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IMPACT OF THE EFFLUENT DISCHARGE FROM A BREWERY PLANT ON THREE COMMUNITIES IN IBADAN MUNICIPALITY, SOUTH WESTERN, NIGERIA

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ABSTRACT

A preliminary assessment of the extent of pollution of water, soil and plant due to an effluent discharge from a brewery industry to the territory of three rural communities in Ibadan municipality was carried out. Chemical analysis of the brewery effluent, receiving stream, ground (well) water, soil and plant samples taken randomly from cultivated land at the stream bank were carried out. The results showed higher concentrations of Cd, Cr, Cu and Ni in most of the water samples with values higher than the WHO, EU and USA standards tolerant levels. The pH for the stream and well water ranged between 5.35 and 6.65, some of which are below the WHO recommended levels of between 6.0 and 9.0 meant for human consumption. Furthermore, the pH of sampled soils ranged from 4.75 to 5.35 indicating acid medium, while concentrations of Pb, Cr, Cu and Ni were observed to be higher in some of the soil samples compared to the reference samples both at 0-20 cm and 20-40 cm. However, plant analysis results showed that some of the samples contained high levels of Cu, Fe and Mn. while Cd, Pb, Ni, and Cr were not detected. There was therefore contamination of surface and ground water, which could probably be hazardous to human health when used primarily for domestic purposes.

KEY WORDS: Effluent; Heavy metals; Water pollution; Soil pollution.

INTRODUCTION

Industrial wastes are regarded as sources of pollution, which need to be disposed off to avoid contact with productive soil, natural water systems as well as ground water and air. In Nigeria, most industrial wastes (effluents) are indiscriminately discharged without treatments into canals, rivers and along roadsides in the vicinity of the industrial plants. These effluents usually contain some amounts of heavy metals and toxic compounds originating from processing of raw materials or including compound additives used in production. Some industrial wastes may contain heavy metals such as, Cd, Cu, Cr, Ni, Pb, Mn, As, Hg and Fe (Aziz et al., 1999; Larsen et al., 1975). Direct and continuous discharge into receiving stream and ground water may result in metal accumulations and its use by man may consequently put human health at risk (Kashem and Singh, 1999).

The presence of some metals such as Ca, Mg, K and Na in effluents discharged from two beverage-processing plants in Ibadan was reported in a recent investigation (Ogunfowokan and Fakankun, 1998). It was suggested that these effluents, although showing safe limit values of the cations, and anions when discharged into a nearby river, their bioaccumulation might give deleterious effects to both aquatic biota and human beings. A number of cases of health problems related to pollution from some heavy metals were also reported in the literature (Gupta and Gupta, 1999; Singh and Steiness, 1994). It was established that, there was possibility of cadmium and mercury poisoning and elevated level of lead and other heavy metals in human blood due to intake of such metals. On the other hand, some heavy metals such as Cu, Fe, Zn, Mn, Mo and Co are termed essential in trace amounts for plant growth and development. However, high concentration or accumulation of these metals in the soil and water can become toxic to biotic life, including microorganisms, plants and man.

The objective of our investigation therefore, was to assess the levels of heavy metal contamination of soil, stream, groundwater and crop plants found in three communities located in the vicinity of a brewery plant in Ibadan municipality.

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Table 1. Chemical characteristics of stream with effluent discharge from a brewery plant and well water close to the stream.

