Assessment of the Effects of Industrial Effluents on the Water Resources in Challawa Industrial Area, Kano, Nigeria

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ABSTRACT

Generally, upstream of the Challawa River, Co, Zn, Cd and Cu were low and within FEPA/WHO standards. Concentrations of these metals decreased downstream in the wet season. In the dry season, Cr, Mn and Fe in both surface and ground water were high. Downstream at 100m intervals, the concentrations of Fe and Pb were highest and decreased with distance in the wet season, but Fe concentration reduced in dry season while the concentration of other elements varied. Cr concentration increased at 100m and 200m intervals and decreased downwards. T-Test analysis of samples from sludge and upstream samples showed that apart from Cd, Mn, and Cu which were significant, other elements were not significantly different in both wet and dry seasons in both sludge and upstream samples.

(Keywords: upstream, downstream, river samples, surface water, groundwater, sludge, heavy metals)

INTRODUCTION

The development of technology is pursued with increasing intensity as a way of remedying ailing economies. In Nigeria, new industries are emerging to reverse the current unpleasant trends in the economy (Dike, 1991; UN 2011). The growing intensity of industrialization inevitably imposes an increasing burden on the environment as both the source of raw materials and the recipient of all effluents (UN, 2011).

The wide range of new processes, raw materials and wastes rejected in association with emergent technologies in industries expose the environment and society to increasing contamination and related hazards (UN, 2011). There is a progressive contraction in the free space available for comfort and safe occupation. The contamination of land, water and food materials is progressive and imposes new and intensifying demands on the management of resources and services.

The ultimate danger posed by either an unmanaged or poorly managed industrializing society is cumulative, emerging as the sum of contributions from individual type of industries. The efficient management of the environment and risks arising from pollution has as a reference point the rules and regulations of the agencies of government charged with responsibilities for the same.

There is a water treatment plant sited at the Challawa industrial area by the state government to cushion the effect of the harm done on inhabitants, soil, and water resources by these effluents. The inhabitants of the area still complain of rashes after using the water. Mukhta and Deeni (1995) are of the view that industrial effluents could cause rashes on human skin, poignant odors, killing of wild and domestic stock and also may have toxic effects on humans.

Farming activities cannot thrive successfully in dry seasons in the Kano region without irrigation, and the only source of irrigation water is the Challawa River. Since some of these effluents are poorly treated or untreated, the effluents change the color of the water from the river at the point of convergence before joining the main river. With the attendant heavy metal deposits commonly suspected in industrial effluents, the soil and water environment may be polluted. The presence of these heavy metals and other environmental unfriendly chemical substances may be implicated in some of the health hazards experienced by humans, plants and animals (Akan *et al.,* 2009).

According to Kirkhan (1983) and Uwah *et al* (2009) the use of polluted water in Nigeria for irrigation is a common practice because some of them are rich in sources of organic matter and plant nutrients, it also contains sufficient amount of soluble salt and heavy metals like iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), lead (Pd), nickel (Ni), tin (Sn), mercury (Hg), chromium (Cr), arsenic (As), and aluminum (Al). When such water is used for irrigation of crops for a long time, these heavy metals may accumulate in soils and may be toxic to plants and may also cause toxicity in soils. When tannery wastes gain access to cultivable lands or when the lands are irrigated with such wastes, fertility of the soil is reported to have been negatively affected (Sastry and Madhavakrishna, 1984; Harihara *et al.,* 1987; Nidhi and Ashwani, 2011; Pradeep and Narasimha, 2012).

Monitoring bodies such as Kano State Environmental Protection Agency (KASEPA), and United Nations Industrial Development Organization (UNIDO), have made several efforts to enforce compliance of these industries to International best practices of production, but their efforts could not yield much result (KASEPA, 2011; Egwuonwu *et al.,* 2011).

Some residents who either drink the water from their taps/ wells or inevitably gulp the Challawa River water while swimming, fishing or harvesting sand from the river have developed some rashes on their bodies. Ibrahim and Abdullahi (2008) are of the view that the site that experiences direct inflow of industrial effluent was the most polluted and consumption of untreated Challawa River water can over time lead to bio-accumulation of heavy metals with possible negative effects on health and wellbeing of man. Aquatic life (fishes, algae and other lives) from the point of discharge into the river are at their highest ebb or non-existent (Egwuonwu *et al*., 2011; Akan *et al*., 2007).

