hardness

With reference to classification of water in terms of hardness (Table 4), the surface water used for irrigation falls in the class of reasonably hard to slightly hard and reduces down the river, the groundwater was found to be in the class of very hard to reasonably hard while the control irrigation water was found to be reasonably soft (Tables 2 and 3).

4.1.8 Alkalinity

The alkalinity in mg/l of $CaCO_3$ in the irrigation water were higher in surface water with a value of 1120mg/l at point A, 942mg/l at B and 305mg/l at point C, the alkalinity in groundwater samples were found to be 315mg/l at Magami irrigated farmlands, 725mg/l at Gidan-kwanso and 490mg/l at Tsafe irrigated farmlands, while the control irrigation water shows an alkalinity value of 75mg/l (Tables 2 and 3).

4.1.9 Conductivity

The conductivity exhibited by the irrigation water was higher than the WHO guideline value of 2250µS/cm with the highest value obtained in groundwater from Gidan-kwanso farmlands having a value of 3520µS/cm (Table 3) followed by surface water at point C after the waste water from Tamburawa water works with a value of 3030µS/cm (Table 2). These can be directly related to the high concentration of total dissolved solids in the two samples and the least conductivity value was obtained in groundwater from Tsafe irrigated farmlands with a value of 2240µS/cm, while the control irrigation water exhibits a value slightly higher than the guideline value.

4.1.10 pH

The pH of the irrigation water along river Tatsawarki was within the guideline range of 6 – 9, the groundwater exhibit a pH of the acidic range while the surface water exhibits a pH in the alkaline range. The trend of the pH in the river was found to be of the descending order with the lowest pH value at point C which can be attributed to dilution with waste water from Tamburawa water works which is of the acidic pH (Tables 3 and 3).

4.1.11 Total Dissolved Solids (TDS)

The concentration of total dissolved solids was in conformity with the WHO guideline as all values are greater than 320mg/l. The highest concentration was observed in groundwater from Gidan-kwanso irrigated farmlands with a concentration of 1716mg/l followed by surface water at point C having a TDS concentration of 1580mg/l the least TDS concentration was observed in groundwater from Tsafe irrigated farmlands with a value of 1053mg/l, while the control irrigation water was found to be having a TDS concentration value of 1087mg/l (Tables 2 and 3).

4.1.12 Suspended Solids

The suspended solids in the surface water used for irrigation in the research area was significantly higher than the 30mg/l WHO guideline for irrigation water, while the suspended solids content of the groundwater was within the acceptable limits with the exception of groundwater from Tsafe irrigated farmlands which has a value of 227mg/l suspended solids. All values observed were found to be higher than the value obtained in the control irrigation water with a value of 1.0mg/l (Tables 2 and 3).

4.1.13 Turbidity

The turbidity of the surface water used for irrigation along river Tatsawarki was well above the set guideline value of 25NTU with a highest value of 932NTU at point A, 701NTU at point B and 538NTU at point C (Table 2). The groundwater exhibits a high turbidity at Tsafe farmlands which can be attributed to the high concentration of suspended solids in the water and/or presence of some metals like manganese and iron (Table 3). The turbidity of the control sample was found to be 0.4NTU.

4.1.14 Temperature

The temperature of the irrigation water along river Tatsawarki was in the range of 27.4˚C – 27.5˚C for groundwater and 25.6˚C – 27.1˚C for surface water, while the control sample exhibits a temperature of 27.6˚C, all temperatures are lower than the 30˚C guideline for irrigation water (Tables 2 and 3).

4.2 Heavy Metals in Irrigation Water

4.2.1 Chromium (Cr)

The concentration of Chromium found in surface and groundwater used for irrigation in all the irrigated farmlands was significantly higher than the FAO/WHO guidelines for irrigation water quality of 0.1mg/l, with the surface water exhibiting higher value of 8.8mg/l on average (Table 5) and the ground water exhibiting an average chromium concentration of 3.3mg/l (Table 6). The concentration of chromium exhibited by both surface and groundwater used for irrigation were found to be higher than that found in the control irrigation water having a value of 0.8mg/l. The surface water shows a value of 8.8mg/l at point A (the beginning of channel from Tamburawa water works) and a concentration of 9.1 at point C (just before its confluence with the Challawa River).

