Research Journal of Applied Sciences 2 (4): 340-344, 2007

Soil Quality Around Chemical Industries in Ibadan Metropolis

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Abstract: The effluent and receiving water and soil quality from six chemical industries in Ibadan metropolis was investigated. The heavy metal, minerals and physicochemical properties of the effluents and receiving waters were determined using standard methods. Results show that Cobalt, chromium, copper, Iron, magnesium, manganese, zinc and lead contents of effluents range between 0.17-0.39, 0.04-0.11, 0.01-0.06, 0.04-0.16, 0.09-1.47, 0.06-0.90, 0.12-0.14 and 0.15-0.37 mg L^{-1}, respectively. The heavy metal contents the effluents fall within recommended range. Iron, lead and zinc levels are significantly ($p<0.05$) higher in environments around compared with the control samples. The effluents are rich in inorganic compounds, free ammonia, phosphates, chlorides and nitrates. Significant decreases were recorded in the electrical conductivity and total solids of receiving waters while significant increases were recorded in hardness, dissolved solids, BOD and COD. The levels of calcium and zinc were low and values within the critical limit thus posing little threat to ground water quality.

Key words: Effluents, receiving water, soil quality, chemical industries, Ibadan

INTRODUCTION

Various devastating ecological and human disasters of the last four decades implicate industries as major contributors to environmental degradation and pollution (Ademoroti and Sridhar, 1979; Abdel-Shafy and Abdel-Basir, 1991; Asia and Ademoroti, 2001; Amoo *et al.*, 2004a, b). Industrial wastes like lead, cadmium, mercury, pesticides, polychlorinated biphenyl's, dioxins, poly-aromatic hydrocarbons, petrochemicals and phenolic compounds contain toxic and hazardous substances most of which are hazardous human health (Foess and Ericson, 1980; Osibanjo, 1989; Amuda *et al.*, 2001).

Surface and ground water contamination, including loss of land and aquatic resources are major environmental problems caused by industrialization. Improper disposal of untreated industrial wastes results in coloured, milky, odorous and unwholesome surface waters, fish kills and loss of recreational amenities (Ciaccio, 1972; FAO, 1978; Mahida, 1983; Purdom and Stanley, 1983). A large number of the population still rely on surface waters for drinking, washing and fishing. Industries also need water of acceptable quality for their manufacturing processes.

The objective of this research was to investigate the effect of effluents from chemical industries on the soil quality in Ibadan metropolis.

MATERIALS AND METHODS

Soil samples were collected cross-sectionally (using an auger) from three points at a depth of 15cm from topsoil located about 50m from the effluent outfall points of 6 different chemical industries in Ibadan metropolis. Control samples content, were collected at least 500m from the nearest industry.

Methods: Freshly collected soil and plant samples from the study areas were air-dried, sieved and acid digested before analysis. The samples were analyzed for physical and chemical characteristics. Temperature was measured using a standard size field thermometer; pH was measured as described by Anderson and Ingram (1989) using a Model 3020 pH meter (JENWAY, UK). A Conductivity meter (Model 4010, JENWAY, UK) calibrated with a conductivity standard (0.01 m Kcl with conductivity 1413 μs cm^{-1}) was used for conductivity measurements at 25°C. In both cases, 20 g of soil samples were weighed and suspended in 50mL of distilled water and stirred before introducing probe. Heavy metals (Ca, Cr, Cu, Fe, Mg, Mn, Pb and Zn) were determined using AAS (Buck Scientific model 500A) as described by Juo (1982). Sodium and potassium were determined using a flame photometer. Phosphate, nitrate, ammonium and chlorides were determined using standard methods (APHA, 1992;

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Taras, 1950). The results are expressed in mg kg^{-1}. Means and standard errors of the mean of triplicate readings obtained in the study were subjected to Analysis of Variance (ANOVA) and Duncan's multiple range test using the Statistical Package for Social Scientist (SPSS 10.0) computer software (Oloyo, 2001).