Industrial discharge is a major cause of water pollution, concentration of Oxygen Demand and nutrient loading of water bodies, promoting toxic algal bloom and leading to a destabilization of aquatic ecosystem (Morrison *et al.,* 2001; Water Research Commission, WRC, 2001; Santchi *et al*., 2001). This problem is compounded in Challawa industrial area where effluents are discharged into River Challawa with little or no treatment. The residents complained about the contamination of air, which causes odor that is highly offensive (Lapai, 1992). The presence of acidic substances in ground water in the area was attributed to contamination by industrial waste, which renders the well waters unpalatable (Dan'azumi and Bichi, 2010). Ground water has been found to be affected where waste water from tanneries is ponded, spread out on land, or discharged into dry river beds.

The ground water is reported to be rendered unfit for drinking and irrigation where the tanneries are concentrated together (Purushtherma, 2003; Srinwas and Ahmed, 1984). It is therefore expected that low agricultural yield in areas affected by the industrial discharge compared to yields in the adjacent control areas may be connected with these industrial effluents. Therefore, the aim of this study is to assess the effects of these effluents on water resources in Challawa industrial area.

STUDY AREA

The different aspects of the study area that are relevant to the subject are discussed as follows:

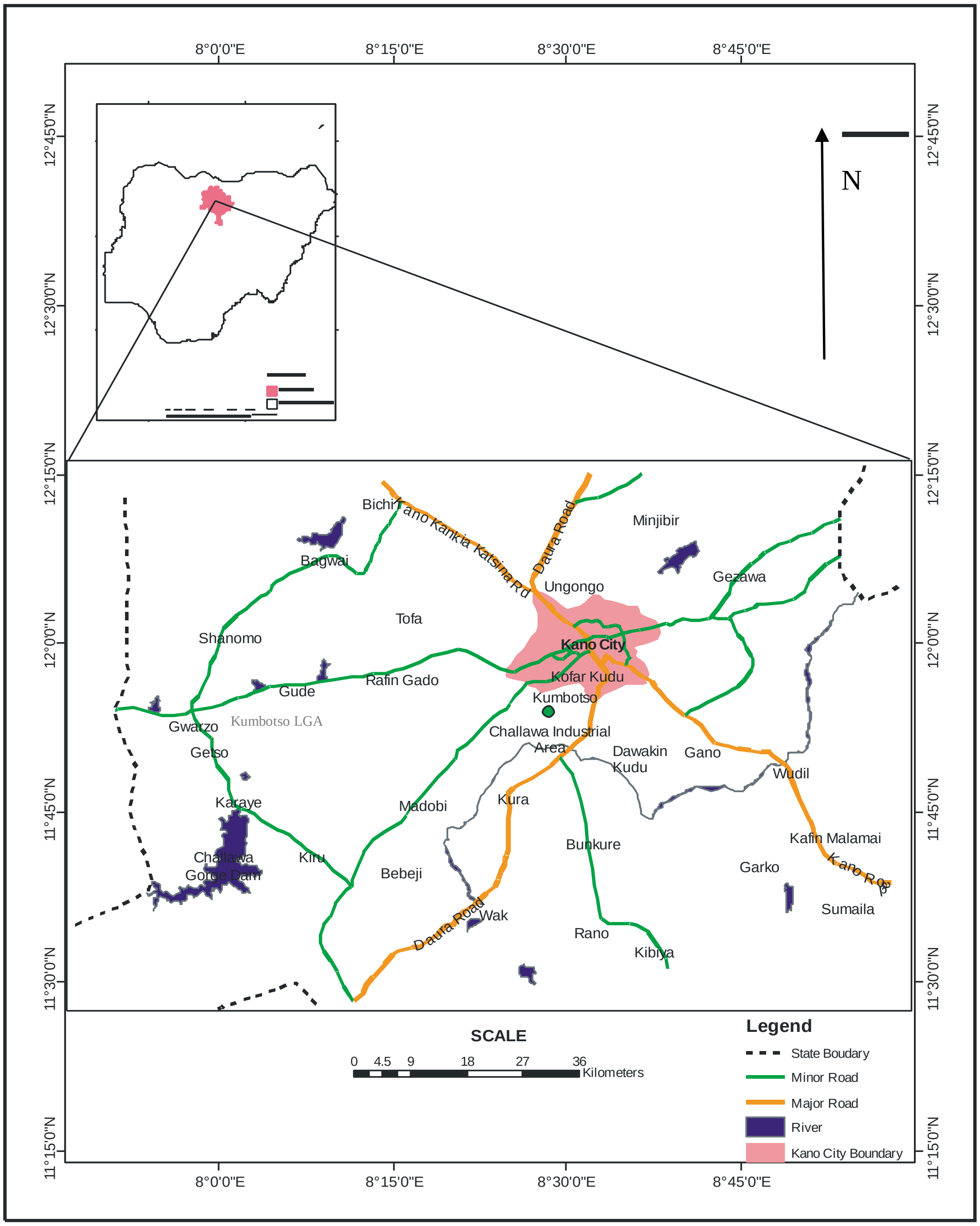
Location

Challawa Industrial Area, Kano, northern Nigeria, is bounded by latitude range of $11^0$52.65 – $11^0$54.29'N and longitude range of $8^0$27.52E-$8^0$28.853'E at an average elevation of about 430m above the mean sea level as shown in Figure 1 (Egwuonwu *et al*., 2011).

A gentle slope tending towards the S-W direction characterizes the study site. All the industries located in the area discharge their effluent into Challawa River located at about 2.0 km downstream from the cluster of industries.

Climate

Kano is influenced by the local semi-sahel climate. During the year, there is little rainfall. This climate is considered to be Aw according to the Koppen – Geiger climate classification.



Source: Adapted and modified from Google Earth (2013)