4.2.2 Copper (Cu)

The concentration of Copper in the irrigation water in all the irrigated farmlands was higher than the value of 0.2mg/l set as guideline for irrigation water by FAO as the surface water shows a higher concentration of 4.9mg/l average (Table 5) and the groundwater exhibiting a concentration of 1.8mg/l on average (Table 6). The Copper concentration in both surface and groundwater was higher than that obtained in the control sample which has a value of 1.2 mg/l. The concentration of Copper in River Tatsawarki maintains a value of 4.7mg/l from point A to point B and then rises to a value of 5.3mg/l at point C. Therefore, signifying a contribution of copper from the waste water from Tamburawa water works through its waste water channel.

4.2.3 Iron (Fe)

The concentration of the metal Iron in the irrigation water in the research area was within the guideline limit set by FAO of 5.0mg/l (Tables 5 and 6). The groundwater shows a higher iron concentration of 1.5mg/l on average than the surface water having an average concentration of 1.0mg/l. This can be attributed to the dissolution of iron bearing rock and/or soils. The iron concentrations obtained in the irrigation water used along the river were found to be higher than the value obtained for the control irrigation water which exhibits a concentration of 1.0mg/l. The trend of iron concentration in the river increases from 0.7mg/l at point A to 0.9mg/l at point B and 1.5mg/l at point C, showing that the concentration of iron in the river cannot be solely attributed to industrial pollution but also the nature of the rock and soils beneath and around the research area.

4.2.4 Manganese (Mn)

The concentration of manganese obtained in the irrigation water for both surface and groundwater in the research area was higher than the FAO guideline value of 0.2mg/l. The groundwater exhibiting the highest concentration value of 3.5mg/l average than the surface water which exhibits average concentration of 3.1mg/l against a concentration of 0.9mg/l obtained in the control sample, these essentially shows the presence and dissolution of manganese bearing rock and/or soils in the irrigated farmlands. The concentration of manganese in the river shows an increasing trend from 2.5mg/l at point A to 3.2mg/l at point B and 3.5mg/l at point C which also signifies the presence of manganese naturally along the river course (Tables 5 and 6).

4.2.5 Lead (Pb)

The concentration of lead in the irrigation water in all irrigation water both surface and ground water were found to be below the FAO guideline value for irrigation water of 5.0mg/l. The groundwater shows a higher value of 1.4 mg/l, while the surface water exhibits a value of 1.3mg/l with both concentrations lower than the 1.9mg/l obtained in the control sample (Tables 5 and 6). This can be related to the fact that there is significant mobility of the metal to the groundwater as the soil from the control farmland bears the highest concentration of lead. The concentration of lead in the research river has a value of 1.4mg/l at point A, 1.1mg/l at point B before the waste water channel from Tamburawa water works and 1.4mg/l at point C before its confluence with river challawa, these shows a contribution of the metal from the waste water from Tamburawa water works.

4.2.6 Zinc (Zn)

The concentration of Zinc obtained in the irrigation water was higher than the 2.0mg/l FAO guideline for irrigation water, with the surface water exhibiting the highest concentration of 10.4mg/l average and the groundwater having an average concentration value of 5.8mg/l, both surface and groundwater exhibiting higher concentrations than the control irrigation water which exhibits a value of 2.0mg/l. The concentration of Zinc in the river shows a falling trend, with point A having a concentration value of 11.4mg/l, point B 10.3mg/l and 9.6mg/l at point C which shows a dilution by the waste water from Tamburawa water works (Tables 5 and 6).

4.2.7 Cobalt (Co)

The concentrations of the metal cobalt in the irrigation water samples from the irrigated farmlands were found to be higher than the 0.05mg/l FAO guideline for cobalt concentration in irrigation water, surface water exhibits higher concentration value of 1.9mg/l on average and the groundwater shows an average value of 0.9mg/l, both having a higher cobalt concentration than the control irrigation water which exhibits a concentration value of 0.5mg/l. The concentration of cobalt along the river was found to be fairly the same; point A and point C having a concentration value of 1.9mg/l and point B 1.8mg/l (Tables 5 and 6).