Water	pH	Pb	Cd	Cr	Cu	Ni	Mn	Fe	Zn	Na	K	Ca	Mg
									mgL^{-1}				
A	5.1	ND	0.046	0.45	0.76	0.040	0.21	24.10	2.50	54.00	8.16	7.80	5.68
B	5.3	ND	0.036	0.27	0.13	0.033	0.05	8.32	3.30	47.25	6.80	15.00	5.43
C	5.9	ND	0.040	0.26	0.16	0.034	0.14	16.10	7.48	52.75	7.14	11.20	6.26
D	5.9	0.17	0.037	0.20	0.58	0.039	0.32	41.20	1.50	50.79	7.14	6.60	5.66
E	5.8	ND	0.030	0.22	0.10	0.032	ND	6.19	0.36	50.25	6.12	10.00	3.86
Mean	5.6	0.03	0.039	0.28	0.35	0.034	0.14	19.18	3.03	49.25	7.07	10.12	5.38
Well:													
1	6.2	ND	0.036	0.16	0.04	0.026	0.005	4.68	3.28	45.25	1.70	17.90	14.6
2	6.3	ND	0.024	0.12	0.04	0.027	ND	8.53	0.30	22.50	6.80	15.40	8.06
3	6.7	ND	ND	0.01	ND	0.025	0.31	3.09	1.05	32.62	7.27	25.00	14.57
Mean	6.4	ND	0.020	0.10	0.03	0.026	0.10	5.53	1.95	26.08	5.10	14.93	8.52
Rain	6.8	ND	0.0020	ND	ND	0.001	0.02	ND	ND	24.75	5.55	3.00	0.82

A, B, C, D, E, represent point of discharge (0m), 5m, 300m, 600m and 1200m respectively away from the effluent discharge point along the stream.
1, 2 and 3 mean 25m, 50m and 100m away, respectively from the stream.
ND means not detected.

MATERIALS AND METHODS

The sampling area was located at the vicinity of a brewery industry in Ibadan municipality, Nigeria. Effluent from the brewery plant was discharged directly into a nearby open channel that was connected to a stream flowing through three rural communities of Majawe, Osun and Papa Adogba. Cultivation of crops mostly vegetables, was being practiced by peasant farmers of these communities in the valley bottom located 5 m on both sides of the stream. The stream partly dries during the dry season. But the effluent discharge is a continuous source of water for irrigation. The stream, therefore, served as source of water supply to the growing crops by manual irrigation during the dry season. During the period of our investigation, about 5% of the land area was already cultivated with cocoyam, plantain, banana, maize and vegetable crops such as, lettuce, amaranthus, celosia and tomato.

Effluent water samples (1L each) were sampled randomly from the point of discharge, and 5m, 300m, 600m and 1200m, respectively along the receiving stream into well-corked plastic bottles. Also, some water samples were taken each from dug up wells located 25m, 50m and 100m away from the stream. Eight composite soil samples were taken each at 0-20cm and 20-40 cm depth, randomly, 5m away from both sides of the effluent stream, on nearby cultivated land using auger. Plant tops of cocoyam, lettuce, celosia, amaranthus and maize were also randomly sampled from the cultivated land. The reference samples were randomly taken and bulked at points located 50m away on both sides of the effluent stream. The rain water was collected into plastic bottles placed in the open air on a stand of six feet high. All the above samples were taken to the laboratory for chemical analysis. The soil and plant samples were air and oven dried (at 65°C), respectively before analysis.

Heavy metals in the soil and plant samples were analyzed after wet digestion with nitric and perchloric acids and detected on the Atomic Absorption Spectrophotometer (AAS) using standard laboratory procedures (IITA, 1978). The metals in water sampler were detected directly by Atomic Absorption Spectrophotometry (AOAC, 1995). The water sample was filtered through a membrane and filtrate was heated gently and evaporated to dryness. After cooling, the content was digested using HNO_3, dissolved with HCl, washed and filtered and finally read on the AAS. The metals determined were Pb, Cd, Cr, Cu, Ni, Mn, Fe, Ca, Mg and Zn. Potassium and Na were determined on the flame photometer; while pH (1:1 soil and water, w/v) was determined in the soil and water samples directly using the pH meter (pH meter 526). Correlation analysis of the data obtained from the study was carried out using the procedure described by Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

Results of the chemical analysis of water samples from the stream, to which the effluent from the brewery plant was discharged, are presented in Table 1. The pH of the water samples from the receiving stream was low ranging from 5.3 to 5.9 and increased with distance from the discharge point down the stream. The pH of the well water (6.2-6.7) was higher than that of the stream water samples and similarly increased with distance