Figure1: Kano City and its Environs, Showing Kumbotso Local Government Area where Challawa Industrial Area is sited

In Kano, where the Challawa industrial area is located, the average rainfall per annum is 873mm, the bulk of which fall between June and September. There is a long period of little or no rainfall from 4 to 8 months (October – April). This period is known as the dry season. The relative humidity is low (20 to 40%) in January and (50 to 60%) in July (Climate Information Nigeria). The scarce rainfall in the area brings about irrigation farming around the Challawa River.

Trade and Demography

Kano is an important trade center of Nigeria since its pre-independent days and is the second biggest city by population in Nigeria after Lagos (African Master Web, Census 2006). There are many manufacturing and agro based industries in Kano, which resulted into the rapid growth in the employment sector of Nigeria. The urbanization of Kano is the chief reason behind its increasing population. According to a recent Nigerian Population Commission census (2006), the population of Kano city was 3,848,885 which were little less than the population of Lagos (Africa Master Web, Census 2006).

MATERIALS AND METHODS

The water samples from River Challawa were collected both at the affected area and the area not affected by the industrial effluents. These samples were collected in plastic containers that have been previously washed in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 24 hours and finally rinsed with de-ionized water before usage (Ademorrotti, 1996).

At the points of sample collection, sampling bottles were rinsed about three times with the sample and then filled to the brim, making sure that air was not trapped in. The filling was done at a depth of 1 meter below the surface of the water. About five samples were drawn along the river channel (down- stream) each 100 meter away from the other at the area affected by the industrial affluent (Inuwa, *et al.,* 2007; Dan'Azumi and Bichi, 2010).

Five samples were drawn randomly along the river channel at the area not affected by the effluent (upstream - control). At the sludge site, five samples were randomly collected as shown in Plates I and II. *In-situ* measurement of the temperature and the pH was done at these points of collection before the samples were sent to the laboratory for analysis at 4^0C.

