Toxicological Implications of Polluted Water from Makera Drain, Kaduna on Some Cereals and Horticultural Crops

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Abstract

Concentrations of some heavy metals in crops such as banana, pawpaw, maize, sugarcane and mango irrigated with water from Makera drain, Kaduna-Nigeria were investigated. These were determined by Atomic Absorption Spectrophotometer (AAS) technique. The metals were found to be in the magnitude of Zn> Pb> Cr >Cu, while that of the trace metals are Mg>Na>Ca in decreasing order of magnitude. There was varying level of significance ($p<0.05$) with increased concentrations of the determined metals. The high lead and chromium concentration (above WHO limit) in the irrigated crops may lead to its toxic effects as it can bio-accumulate in the tissues and muscles of human and domestic animals that utilize them as feed. It is thus observed that the water from the Makera drain used to irrigate crops may have delibetating effect on the consumers. Consumption of crops irrigated along the drain should be discouraged as it might contain high concentration of chromium and other toxic substances.

Keywords: *Polluted water, Crops, Metals*

Introduction

In the past, the adverse effects of human activities were dispersed over large expanse of land and sea. In recent years, particularly in many African countries, there has been a remarkable increase in urbanization, leading to exploitations of resources and industrial activities. These transformations have brought about huge increase in the quantity of discharges and a wide diversification of pollutants that are discharged into the environment through air emissions, effluent from industries and solids wastes from diverse human activities (CIFA, 1992). The presence of metals in the aquatic environment has been of concern since their toxicity was first documented in 1960s (Uchida *et al.*, 1961).Metals analysis are an important part of environmental pollution studies (Loska *et al.*, 2000; Chibowski, 2000; Solecki and Chibowski, 2000; Czarrnowska and Milewska, 2000**).** Some trace metals are essential in plant nutrition, but plants growing in a polluted environment can accumulate elements at high concentrations, causing a serious risk to human health (Vousta *et al*. 1996; Sharma *et al.*, 2004). Metals tend to accumulate in aquatic animals and plants by absorption through body and respiratory surfaces, and by ingestion of particulate matter and food. The main sources of trace metals to plants are the air and soil from which metals are taken up by the root or foliage. The uptake of metal concentration by roots depends on speciation of metal and soil characteristics and type of plant species etc. Consequently, metal mobility and plant availability are very important when assessing the effect of soil contamination on plant metal uptake, as well as translocation and toxicity or ultra structural alterations (Chandra Sekhar *et al.*, 2001). Toxicity manifests as impairment of metabolic function, with possible changes to the distribution and abundance of population (Anon, 1990). Repeated contaminated water application to soil can lead to the accumulation of trace metals in soils of the cultivated zone, and potential metal accumulation in agricultural produce and the buildup of heavy metals in soils may constitute a hazard to the consumers of harvested crops (Younas *et al*., 1998). Plants can tolerate a relatively high content of heavy metals in soils, but if they accumulate to large quantities, they may cause harmful effects not only to plant growth but also to humans and animals feeding on these plants (Gupta and Gupta, 1998).

Materials and Method

Kaduna metropolis is located in Northern Nigeria (lat. 10.20°N, long. 7.23°E). The wet season is characterized by torrential rainfall from May to October, while the dry season is November to April. The natural vegetation cover is tropical grassland of the Northern guinea savannah type with short scattered trees interspersed with tall grasses (Oniye *et al*., 2002). Urbanization has taken over the original vegetation of Kaduna. The soil is mainly sandy clay, which reduce infiltration and accelerate overland flow and erosion particularly where the soil surface has little or no vegetation cover.

Makera drain is located in the southern part of Kaduna; and receives effluent from United Nigerian Textile Plc, Kaduna Textile Limited (KTL), Zamfara Textile Limited, Nigerian Brewery Limited and Chanchangi oil depots. It is one of 53 drains that empty to river Kaduna.

Studyarea:

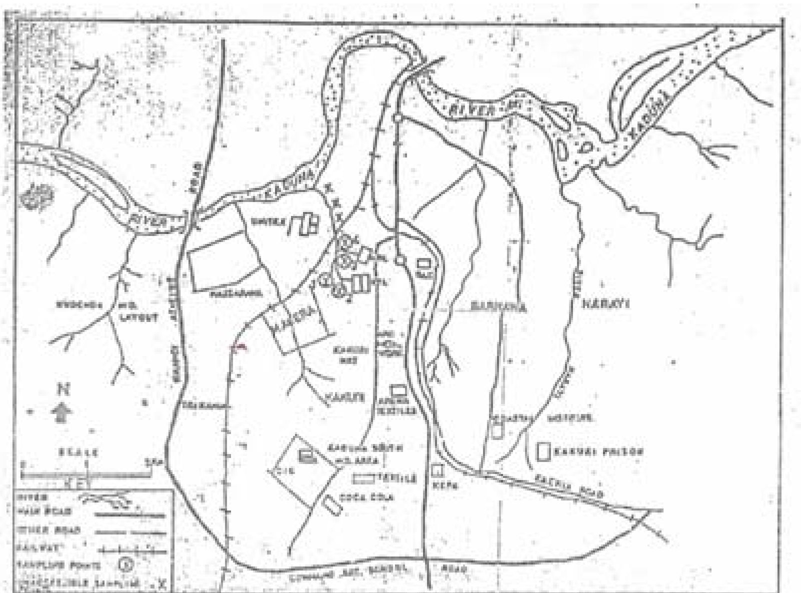

FIG.1 THE STUDY AREA; INDUSTRIES, THEIR EFFLUENTS AND SAMPLING POINTS

Sampling Sites

Site 1 is a tributary that receives domestic waste from the town, dominated by macrophytes like *Tridax procambens, Ipomea hederifig L.* and *Lantana camara*. Site 2 is the beginning of the drain and receives industrial effluent from KTL with *Cassia tora* linn*, Cassia asiamea* linn and *Obtusifolia* linn as the most dominated macrophytes. Site 3 is the confluence of the tributary and the main drain, where macrohytes like Vosia cuspidate, Amaranthus spinosus and Nymphaea lotus were the most common while site 4 is the downstream which receives effluents from NBL, UNTL, Changchangi oil depot and Norspin dominated by all the macrophyes identified in the other sampling sites.

Metal Analysis in Crops

Sampling and Analysis of soil and water
Soil samples were collected monthly by manual core sampler (0-15cm) from four sampling points; stored in glass bottles and dried at room temperature. 10.0g of dry soil from each point was poured into a beaker and 100ml of 20% HNO_3 was added. This was boiled gently for 10 minutes, filtered while warm to avoid reprecipitation and diluted to 100.0ml with deionised water. Water samples were collected, from the four sampling points in a two (2) liter plastic jar, the jars were screwed – tight, placed in a plastic box containing ice and transported to chemical laboratory of Kaduna Refinery Petrochemical Company (KRPC) for analyses.

Samples were then analysed for metal ions with Unicam 919 atomic absorption spectrophotometer (AAS) using 1% HNO_3 as blank as described by American Standard for Testing and Materials (ASTM, 2001).

Results and Discussion

Maize
The metals concentrations of sodium, zinc, lead copper magnesium; chromium and calcium in the present study are presented in Table 1. All the metals examined were found to be present in the various selected crops. Table 1 showed Analysis of the data in the present study, where the level of concentration of lead in maize is 0.51mg/l, while the permissible limit is 0.1mg/ (WHO, 1994)). This is toxic for the consumer of maize cultivated with the drain water, considering the effect of accumulation in food chain, leading to its bioaccumulation in human body, which threatens human life. Unlike organic compounds, lead is non-degradable and persistence in nature. Too high lead intake by man (and animals) may lead to toxic effects following accumulation in liver, kidneys and bones (ATSDR, 2005**).** Largest intake under normal conditions is through food, especially in the form of vegetables and meat. Children are particularly at risk and can suffer a variety of ill effects such as hyperactivity, a lowered IQ and even brain damage (ATSDR, 2005**).** Lead contamination in spinach, tomatoes and fish in River Kaduna were reported by Igusi et al (2002). Chromium was also high but the level of Zinc and copper were less than the permissible limits while that of chromium was higher than the permissible limit. This means consumers of maize are at risk of chromium poisoning. Sodium is an essential nutrient involved in fluid and electrolyte balance and is required for normal cellular function. Dietary deficiency of sodium is very uncommon due to the widespread occurrence of sodium in foods. For sodium, the acceptable range of intakes for adults established by the Scientific Committee on Food was 25 t0 150 mmol/day (SCF, 1993). Calcium on the other hand must be ingested with the diet in sufficient amounts to allow for calcium deposition during bone growth and modeling and to compensate for obligatory intestinal, faecal and dermal losses during the life-time (SCE, 2006).

Sugar Cane

The level of chromium concentration in sugar cane was 0.3mg/l, while the permissible limit was 0.05 (Table 1). This result showed that chromium poisoning of sugar cane can occur where the water is used for irrigating sugar cane. Cchromium VI can produce lung tumors when inhaled and readily induces skin irritation (ATSDR, 2005). Chromium was high in analysed sugar can and the implication of consuming such crop include cancer of the skin, lung tumor, irritation of the digestive system and poisoning of the blood (ATSDR, 2005). Heavy metals accumulate in biological systems and in passing through the food chains, undergo bio-magnification. It has been reported that heavy metals contaminations found in human bodies in urban industrial areas were the result of consuming contaminated foods, rather than through air pollution (Flynn, 1999).

Mango and Banana

Mango and banana are among the fruits that are consumed fresh and raw and therefore concerted effort must made to ensure that consumers are not prone to risk of metal element poisoning. The level of concentration of zinc, lead and copper are below permissible limit in mango. The level of concentration of chromium was higher than the permissible limit, which implies consumers of mango irrigated with the drain water are at risk of chromium poisoning. The test results of the levels of concentration of zinc, lead and copper were below permissible limit. The concentration level of chromium was as high as 0.3mg/kg, while permissible limit is 0.05mg/l.