RESULTS AND DISCUSSION

The heavy metal composition of heavy metal contents of effluent and receiving waters from various chemical industries in Ibadan metropolis are presented in Table 1 and 2. Table 3 and 4 shows the heavy metal content of soil and plants around the chemical industries studied. Cobalt, chromium, copper, Iron, magnesium, manganese, zinc and lead contents of effluents range between 0.17-0.39, 0.04-0.11, 0.01-0.06, 0.04-0.16, 0.09-1.47, 0.06-0.90, 0.12-0.14 and 0.15-0.37 mg L^{-1}, respectively. Cobalt, copper, magnesium, manganese and zinc contents are highest in effluents from Associated Match (manufactures matches). Pb contents of effluents from chemical industries are comparable. The heavy metal contents the effluents fall within the range recommended by FEPA (1991), Tang and Ferris (2001). As shown in Table 2, cobalt is highest in the effluent and has comparable values with soil obtained in environments around chemical industries (Table 3). Cobalt content of plants (Table 4) around the effluent discharge points are significantly lower ($p<0.05$) than values obtained for effluent and soil. Copper, iron, manganese, lead and zinc contents are significantly higher in the plant and soil (Table 3 and 4) compared with the effluent and receiving waters. This suggests that the high levels observed in the plant and soil may not be due to effluent discharge. Long term accumulation of these metals may account for the high values obtained in this study. The difference obtained in the upper and lower course of the receiving water showed that effluent discharge do impact on the quality of streams and rivers.

The mineral composition of effluent and receiving waters and mineral composition of plants and soils around chemical industries are presented in Table 5 and 6, respectively. Results show that sodium is higher prior to effluent discharge by Niger Hygiene and Exton industries. The other minerals and ions were higher prior to effluent discharge by the industries. This suggests that mineral and ion load may not be directly attributed to effluent discharge by these industries. This may be attributed to urban and/or other industrial wastes and run-off wastewater carrying wastes into streams and rivers. The magnesium content of soil around effluent discharge points in Ibadan (is lower than values reported for industrial waste dumpsite in Portharcourt (Ana and Sridhar, 2004) while iron, lead and zinc levels are higher in

Table 1: Heavy metal contents (mg L^{-1}) of effluents of individual chemical industries in Ibadan metropolis

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Niger hygiene	0.39c±0.01	0.11b±0.01	0.03a±0.001	0.16c±0.01	0.40b±0.01	0.06a±0.002	0.12±0.01	0.24b±0.01
Siperco	0.17a±0.01	0.11b±0.01	0.01a±0.001	ND	1.16d±0.03	ND	0.14±0.01	0.27b±0.01
Scanink	0.22b±0.01	0.05a±0.002	0.02a±0.001	0.05a±0.001	0.62c±0.02	0.15b±0.01	0.15±0.01	0.15a±0.01
CAPL	0.22b±0.01	0.04a±0.002	0.02a±0.001	0.03a±0.001	0.62c±0.02	0.37c±0.01	0.14±0.01	0.15a±0.01
Exton	0.57d±0.02	0.04a±0.001	0.03a±0.001	0.04a±0.002	0.09a±0.002	0.46d±0.01	0.14±0.01	0.16a±0.01
Associated match Industry	0.74e±0.02	0.10b±0.01	0.06b±0.001	0.08b±0.001	1.47e±0.04	0.90e±0.03	0.14±0.01	0.37c±0.01

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 2: Mean heavy metal (mg L^{-1}) contents of effluents, receiving water from chemical industries and their environs in Ibadan metropolis

Source	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Effluent	0.39bc±0.05	0.08a±0.01	0.03a±0.01	0.06a±0.01	0.73a±0.11	0.32a±0.07	0.14a±0.01	0.22a±0.02
Soil	0.37bc±0.04	0.17b±0.02	1.85b±0.23	377.69c±49.92	0.38a±0.03	108.01b±9.71	5.32b±1.14	47.60c±5.06
Plant	0.07a±0.01	0.10a±0.01	2.70c±0.19	179.59b±48.58	0.26a±0.02	13.17a±2.23	0.21a±0.03	9.93b±1.69
Receiving (Upper)	0.43c±0.05	0.20a±0.04	0.17a±0.02	0.50a±0.02	2.02b±0.39	5.06a±0.82	0.17a±0.03	1.43a±0.25
Receiving (Lower)	0.28b±0.03	0.10a±0.01	0.16a±0.03	0.57a±0.07	2.99b±0.34	6.15a±0.56	0.21a±0.02	2.43a±0.25