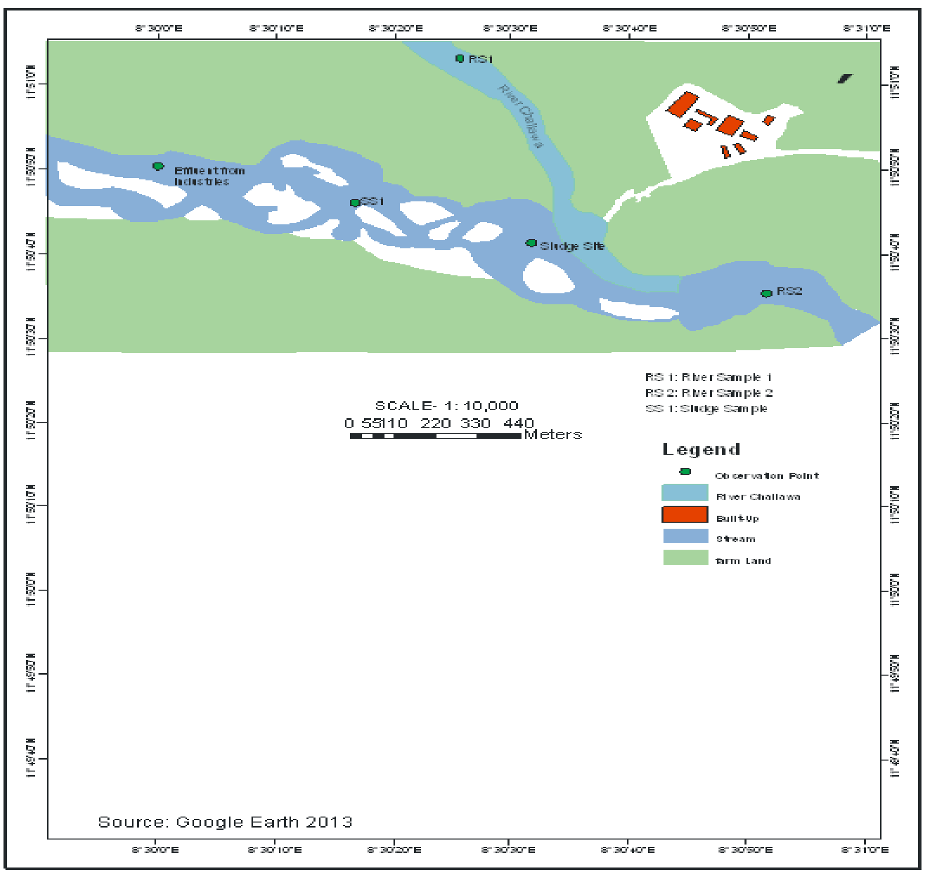
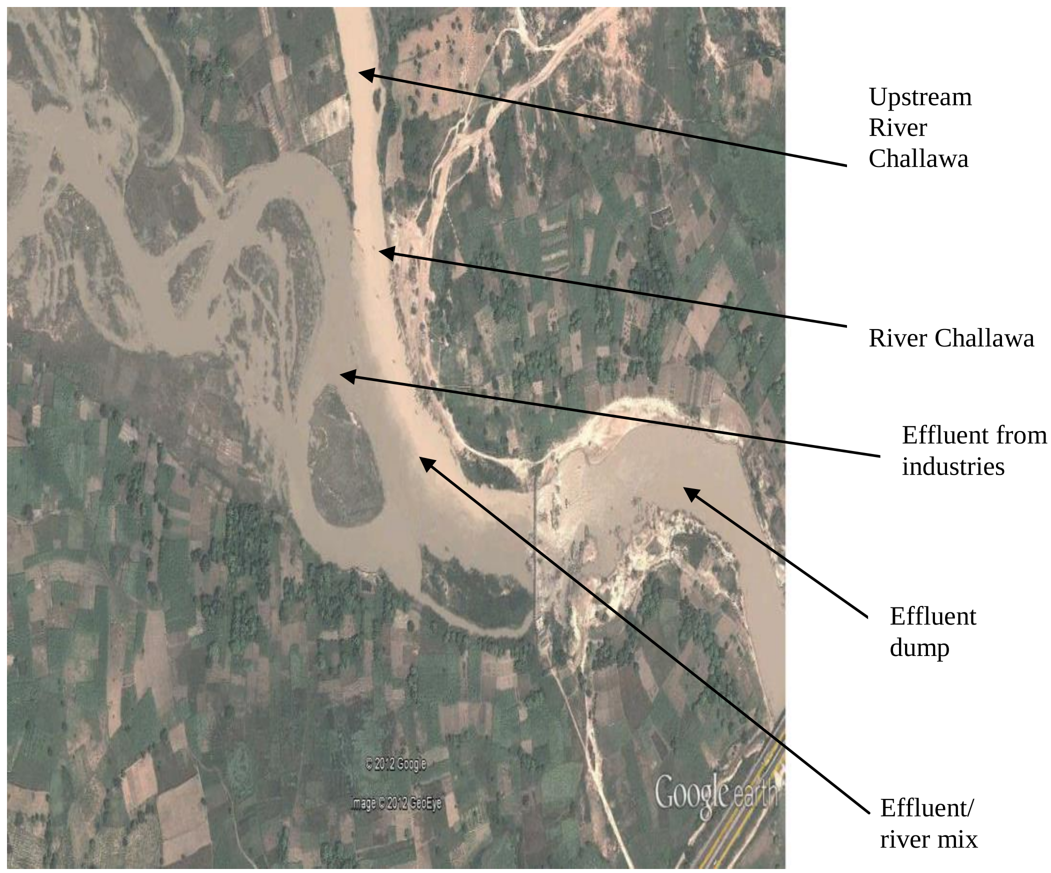


Plate 1: River Challawa showing Collection Points.