Pawpaw

Chromium concentration in pawpaw was 0.18mg/l while the permissible limit is 0.05mg/l, which implies that the water is polluted by chromium. Ingesting large amounts of chromium (VI) can cause stomach upsets and ulcers, convulsion, kidney and liver damage and even death, while skin contact results in irritation and ulcers. (ATSDR; 2005). The adverse consequences of consuming water and food containing high level of chromium VI which include lung tumors and skin irritation have also been reported (Trouser *et al.*, 1994). Consequently poisoning consumers of pawpaw cultivated by water from this drain when accumulated. Zinc, lead and copper concentrations were below permissible limit of metallic contamination in food which made pawpaw consumers free of metallic element poisoning. The comparatively high calcium concentration obtained in soil and surface water could be attributed to industrial and domestic discharge, Oniye *et al.* (2002) attributed high concentration of metallic ions to composition of the catchment's area of an aquatic environment, fertilizers, insecticides and herbicides used within the immediate vicinity

Table 1: *Mean values of some metal elements in some crops irrigated with Makera drain- Kaduna, Nigeria (mg/l)*

Crops	**Metal Element**													
	Na		**Zn**		**PB**		**Cu**		**Mg**		**Cr**		**Ca**	
	TR	PL	TR	PL	TR	PL	TR	PL	TR	PL	TR	PL	TR	PL
Maize	1.85	-	1.03	5.0	0.51*	0.05	0.03	5.00	8.34	-	0.25*	0.05	2.27	-
Sugar cane	4.92	-	1.28	5.00	0.64	2.00	0.28	5.00	3.26	-	0.34*	0.05	3.19	-
Mango	8.83	-	1.13	5.00	1.02	2.00	0.32	5.00	8.67	-	0.27*	0.05	2.72	-
Banana	4.75	-	1.28	50.0	2.21	7.00	0.26	50.0	8.49	-	0.30*	0.05	6.92	-
Pawpaw	4.95	-	1.15	50.0	0.71	2.00	0.27	50.0	9.75	-	0.18*	0.05	5.17	-

TR *= test result,* ***PL*** *= Permisible limit of metallic contamination in food and * = above PL*

Table 2: *Mean Values of Some Heavy Metals in Soil and Water of Makera Drain, Kaduna-Nigeria (ppm)*

Parameters (ppm)	**Months**								
	Aug.	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**SE±**	**CV (%)**
soil									
Na	37.35	38.88	14.30	8.95	3.6	16.70	39.89	3.00	0
Zn	11.3	0	4.41	1.43	1.35	146	2.20	0.83	60.2
Pb	0.01	0.10	0.15	1.63	0.81	1.65	0.38	0.83	55.5
Cu	20.40	0.28	0.60	0.55	0.14	0	0	43.10	0
Mg	35.43	4.53	8.48	7.54	5.33	8.10	18.98	1.46	118.8
Cr	0.73	0.80	0.42	0.38	0.41	0.31	2.66	3.30	37.4
Ca	4.05	14.08	5.22	3.00	5.95	6.75	12.02	176	135
Water									
Na	0.40	49.28	38.86	29.98	21.11	37.93	38.20	3.03	16.4
Zn	0.12	0	1.03	0.72	0.01	0.03	0.33	0.09	7.6
Pb	0.18	0.22	0.11	1.51	0.50	1.96	0.49	0.16	0.0
Cu	0,24	1.88	0.28	0.35	0.28	0	0	0.16	41.69
Mg	0.35	5.62	4.53	7.17	5.33	8.10	8.10	0.80	65.48
Cr	0.86	0.33	- 0.71	0.03	0.30	0.54	3.04	0.22	0.2
Ca	7.67	4.45	8.52	6.36	11.94	13.74	13.74	1.31	84.5

The monthly levels of the metal concentrations and the mean metal concentration of the four sampled stations showed that Cr>Cu>Pb>Zn in water while it was Cu> Cr>Pb>Zn in soil that is, in decreasing order of magnitude as shown in table 2. The trace metals on the other hand was sodium>Magnesium>Calcium in that order of decreasing magnitude as shown in table 2. Balarabe (2001) reported alkalis and alkaline metals concentration in this order of decreasing magnitude Na>Ca>Mg>K at Kwangila pond. Lead concentration was high during the dry season compared to wet season, this could be due to textile and brewery effluents which contain this element, low dilution due to absence of rain and higher evaporation during the dry season. Other plausible sources of lead into the drain may be used engine oil and automobile exhaust discharges, cells of batteries and fumes from industrial chimneys. The concentration of Pb was above WHO limit for drinking water (0.01mg/l) consequently the direct use of water from this drain by rural dwellers without treatment could be detrimental to human health, as it may result in possible neurological damage to foetuses, abortion and other complication in children under three years old (Pacific, 2005).

Conclusion

High lead and chromium (above WHO limit) in irrigated crops revealed in this study may lead to toxic effects following accumulation in liver, kidneys, bones, and also hyper activity, lowered IQ and even brain damage in human and domestic animals that feed on the crops. Hexavalent chromium observed can cause lung tumors and induce skin irritation.

Recommendation

Consumption of crops irrigated along the drain should be discouraged as it might contain high concentration of chromium and other toxic substances.

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