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Concentrations of Pb, Cu, Fe and Cd during the dry season in River Jakara, Kano, Nigeria

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ABSTRACT

The concentration of Pb, Cu, Fe and Cd in River Jakara in Kano was determined during the dry season of January to April 2003 by atomic absorption spectrophotometer (AAS). The monthly levels of the metal concentrations and the mean metal concentrations of the five sites showed that Fe > Pb > Cu > Cd. The concentration of these metals were higher than the World Health Organisation's (WHO) recommended levels of 0.1 mg/l, 0.05 mg/l, 0.1 mg/l and 0.01 mg/l for Pb, Cu, Fe and Cd respectively for drinking water. The concentration of Cd in some sites in April (0.1 - 0.2 mg/l) was slightly higher than the recommendation (0.05 - 0.1 mg/l) in water meant for irrigation. There was no significant variation ($p > 0.05$) in the concentration of Pb, Cu and Fe between the months, but Cd varied significantly ($p < 0.05$) between months. There was also no significant difference ($p > 0.05$) in metal concentrations between the sites. The study highlights the implication of the high concentration of these metals, particularly Cd in the biota and its consequences on vegetables irrigated with River Jakara water, and ultimately on consumers of the vegetables.

INTRODUCTION

Rapid increase in populations, coupled with other factors such as urbanisation, 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. Pollution of water bodies with heavy metals from variety of sources is becoming a matter of global concern. Nigeria generates over 500,000 tons of waste annually and Lagos alone generates over 200,000 tons much of which are dumped into the Lagos lagoons, creek and the sea [1]. Studies on the Lagos lagoon [2] reported heavy metal enrichment by Cd, Co, Cu, Cr, Fe, Mn, Ni, Pb and Zn; land based urban and industrial waste sources were implicated as major pollutants. In the Kaduna River, heavy metals such as Fe, Co, Pb, Cd, Hg and Ar were recorded in the surface water in very high concentrations [3]. The occurrence of Fe, Cu, Zn and Pb in the Upper Kubanni Basin in high concentrations above recommended standards for drinking have also been revealed [4] and [5], while [6] reported high concentration of Fe, Ni, Pb, cu, Mn and Cr in Challawa River in Kano.

River Jakara, also in Kano State, receives industrial effluent, domestic wastes from homes, commercial establishments, agricultural fields, abattoir, mechanical workshops and other sources which have undermined the potability of the river water. The pollutants from these sources may contribute heavy metals to the river which is now being used extensively for irrigation of vegetables and fruits especially during the dry season. This study therefore was designed to determine the concentration of some heavy metals in the surface water of River Jakara that is used for irrigation.

MATERIALS AND METHODS

Sampling Points

Five designated points along the River Jakara were used for the study. Site 1 is the 'T' junction of Ibrahim Badamosi Babangida and Ibrahim Taiwo roads. Site 2 is the abatooir and Katsina roads junction. Site 3 is the Burma and Zungeru roads junction. Site 4 is the airport road bridge and Site 5 is the PRP village (Figure 1). While Site 1 receives little or no pollution, Site 2 receives domestic sewage and effluent from Fagge and abattoir respectively. Site 3 receives sewage from Sabon-Gari and mechanic wastes from off Katsina road and Egbe street. Site 4 receives wastes from Sabon-Gari (no-man's land) extension while Site 5 receives wastes from Gwagwarwa and PRP quarters.

Sampling

Water samples were collected from the designated points in triplicates in clean dark two-litre plastic containers with screw caps. The samples were taken to

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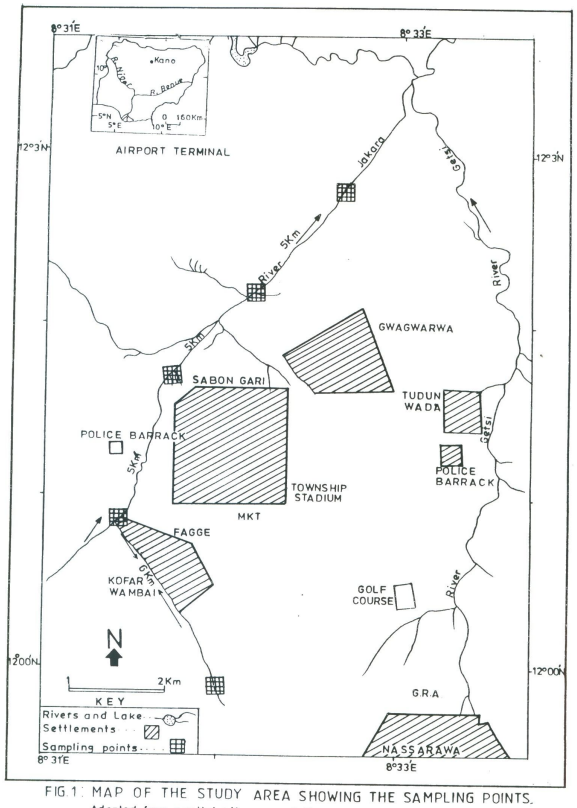


FIG.1: MAP OF THE STUDY AREA SHOWING THE SAMPLING POINTS.
Adopted from capital city map of Kano by federal survey, Lagos 1992.

the laboratory in boxes containing ice. Samples were

collected monthly during the dry season (January to April 2003) between the hours of 10 am and 12 noon.