(Source: Google)

Plate II: Ariel View Challawa Industrial Estate showing the Observation Points.

Ground Water Samples Collection

The underground water samples were collected from the profile pit at the area affected by the industrial effluents. But before transportation, temperature of the surface and underground water was taken at the point of collection, and stored at a temperature of about 4^0C prior to analysis (to avoid some chemical reactions taking place before the analysis).

Data Analysis

The results got from the water and soil analysis were analysed statistically using SAS statistical analytical system (T-test, ANOVA, and Correlation analysis). All the analyses were done at the Data Processing Unit of Institute of Agricultural Research (IAR) Zaria.

RESULTS AND DISCUSSION

Effects of Industrial Effluents on the Chemical Water from Upstream/Downstream of River Challawa, Sludge, and Groundwater at the Industrial Area

Table 1 shows that Co values ranged between 0.02 at downstream and sludge to 0.25mgl^{-1} at the ground water, and 0.11 at sludge to 0.55 mg/l at ground water during dry and wet seasons, respectively.

Table 1: Concentration of Chemical Elements in River at Upstream/Downstream of River Challawa, Sludge, and Groundwater at the Industrial Area (mg/l).

Elements	Wet season				Dry Season				
Mg/l	Upstream	D. stream	Sludge	G.water	Upstream	D.stream	Sludge	G.water	FEPA/WHO
Co	0.44	0.52	0.11	0.55	0.21	0.02	0.02	0.25	-
Cd	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	<1
Zn	0.11	0.04	0.01	0.17	0.01	0.01	0.01	0.17	3
Mn	0.32	0.21	0.17	5.16	0.14	0.2	0.17	5.17	5
Cr	0.06	0.05	0.14	0.04	6.15	3.95	1.1	5.18	<1
Fe	27.19	29.15	0.8	5.18	0.02	0.01	0.01	1.08	20
Pb	1.48	0.92	0.86	1.08	0.05	0.1	1.14	0.02	<1
Cu	0.02	0.02	0.02	0.02	0.46	0.16	0.4	0.04	<1

Source: Field work (2013)

KEY;
D.stream Downstream.
G.stream Groundwater.
FEPA Federal Environmental Protection Agency
WHO World Health Organization.

The results indicated that slight variation occurred from different sources of water across the seasons, though the variation were not significant at P>0.05. In the same vein, Cd concentration varied between 0.012 at sludge to 0.018mgl^{-1} (downstream), and 0.01 at the sludge, downstream and upstream to 0.02mgl^{-1} at the underground in dry and wet seasons, respectively.

ANOVA showed that no significant variation was observed in Cd concentrations in the water samples based on sources as shown on Table 1.

Metal profile in the water samples collected shows that: Cr > Fe > Pd > Co > Mn > Cd > Cu > Zn for sludge; Fe > Mn > Co > Pd > Cr > Cd > Zn > Cu for downstream; Fe > Pd > Co > Mn > Cr > Cu > Cd > Mn for upstream and Fe > Mn > Cu > Co > Zn > Pd > Cd > Cr for underground in dry season. While in wet season, the metal profile in the water samples collected showed that; Pd > Fe > Mn > Cr > Co > Cu > Cd > Zn for sludge; Fe > Pd > Co > Zn > Cr > Zn > Cu > Cd for downstream; Fe > Pd > Co > Mn > Zn > Cr > Cu > Cd for upstream and Fe > Mn > Pd > Co > Zn > Cr > Cu > Cd for underground as shown on Table 1.

With few exceptions, highest concentration of Fe was observed in all samples in wet seasons, this could imply natural enrichment of Fe in the sediment of river Challawa and environment. However, analysis of variance across the seasons showed significant differences at 95% for Fe while there is no significant different for others.

Generally higher values were obtained for the metals in the dry season than in wet season. This situation is expected in view of the reduction in the pollution in the wet season arising from increased dilution, and that the river is at its highest volume and flow in the wet season.