Table 2. Concentration of heavy metals in soil, plant at toxic values and water at limiting values in drinking water

Element	*Soil	*Plant	aWater
	mg kg^{-1}		mgL^{-1}
Mn	1500	300-500	0.1
Zn	300	100-400	5.0
Cu	100	20-100	1.0
Fe	1000	300	-
Cd	8	5-30	0.005
Cr	100	5-30	0.05
Ni	100	10-100	0.05[b]

* Source: Pendias and Pendias (1989)
[a]Source: World Health Organization (1984)
[b]Source: EC Guidelines (CEC, 1980)

Table 3. Correlation (r^2) matrix between pH and the heavy metals and for the heavy metals in water samples.

	pH	Cr	Cd	Ni	Cu	Fe
pH	-	-0.926	-0.744	-0.736	-0.516	-0.332
Cr		-	0.866	0.631	0.694	0.332
Cd			-	0.647	0.493	0.565
Ni				-	0.550	0.703
Cu					-	0.843
Fe						-

Table 4. Chemical characteristics of soil close to the stream that received the effluent discharge from a brewery plant and cropped by farmers.

Soil		Depth (cm)	pH	Pb	Cd	Cr	Cu	Ni	Mn	Fe	Zn	Na	K	Ca	Mg
				mgkg^{-1}								Cmol kg^{-1}			
A		0-20	5.30	4.62	0.29	6.25	3.10	3.85	2.50	27.00	3.70	2.20	0.51	3.45	1.71
		20-40	5.05	1.80	0.15	6.20	2.30	2.15	3.44	19.80	2.55	1.98	0.48	2.14	1.08
B	Range:	0-20	4.75 5.15	4.25 10.65	0.17 0.28	4.82 12.37	5.00 13.80	2.65 5.05	1.70 6.40	21.95 89.50	19.50 65.50	2.07 2.39	0.17 0.37	1.56 2.27	0.31 1.04
		20-40	5.05 5.35	3.00 7.87	0.17 0.23	3.10 10.22	2.50 9.30	2.25 4.05	1.50 2.00	9.40 41.00	5.90 51.00	2.10 2.70	0.23 0.35	2.27 9.42	1.04 1.27
	Mean:	0-20	4.89	8.01	0.24	8.61	10.4	3.95	3.87	57.36	46.00	2.22	0.30	1.98	0.74
		20-40	5.20	5.43	0.20	6.66	5.9	3.15	1.75	25.20	28.45	2.10	0.29	5.84	1.17

Soil A – Reference soil samples taken at points located 50 m away from the effluent stream
Soil B – Soil samples taken at points located 5 m away on farmland at both sides of the effluent stream
Numerator is the lowest number in the range
Denominator is the highest number in the range

from the discharge point. However, the pH of rainwater was close to neutral and remained the highest among the water samples.

The concentration of heavy metals such as Pb, Cd, Cr, Ni, Fe and Mn were found to be relatively higher in the stream water samples than in those of well water. The well situated close to the stream however, showed higher concentrations of Cd, Cr and Ni in water samples than other wells located farther away. The levels of these metals were found to decrease with distance from the stream. This could be partly due to dilution of the effluent by the underground water. Water samples showed mean concentrations (mgL^{-1}) of Cd (0.039), Cr (0.28) and Fe (19.18) that were above the World Health Organization (WHO) limits for drinking water (Table 2). Only one water sample (300m from the effluent discharge point) from the stream contained Zn at levels above the WHO limit, while Cu in the samples remained within the maximum allowable concentrations in drinking water. The mean level of Mn in the water samples was found to exceed the permissible levels. Continuous intake of such water would therefore be harmful to human health both in the short and long run (Kashem and Singh, 1999).