Values are means of 3×6 readings±SEM from six chemical industries, Means followed by different letters are significantly different ($p<0.05$)

Table 3: Heavy metal content (mg kg^{-1}) of soils around chemical industries in Ibadan

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Niger hygiene	0.22ab±0.01	0.07a±0.001	1.52c±0.04	183.80b±5.31	0.26b±0.01	110.47b±3.19	1.10a±0.03	22.84a±0.66
Siperco (cosmetics)	0.51d±0.01	0.21d±0.01	1.70c±0.05	275.12c±7.94	0.33c±0.01	73.25a±2.11	1.65a±0.05	38.32b±1.11
Scanink	0.20a±0.01	0.12b±0.01	3.66e±0.11	487.06d±14.06	0.58f±0.02	73.25a±2.11	3.66b±0.11	71.08d±2.05
CAPL	0.25b±0.01	0.14c±0.01	1.03b±0.03	718.06e±20.73	0.19a±0.01	83.52a±2.41	3.24b±0.09	22.30a±0.64
Exton	0.70e±0.02	0.26e±0.01	0.78a±0.02	121.26a±3.50	0.41d±0.01	187.45c±5.41	14.80d±0.43	60.71c±1.75
Associated Match industry	0.34c±0.01	0.19d±0.01	2.41d±0.07	480.84d±13.88	0.52e±0.02	120.10b±3.47	7.44c±0.21	70.37d±2.03

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 4: Heavy metal content (mg kg^{-1}) of plants around chemical industries in Ibadan

Industry	Cobalt	Chromium	Copper	Iron	Magnesium	Manganese	Lead	Zinc
Niger hygiene	0.06b±0.003	0.08b±0.002	1.31a±0.04	312.60c±9.02	0.24c±0.01	14.91d±0.43	0.07a±0.003	18.79d±0.54
Siperco (cosmetics)	0.06b±0.002	0.08b±0.002	2.44b±0.07	56.30b±1.63	0.24c±0.01	5.67a±0.16	0.21c±0.01	6.92c±0.20
Scanink	0.04a±0.002	0.06a±0.002	3.42c±0.10	570.30d±16.46	0.43e±0.01	32.22e±0.93	0.07a±0.001	20.52e±0.59
CAPL	0.10d±0.001	0.11c±0.001	3.42c±0.10	46.42ab±1.34	0.15a±0.01	5.65a±0.16	0.34d±0.01	3.51a±0.10
Exton	0.10d±0.001	0.12d±0.01	3.24c±0.09	68.27b±1.97	0.18b±0.01	7.92b±0.23	0.45e±0.01	4.61b±0.13
Associated match industry	0.08c±0.01	0.12d±0.01	2.36b±0.07	23.64a±0.68	0.33d±0.01	12.62c±0.36	0.11b±0.01	5.23b±0.15

Values are means of triplicate readings±SEM, Means followed by different lowercase letters are significantly different ($p<0.05$)

Table 5: Mineral composition of effluents and receiving waters from chemical industries in Ibadan metropolis