Determination of Pb, Cu, Fe and Cd

Digestion of samples was first carried out based on the methods of [7], using concentrated HNO_3 and the metal concentrations were determined using flame atomic absorption spectrophotometer (AAS), Buck Scientific Model 210 at National Research Institute for Chemical Technology, Basawa - Zaria, Nigeria.

Data analysis

Variations in metal presence and concentrations between the months of study and between the five sampled sites were compared, using a one-way analysis of variance (ANOVA).

RESULTS

The monthly concentrations of Pb, Cu, Fe and Cd and their trends over time in water samples from five sites are presented in Figures 2-6. The equations of the trend lines for the different sites are presented in Table 1. In Sites 2-5, Pb showed positive trend while Site 1 showed a negative trend. Copper and Fe had negative trend lines in most sites except Site 2 which was positive. Cadmium also maintained positive trend also in all the sites except in Site 2 where the level of concentration was too low to show any trend. Generally, the metals were found to be in the magnitude of Fe > Pb > Cu > Cd.

The mean metal concentrations at the five sites are presented in Table 2. They occurred in the same order as the monthly concentrations. Mean Fe concentrations were lowest in Site 1 (1.220 ± 0.43 mg/l) and highest in Site 2 (10.213 ± 3.69 mg/l), while mean Pb concentration was highest (1.818 ± 0.47 mg/l) in site 5 and lowest (1.005 ± 0.23 mg/l) in Site 4.

Mean Cu concentrations were lowest in Site 3 (0.245 ± 0.09 mg/l) and highest in Site 2 (1.390 ± 0.84 mg/l). In Sites 2 and 3, Cd mean concentrations were 0.029 ± 0.020 mg/l and 0.031 ± 0.021 mg/l respectively.

Analysis of variance of mean metal concentrations did not vary significantly ($p > 0.05$) from one month to another, but Cd varied significantly ($p < 0.05$) between months. There was also no significant difference ($p > 0.05$) in metal concentrations between the sites.

DISCUSSION

The concentration of Pb, Cu, Fe and Cd in River Jakara exceeded the international recommended

Table 1: Equation for trend lines for the different sites

Site 1	Site 2	Site 3	Site 4	Site 5
Pb y = 0.43x + 2.49	Pb y = 0.07x + 1.14	Pb y = 0.23x + 0.71	Pb y = 0.23x + 0.42	Pb y = 0.26x + 1.16
Cu y = -0.11x + 0.56	Cu y = 0.23x + 0.82	Cu y = -0.11x + 0.5	Cu y = -0.19x + 0.79	Cu y = -0.20x + 0.81
Fe y = -0.43x + 2.3	Fe y = 4.17x - 0.202	Fe y = -2.34x + 9.48	Fe y = -2.22x + 8.82	Fe y = -2.24x + 9.24
Cd y = 0.03x - 0.04	Cd concentration too low	Cd y = 0.03x - 0.04	Cd y = 0.03x - 0.04	Cd y = 0.03x - 0.04

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Table 2: Mean metal concentrations in the sites (mg/l ± S. E.)

		Sites				
Metal	Months	1	2	3	4	5
Pb	Jan-Apr	1.405 ± 0.27	1.310 ± 0.21	1.278 ± 0.21	1.005 ± 0.23	1.818 ± 0.47
Cu	Jan-Apr	0.285 ± 0.11	1.390 ± 0.84	0.245 ± 0.09	0.313 ± 0.14	0.303 ± 0.15
Fe	Jan-Apr	1.220 ± 0.43	10.213 ± 3.69	3.630 ± 1.40	2.980 ± 1.35	3.635 ± 1.31
Cd	Jan-Apr	0.030 ± 0.019	0.029 ± 0.020	0.031 ± 0.021	0.030 ± 0.021	0.030 ± 0.021