The effects of this industrial effluent on the micro elements (heavy metals) in the water are as follows:

Cobalt: Cobalt is an essential element which could be introduced anthropogenically into aquatic ecosystem as runoff from industrial activities. The levels of cobalt in the water samples did not exceed the WHO guideline value of 2.00 mg/l (downstream during dry season and sludge during wet season). This means that cobalt was relatively less in these samples compared to other metals during these seasons and possibly may not be a major constituent of the effluent.

The low value of Co in the underground indicated non toxicity of Co to human through the water source especially the underground water. The potentials of cobalt are quite low compared to many other heavy metals; however, exposure to very high doses could cause severe health effect.

Akan *et al* (2009b) reported that high Co were observed from effluent point at river Challawa industrial estate up to 600 meters from confluence point but they are not significantly different.

Cadmium: Cadmium is a non-essential trace element that enters the environment via anthropogenic activities such as industrial effluent, sewage-sludge, fertilizers and pesticides (DWAF, 1996). Cadmium adsorbs strongly to sediments and organic matter and has a range of negative physiological effects on organism, such as decreased growth rates and negative effects on embryonic development (Newman and Macintosh, 1991). Although cadmium is a sulphur seeking metal that tend to precipitate in anoxic sediments, experiments carried out at concentrations lower than values found in this study, showed that cadmium can still be assimilated from anoxic sediments with high organic matter content (Griscom *et al*., 2000; Chong and Wong, 2000; Lee *et al*., 2000; Muniz *et al*., 2004).

The levels of Cd in the water samples were slightly above the FEPA/ WHO standard values of 0.01 mg/l especially in dry season (WHO, 2004). This level of cadmium must have come from fertilizers used by farmers to enrich their farmlands and some from industrial effluent.

Zinc: Zinc is equally an essential element in the human diet. Zn deficiency in the diet may be more detrimental to human health than too much of it in the diet (ATSDR, 1994). In aquatic ecosystem, Zn is highly toxic to some aquatic organisms. Although Zn is not carcinogenic to humans, ingestion of large doses can cause death (ATSDR, 1994). Zinc is also an essential micronutrient for all organisms and forms the active site for various metallo-enzymes (DWAF, 1996). Excessive intake of Zn may lead to vomiting, dehydration, abdominal pain, nausea, lethargy and dizziness (ATSDR, 1994).

The levels of Zinc in the water samples were well below the WHO guideline value of 3.00 mg/l. The source of this zinc may be attributed to the industrial effluent and also from erosion debris.

Manganese: Manganese is an essential element that has a functional component in nitrate assimilation and is used as a catalyst in many enzymatic systems in both plants and animals (DWAF, 1996). Manganese is an essential element and co-factor for several enzymatic reactions. WHO (1984) action level for Mn is 0.1 mg/L. This result agrees with findings of Dan'azumi and Bichi (2010) in their work on the Industrial Pollution and Heavy metal Profile of Challawa River and Akan *et al* (2007a) in their assessment of tannery industrial effluent in Kano in which they discovered that the concentration of Mn was below acceptable limit. Therefore, results from the samples showed no threat from Mn poisoning especially for underground water (5.180mg/l during dry season) indicating low contamination of Challawa River but may pose a hazard to the aquatic biota.

The presence of manganese in River Challawa may be attributed to anthropogenic discharge of manganese waste from industrial processes within this area. Plate 3 shows the sludge site laden with manganese as indicated on Table 1. Toxicity from Mn manifests with profound increase in the incidence of respiratory diseases. In chronic cases, there may be a neuro-psychiatric disorder characterized by irritability, difficulty in walking, speech disturbance, compulsive behavior that may involve running, fighting and singing. If there is chronic Mn toxicity, it results to Parkinson-like syndrome (Mena, 1967) if it bio-accumulates.

Source: Field work (2013)

Plate 3: Sludge Site showing Channels of Effluents from Different Industries.

Chromium: Chromium concentration was generally very high in all the water analysed in dry season as shown on Table 1 (Dan'azumi and Bichi 2010; Akan *et al* 2007). Chromium is a relatively scarce metal that occurs in several states. The most toxic of these states is the chromium VI or hexavalent state. According to WHO/USEPA guideline value, the concentration value of 0.1 mg/l (water) Cr is acceptable (Radojevic and Bashkin, 1999). The values above 0.1 mg/l could result into condition known as allergic dermatoid (EPA, 1999).