Industry		Sodium	Calcium	Potassium	Phosphate	Ammonium	Nitrate	Chloride
Niger Hygiene	Effluent	11.40a±0.33	1.58c±0.05	5.63a±0.16	0.05b±0.001	1.74f±0.05	0.44a±0.01	36.00a±1.04
	Receiving (Upper)	221.14k±6.38	1.93cd±0.06	27.86b±0.80	0.16c±0.01	0.18c±0.01	0.52ab±0.02	52.00c±1.50
	Receiving (Lower)	128.25i±3.70	2.45e±0.07	43.27de±1.25	ND	0.03a±0.002	0.83b±0.02	40.00ab±1.15
Siperco (cosmetics)	Effluent	27.27b±0.79	2.03de±0.06	7.08a±0.20	0.01a±0.001	2.53g±0.07	0.13a±0.01	36.00a±1.04
	Receiving (Upper)	105.93h±3.06	9.60j±0.28	57.80g±1.67	2.50f±0.07	0.86e±0.02	2.04d±0.06	48.00bc±1.39
	Receiving (Lower)	300.00l±8.66	1.08b±0.03	125.64h±3.63	5.34g±0.15	8.88j±0.26	4.63e±0.13	70.00e±2.02
Scanink	Effluent	10.18a±0.29	2.21e±0.06	7.20a±0.21	0.02a±0.002	0.03a±0.001	0.54ab±0.02	32.00a±0.92
	Receiving (Upper)	299.27l±8.64	1.93cd±0.06	466.12l±13.46	ND	0.39d±0.01	0.26a±0.01	42.00ab±1.21
	Receiving (Lower)	607.35m±17.53	0.76a±0.02	350.17k±10.11	1.26e±0.04	7.98j±0.23	2.12d±0.06	48.00bc±1.39
CAPL	Effluent	22.14b±0.64	2.34e±0.07	6.99±0.20	0.02a±0.001	0.09b±0.003	1.02c±0.03	31.00a±0.89
	Receiving (Upper)	218.18k±6.30	1.42c±0.04	152.48i±4.40	0.51d±0.01	0.17c±0.01	2.20d±0.06	100.00f±2.89
	Receiving (Lower)	230.86k±6.66	3.15gh±0.09	246.74j±7.12	0.12c±0.01	3.52h±0.10	4.81e±0.14	82.00e±2.37
Exton	Effluent	46.54d±1.34	2.90fg±0.08	33.57c±0.97	0.98e±0.03	6.74j±0.19	0.27a±0.01	52.00cd±1.50
	Receiving (Upper)	190.26j±5.49	2.86f±0.08	39.16cd±1.13	0.04ab±0.001	3.42h±0.10	0.86bc±0.02	130.00g±3.75
	Receiving (Lower)	65.44ef±1.89	3.94h±0.11	53.17f±1.53	0.04ab±0.001	4.66i±0.13	5.26e±0.15	100.00±2.89
Associated Match Industry	Effluent	73.45fg±2.12	5.73i±0.17	67.53g±1.95	22.15h±0.64	19.76k±0.57	0.93bc±0.03	212.00h±6.12
	Receiving (Upper)	33.46c±0.97	2.68f±0.08	59.85fg±1.73	0.06b±0.001	1.84f±0.05	0.01±0.001	60.00d±1.73
	Receiving (Lower)	83.66g±2.42	2.18e±0.06	48.24e±1.39	2.95f±0.09	98.00l±2.83	2.15d±0.06	52.00cd±1.50

Values are means of triplicate readings±SEM; Means followed by different lowercase letters in each column are significantly different ($p<0.05$)

Ibadan. When compared with the control samples, these values are significantly higher. Although the soil had high values for these metals, values obtained for plant grown on them are comparatively lower. The high values obtained for these heavy metals may thus be attributed to industrial activities going on in the area. Lead and zinc are highest in Exton (battery manufacturer), Associated Match (manufactures matches), Scanink and CAPL environs. The values obtained for these metals are higher than FEPA recommended values. Lead occurs widely in the environment and is a well known contaminant of drinking water (Conning and Lansdown, 1983). Certain foods, when are cooked in water containing lead, concentrate the metal and upon ingestion, may impair fertility and reproductive function in males (Moor *et al.*, 1979).

The quality of effluents indicated that the effluents are very rich in inorganic compounds, free ammonia, phosphates, chlorides and nitrates. The implication of this is that the quality of soil samples in these sites would be affected by the disposal practices of the chemical industries studied.

The presence of metals and other mineral elements at various concentrations revealed that the industrial wastes contaminated the soils, a condition similar to that reported by Tripathi (1990). The high potassium level recorded at the dumpsites is an indication that substances rich in potash were discharged into receiving waters. This may have some degree of impact on the ground water quality especially at the test area. The levels of calcium and zinc were low and values within the critical limit thus posing little threat to ground water quality.