The concentrations of elements such as Na, and K, were also found to be relatively higher in the stream water than in well water, which was in turn higher than in rainwater. Metals such as Ca and Mg were observed to be higher in well water than in other water samples, which could cause hardness of the well water. The high levels of these elements in the well could occur possibly partly due to the nature of the soil parent material, and due to the brewery effluent water. Table 3 presents the correlation matrix (Gomez and Gomez, 1984) for heavy metals in the water samples. The results showed that most of the metals were positively significantly interrelated with each other ($p<0.01$). The exception was Fe, which was poorly correlated with Cr. On the other hand, the pH of the water samples was found to correlate negatively with all the heavy metals. It was established that, the more acidic the water was, the higher the level of heavy metals in the water samples. According to Petruzzelli (1989), the availability of heavy metals tends to be lower at higher pH owing to the formation of very strong precipitates, adsorption and increased stability of complexes with humic substances. Soluble complexes with various heavy metals in the organic compounds might be formed and these complexes therefore might become mobile and available in the effluent water sample

Table 4 presents the chemical characteristics of the soils sampled for analysis. The soil was generally acidic as the pH ranged from 4.75 to 5.15 in the topsoil and 5.05 to 5.35 in the subsoil. Most of the heavy metals were found

Table 5. Chemical characteristics of crop plants grown on soil located around the effluent discharge from the brewery industry.

Element.	Cd, Pb	Ni, Cr	Cu	Mn	Fe	Zn	Na	K	Ca	Mg
	mgkg^{-1}						%			
Range values	ND	ND	7.5 / 35.0	30 / 1575	110 / 1075	50.0 / 745.0	0.12 / 2.78	1.67 / 2.47	0.13 / 1.10	0.10 / 0.38
Mean Values	ND	ND	12.8	498	337.8	184.7	0.60	2.12	0.71	0.29
Check	ND	ND	7.5	300	162.5	62.5	0.17	3.40	0.86	0.23

ND – Not detected
Check – Plants from farmland located 50 m away from the effluent stream.
Numerator is the lowest number in the range
Denominator is the highest number in the range

to be lower in the reference soils than in soils sampled close to the stream. The topsoil contained higher concentrations of most of the heavy metals determined than in the subsoil indicating higher contamination of the former than the later. The concentrations of Cu, Fe, Pb, and Mn, were 235%, 112%, 73 %, and 55% higher, while Zn was twelve times higher in the top soil than in the reference soil. Although there were fairly large variations in the concentration of Pb, Cu and Cr in the soil, distribution of the metals with distance from the effluent discharge point was not consistent indicating possible interference by soil reaction due to natural factors or cropping activities by farmers. However, the levels of these metals in the soil appeared to be lower than the toxic values quoted by Kabata and Pendias (1989).

Heavy metals such as Pb, Cd, Cr and Ni were not detected in the plant samples (Table 5). This might be due to the selective absorption of the nutrients by the various crops growing in the area close to the stream. However, the concentrations of metals such as Mn, Cu, Fe and Zn ranged from moderate to high in the plant tissue. They were found to be higher in plants grown on soil close to the stream than on the reference soil located 50 m away by 66%, 71%, 108% and 195%, respectively. The levels of the metals except Cu in plant samples as shown in Table 5 were in the toxicity range (Gupta and Gupta, 1999; Pedias and Pedias, 1989). On the other hand, Ca and Mg were moderately concentrated in the plants.

CONCLUSIONS

The results of the present study suggest that the effluents discharged from a brewery plant were responsible for heavy metal pollution of the stream that flows through and well water in the three communities located at the vicinity of the plant in Ibadan municipality. Contamination of most of the wells by Cd, Cr, Cu and Fe was evident based on standards established by scientific findings, and current WHO and EC limits for permissible levels of water quality. The pH of the water was also below permissible level. On the whole, such water would definitely cause health hazard to man when used for consumption. Among the heavy metals analyzed, high levels of Mn, Fe and Zn were found in crop plants.

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