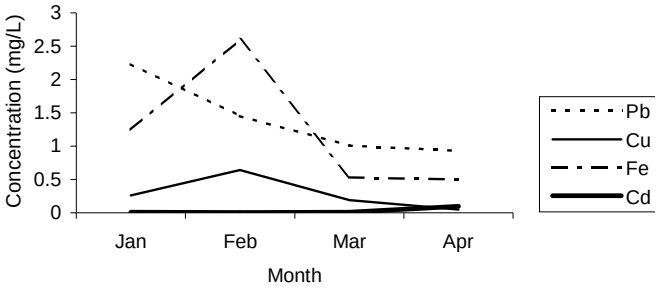


Figure 2: Trend over time for metals in water samples collected in site 1

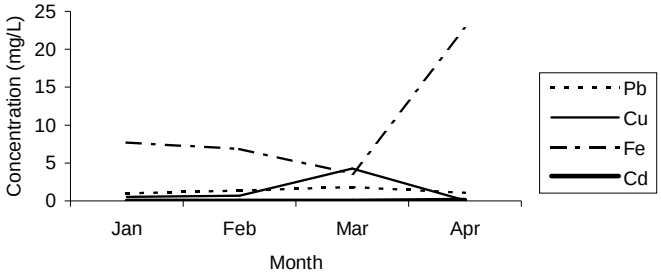


Figure 3: Trend over time series for metals in water samples collected in site 2

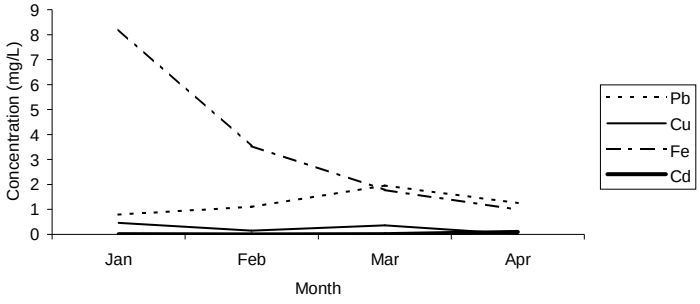


Figure 4: Trend over time series for metals in water samples collected in site 3

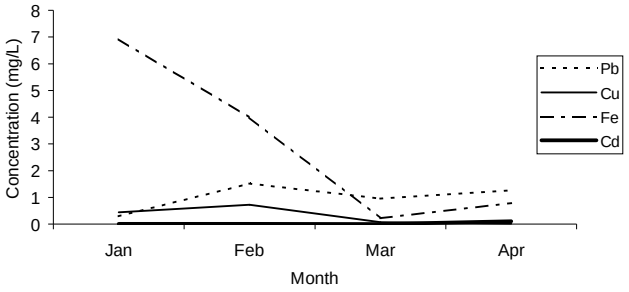


Figure 5: Trend over time series for metals in water samples collected in site 4

desirable levels for drinking water. The World Health Organisation (WHO standard guidelines for Pb, Cu, Fe and Cd are 0.1 mg/l, 0.05 mg/l, 0.1 mg/l and 0.01 mg/l respectively [7].

Similarly, high levels of these metals in the surface water of some Nigerian rivers were reported by [2,3,4]. All the metal values obtained were within the limits for irrigation.

The recommended maximum concentration for irrigation for Pb, Cu, Fe and Cd are 5 - 10 mg/l, 0.2 - 5.0 mg/l, 5 - 20 mg/l and 0.05 - 0.10 mg/l respectively [9 and 10]. However, the values of Cd were slightly higher in all the sites in the month of April. The concentration of Cd uptake in plants that may eventually be consumed by

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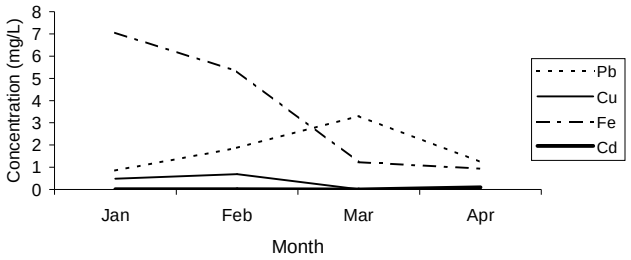


Figure 6: Trend over time series for metals in samples collected from site 5

man raises serious health concern. Cadmium is suspected to have carcinogenic and mutagenic effects in humans that are exposed to Cd contaminated foods or water [11].

The high level of metal concentrations could be attributed to the period of sampling which was in the dry season, and different anthropogenic inputs such as industrial, agricultural and sewage effluents. Land based urban and industrial waste sources have been implicated as major sources of metal enrichment in some Nigerian rivers [2, 6,12] and rivers in other African countries [13,14,15].

Iron compounds are generally reduced from ferric (Fe^{3+}) to ferrous (Fe^{2+}) in the absence of oxygen and presence of organic matter. Ferrous (Fe^{2+}) is more soluble than Fe^{3+} and this accounts for the higher concentration of Fe in all the sites than other elements. High iron levels above WHO desirable limit in the surface water of the upper Kubanni Basin in Kaduna State and Challawa River in Kano State were reported by [16] and [6] respectively. Although iron is an essential nutrient of blood and skeleton, ingestion of large amounts can lead to its accumulation in the body, tissue damage and hyperhaemoglobularia [17]. Cadmium concentration in all the sites may appear low it could be attributed to the high mobility of the metal, and that huge amount of it is required for its accumulation [18].

CONCLUSION

River Jakara is highly polluted through anthropogenic sources. Though the water is not potable for drinking, it is used for the irrigation of vegetables and fruits, which is consumed by the inhabitants of Kano and its environs. Therefore, the biomagnification of these metals in irrigated farmland, crops and vegetables requires continuous monitoring and further elucidation.

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