Table 6: Mineral composition of soils and plants around chemical industries in Ibadan

Industry	Location	Sodium	Calcium	Potassium
Niger hygiene	Soil	0.18a±0.01	4.81d±0.14	0.07a±0.01
	Plant	154.68e±4.47	1.14a±0.03	2.15d±0.06
Siperco	Soil	0.14a±0.01	4.57d±0.13	0.16b±0.01
	Plant	355.10f±10.25	1.01a±0.03	1.67c±0.05
Scanink	Soil	0.26b±0.01	12.78e±0.37	0.17b±0.01
	Plant	1296.37g±37.42	2.21b±0.06	3.01e±0.09
CAPL	Soil	0.16a±0.01	3.09c±0.09	0.08a±0.01
	Plant	338.98f±9.79	1.48a±0.04	1.39c±0.04
Exton	Soil	0.16a±0.01	13.77e±0.40	0.12a±0.01
	Plant	91.69c±2.65	0.92a±0.03	1.33c±0.04
Associated match industry	Soil	0.32b±0.01	15.12e±0.44	0.23b±0.01
	Plant	130.28d±3.76	1.86ab±0.05	2.10d±0.06

Values are means of triplicate readings±SEM, Means followed by different lowercase letters in each column are significantly different ($P < 0.05$)

Table 7: Mean physicochemical properties of effluents and receiving water around chemical industries in Ibadan

Sample	pH	Electrical conductivity	Hardness	Turbidity	Dissolved solids	Total solids	Dissolved oxygen	BOD	COD
Receiving									
Upper	7.78±0.33	17.46c±1.23	81.29a±14.69	22.55±3.59	525.00±59.17	1858.33b±215.10	8.69a±1.26	59.56±7.28	52.06±4.44
Lower	7.65±0.29	9.36b±1.58	109.50b±18.97	23.38±3.58	658.33±121.83	1625.00b±260.12	8.09a±0.78	67.80±8.29	75.36±10.62
% change*	(1.67)	(46.39)	34.70	3.68	25.40	(12.56)	(6.90)	13.83	44.76
Effluent	6.90±0.15	3.55a±0.27	129.83b±19.03	22.12±6.32	533.33±102.80	1283.33a±96.32	14.76b±1.84	72.33±11.08	58.17±7.94

*% change = $[^{(\text{lower-upper})}/_{\text{lower}}] \times 100$. values in parenthesis are negative, Values are means of 3 x 7 readings±SEM from seven industries, Means followed by different lowercase letters in each column are significantly different ($p<0.05$)

The physicochemical properties of effluents and receiving waters before and after effluent discharge are shown in Table 7. Results show significant decreases in the electrical conductivity and total solids of receiving waters while significant increases were recorded in hardness, dissolved solids, BOD and COD. Values obtained for effluents compare favourably with receiving water prior to discharge of effluents with respect to pH, turbidity, dissolved solids, BOD and COD. The BOD and COD values obtained for all the industries are significantly higher than FEPA (1991) recommended values (30 and 40 mg L^{-1}, respectively). Many of the wastes in the effluent from chemical industries are organic and inorganic compounds and some lost product. As these substances undergo oxidation, they combine with some of the oxygen dissolved in the water. The amount of oxygen used is therefore a good indicator of the amount of organic waste present. The BOD values obtained following discharge of the effluents into receiving water indicates that the amount of oxygen (mg L^{-1}) needed to oxidize these products is high. COD values are generally higher since it measures oxygen demand by biodegradable and non-biodegradable pollutants (Turner and Carawan, 1996). The high values obtained may suggest that a high amount of the product is lost to the waste stream.

CONCLUSION

This research has shown that effluent discharge by chemical industries in Ibadan metropolis significantly influenced receiving water and soil quality. The levels of calcium and zinc were low and values within recommended limits thus posing little threat to ground water quality. Their presence at these levels may however prove advantageous to crop growth.

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