From the result of these analyses, the concentrations of chromium in sludge samples exceeded the standard limits in dry season as shown on Table 1, indicating possible contamination of water bodies, soil and underground water, and possible severe pollution by chromium in years to come in Challawa. A reconnaissance survey of the industrial site brought me in contact with the inhabitants of the area who complained that during dry seasons (October – April), they suspend the use of well water for domestic purposes because of its odor and taste and even the surface water is not any better.

Plate 4 shows the effect of chromium on the river. Chromium gives the river a blue coloration and destroys grasses around the river bank. Farm produce from the site are also reported to have lost their natural taste, especially those harvested from fadama planting, this is because farmers in the area use water from the river for their irrigation. Though there is a water treatment facility located in that area, residents still complained of body rashes after using the water. This may be due to inadequate treatment of the water collected from the Challawa River. These rashes also come after swimming and using their canoe to fish or harvest sand from the river bed.

Source: Field work (2013)

Plate 4: River Challawa showing its Blue Color due to Industrial Effluent and the Grasses Destroyed by the Effluent.

Iron: Also, iron is an essential metal but due to frequent acute and chronic Fe over load which may result to renal failure and hepatic cirrhosis, it is worthy to note its adverse effects which is usually common (Muller-Eberhard *et al*., 1977).

There were very unacceptable levels of iron in all the samples in wet season as shown on Table 1which may constitute risks to health (Dan'azumi and Bichi, 2010). Considering the FEPA/ WHO standard of 0.01 mg/l, some of the samples were excessively overloaded. This high level of iron may possibly be connected with the underlying parent material of soil and possibly some from the industrial effluent. This indeed is a cause for great concern.

Copper: Copper is a common environmental metal and is essential in cellular metabolism but at high concentrations, it can be highly toxic to fish (Grosell *et al*., 1997). Copper is an essential substance to human life, however, in high concentrations, it can cause anemia, liver and kidney damage, stomach and intestinal irritation (Turnland, 1988). Copper is generally remobilized with acid-base ion exchange or oxidation mechanism (Gomez *et al*., 2000). Long term exposure to copper may lead to liver and kidney damage (EPA, 1999).

The levels of copper in the water samples as shown on Table 1 were below the (WHO, 2004) standard values of 1.00 mg/l except for underground sample (dry season). This agrees with Akan (2007c). Plate 5 shows children fishing and harvesting sand from the river. These children gulp in this water from time to time and copper is gradually deposited into their system which is detrimental to their health. This copper may possibly be from industrial effluent.

Comparison

The water samples collected at the interval of 100m apart down the River Challawa shows that the concentration of cobalt ranged between 0.16mg/l (100m) - 0.79mg/l (400m) in wet season and 0.07mg.l (100m) - 0.31 (500m) in dry season as shown on Table 2. This result shows variation in the value of cobalt across the seasons and across the distances.

Source: Field work (2013)

Plate 5: Children Fishing and Harvesting Sand and the Eroded River Bank.

The increase in the value of this metal as the distance increased during wet and dry season may be as a result of the industrial effluent and agricultural activities in the area. All the variations are in wet and dry season, respectively. The values of Fe and Pb in wet season reduced as the distance increased but the values of other metals increased except chromium that did not have a defined variation.

During the dry season, apart from the values of Cr, Zn, and Fe which reduced as the distance increased, the values of other metals increased. This variation in values during the dry season may be attributed to slow flow of the river which allows for sedimentation of some of the heavy metals as they form complexes at the river bed thereby decreasing their concentration as the river flows by. This may also suggest that the industries treat their effluents to an extent before sending to the environment. The metal profile for the concentration of metals in water sample collected downstream river Challawa 100m apart during wet season was:

100m, Fe > Pd > Co > Cr > Mn > Zn > Cd > Cu

200m, Fe > Pd > Co > Mn > Zn > Cu > Cd > Cr

300m, Fe > Pd > Co > Mn > Cr > Zn > Cu > Cd

400m, Fe > Co > Pd > Mn > Cr > Zn > Cd >Cu

500m, Fe > Pd > Mn > Co > Cr > Cu > Zn > Cd

The metal profile for the concentration of metals in water sample collected downstream 100m apart during dry season was:

100m, Cr > Mn > Co > Pb> Cu > Cd > Zn > Fe

200m, Cr > Cu >Mn > Co > Cu > Pb> Cd > Zn

300m, Mn > Co > Pb > Cd > Zn > Fe> Cr>Cu

400m, Cr > Cu > Pb > Co > Cd > Mn > Zn > Fe

500m, Cr> Co > Mn >Pb > Cu > Cd > Zn > Fe

In wet season, Fe was noticed to have the highest concentration in all the distances from where samples were collected because, the soil is possibly ferruginous in nature, this agrees with Dan'azumi and Bichi(2010). This was followed by Co. The highest value of Fe (44.68mg/l) at 100m distance in wet season reduced to 9.09mg/l at 500m distance in the same season and also reduced to 3.46mg/l in dry season.

The lowest concentration was that of Cu and Cd as shown on Table 2. The concentration of Co, Mn and Cu increased as the distance increased in wet season and they also increased in the same manner in dry season, this may possibly be as a result of increased rush in the flow of the river which tends to carry down most of the materials along its course.

Zn, Fe, Pd and Cr decreased as we go down the river in wet season because some of the metals form complexes. Fe decreased drastically down the river in dry season, possibly due to reduction in flow, while others increased. Also in the dry season, Cr had the greatest concentration which was followed by Cu.

Fe and Zn had the least concentration, this may also be as a result of reduction in flow. Generally, the values of these metals down the river decreased in the dry season. Mn and Zn do not have definite variation in both wet and dry seasons, may be because they are not major pollutants in the effluent.

All these variations when compared with the values obtained upstream shown on Table 2, shows variation in the concentration of these metals across the seasons.

Table 2: Concentration of Chemical Elements in Water and Soil Collected Downstream of River Challawa 100m interval (mg/l).

Chemical Properties Downstream 100m Interval								
Wet Season Distance	**Co**	**Cd**	**Zn**	**Mn**	**Cr**	**Fe**	**Pb**	**Cu**
100m	0.16	0.01	0.04	0.04	0.05	44.68	1.9	0.01
200m	0.68	0.01	0.03	0.06	0.01	39.89	0.8	0.02
300m	0.76	0.01	0.04	0.53	0.09	43	1.1	0.02
400m	0.79	0.01	0.06	0.06	0.06	9.09	0.42	0.01
500m	0.22	0.01	0.02	0.33	0.04	9.09	0.38	0.03
Dry Season Distance	**Co**	**Cd**	**Zn**	**Mn**	**Cr**	**Fe**	**Pb**	**Cu**
100m	0.07	0.02	0	0.19	3.46	0	0.05	0.05
200m	0.24	0.01	0.01	0.25	15.27	0.02	0.05	0.69
300m	0.28	0.01	0.01	0.29	0.2	0	0.06	-0.2
400m	0.08	0.02	0.01	0.01	0.46	0	0.13	0.23
500m	0.31	0.02	0.01	0.24	0.37	0	0.22	0.03

CONCLUSION

The research on the effects of industrial effluents on the water resources of Challawa industrial area which was prompted as a result of numerous health, economic and environmental complaints by the inhabitants of the area was done by analyzing chemically the water resources from the industrial area and critically compared them with those of the adjacent unaffected area and these conclusion were drawn:

Since the result of the sludge analysis showed a decrease in the concentration of Co, Zn, Mn, Fe and Pb in the wet season and during dry season, Co, Cd, Cr and Fe were equally less when compared with the concentrations at the upstream, downstream and groundwater, therefore, these industries may have been treating their effluent in-house before discharging them into the environment but may not have been treating them thoroughly and this shows that water resources at the industrial area may not be as polluted as suspected at the present but in future, the accumulated elements may infiltrate into it and pose great danger to human health.

The increase in the concentration of chemical elements down River Challawa revealed that there is proliferation of effluent channels into the river which invariably may be causing pollution downstream.

RECOMMENDATIONS

i Fishing activities in the river should be prohibited because; long time exposure of humans to these heavy metals that may be contained in the fish through food intake may be dangerous due to bio- accumulation.

ii. There is great need for serious enlightenment program by all stake holders.

iii. Strict enforcement measures on the defaulting industries in treating their effluent thoroughly in- house before discharging them into the environment be encouraged and siting of residential quarters at industrial areas should be prohibited.

iv. The industries should be forced to always subject their effluent for analysis by research students and the monitoring bodies.

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