V. CONCLUSION

From the findings of the research it can be concluded that the concentrations of the heavy metals in irrigation water is very high and unfit for the purpose as the metals were found to be higher than the FAO guideline values with the exception of Fe and Pb which were found to be below the FAO guideline values, all irrigation water samples were also found to have higher metals level in comparison with the levels obtained in control sample with the exception of Pb. Also, the irrigation water is generally unfit as the physico-chemical parameters investigated reveals higher levels of turbidity, suspended solids, TDS, conductivity, magnesium and chlorides higher than the WHO guideline values for irrigation water quality and the values obtained in the control irrigation water.

From the findings of the research it is recommended that the standards for different end uses be reviewed in order to recognize the variation in risks and benefits; and a more realistic, gradual and strategic implementation of the standards should be ensured with achievable targets set. Environmental and health impact assessments should be conducted in order to ascertain the damaged that is being done so as to start thinking of the remedy. Effective market-based incentives to reduce pollution, such as the 'polluter pays' principle, or grants, subsidies and tax credits for environmentally friendly behavior should also be encouraged.

REFERENCES

[1] Osibanjo, O., Historical perspective of environment and development nexus, *Paper presented at IPAN 2-day training workshop on Environmental analysis for sustainable development at Ikeja Lagos, 2009.*

[2] Udosen, E.D., Determination of trace metals and fluxes in sediments along a segment of Qua Ibeo River in Southern Nigeria. *Journal of Natural and Applied Sciences,, 2, 2006, pp82-90.*

[3] Danazumi, S. & Bichi, M.H - Industrial pollution and heavy metals profile of Challawa river in Kano, Nigeria. *Journal of Applied Sciences in Environmental Sanitation, 5 (1): (2010)a, 23-29.*

[4] Danazumi, S. & Bichi, M.H - Industrial Pollution and Implication on Source of Water Supply in Kano, Nigeria, *International Journal of Engineering & Technology IJET-IJENS, 10(1), 2010b, pp101-110.*

[5] Aikman, D.I; Waste water re-use from the standpoint of irrigated agriculture, *The Public Health Engineer, Vol. II No. 1,1983, pp 35-41.*

[6] World Bank, *Toward the Development of an Environmental Action Plan for Nigeria*. (World Bank Report, Western Africa Department, May 1990, Washington, DC, 1990) . In Binns et al., Water, land and health in urban and peri-urban food production: the case of Kano, Nigeria(2003). www.cityfarmer.org/WaterLandHealthKano

[7] Binns, J.A. Maconachie, R.A. Tanko, A.I. ; Water, land and health in urban and peri-urban food production: the case of Kano, Nigeria(2003), www.cityfarmer.org/WaterLandHealthKano *International Journal of Engineering & Technology IJET-IJENS Vol: 10 No: 01, (2010)b, pp101-110*

[8] Dike, N I; Ezealor, A U; Oniye, S J: Concentration of Pb, Cu, Fe, and Cd during the dry season in river Jakara, Kano Nigeria, *Chem Class Journal, 1, 2004, pp78-81.*

[9] FAO (1992): Food and Agriculture Organisation of the United Nations, Wastewater treatment and use in agriculture – FAO irrigation and drainage paper 47 http://www.fao.org/docrep/T0551E/t0551e0c.htm

[10] Ferner D.J,; Toxicity, Heavy Metals. *eMed. Jour. 2(5), 2001.* Institute of Environmental Conservation and Research (INECAR), Position Paper Against Mining in Rapu-Rapu, Published by INECAR, Ateneo de Naga University, Philippines, 2001. www.adnu.edu.ph/Institutes/Inecar/pospaper1.asp., 2000.

[11] World Bank, *Nigeria: Strategic Options for Redressing Industrial Pollution,* Volume I, February 3, 1995. Enterprise Development and Public Sector Management Division, West Central Africa Department, Washington, DC.

[12] Osae-Addo, A., *Nigeria: Industrial pollution control. Sector Report Draft.* (cited in World Bank, 1995:5)., 1992.

[13] Bichi, M.H. and B.U. Anyata "Industrial Waste Pollution in the Kano River Basin" *Environmental Management and Health, 10(2),* 1999, *pp. 112-116.*

[14] DWAF, *Standard procedures for sample collection and preservation*, Department of waters affairs and forestry Pretoria South Africa, 1992.

[15] AWWA, *Standard Methods for the Examination of Water and Waste Water*, (American Water Works Association, Washington, DC, 1990).

[16] Schutte, F , *Handbook for the Operation of Water Treatment Works*. (The Water Institute of Southern Africa,2006).