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MONTHLY VARIATION OF THE PHYSICOCHEMICAL PROPERTIES OF EFFLUENTS FROM RIMCO INDUSTRIES NNEWI, NIGERIA

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ABSTRACT

The physicochemical properties of effluent waste and sediments from Resources Improvement and Manufacturing Company Limited (Rimco) discharged into down stream end of the Mili Ele pond was monitored monthly from January 2001 to December 2001. Data for most water quality parameters were presented apart from nitrite and sulphite ions that were not detected in the effluent. Although none of the metals was detected at toxic levels their concentration levels in the effluent were highest in the month of February. Biochemical oxygen demand recorded values that ranged between 1.0 – 2.3 mg O_2/L for most part of the year and a remarkable value of 9.4 mg O_2/L in the month of February. The pH values of the effluent ranged between 4.0-7.8. For most part of the year the pH values were less than 5, suggesting that the effluent is generally slightly acidic. Based on analysis of data acquired, the investigation concluded that effluents from Rimco industries are polluting the Akwu Uru area of Nnewi with hydrocarbon and odour of decaying vegetable and palm kernel oil. The monthly profiles of all the physicochemical parameters investigated were presented and were found to follow similar trend.

KEY WORDS: Industrial pollution, effluent, sediments, physicochemical studies, monthly profiles.

INTRODUCTION

Pollution from industrial waste disposal and effluent discharges is becoming a serious environmental issue in Nigeria and in many developing countries of Africa. Industries that manufacture agro-chemical, vegetable oil and allied products are the main sources of many chemical wastes, edible oil effluents and debris. When these debris accumulate they pose significant threats to marine lives and the environment. Sedimentation may occur and this has been reported to have significant role in the complex interaction between pollution and water quality such that it can be used to trace the effect of pollutants on water quality (Reddy, 1979). Pollution can also occur from runoffs of excessive fertilisation of farm lands (White-Head 1964).

The Eastern part of Nigeria has witnessed a tremendous growth in the establishment of industries within the last two decades. These industries specialise in manufacturing vegetable oil for domestic uses, formulation of engine oil, automobile spare parts production and other accessories. None of these industries has any established programme for the proper disposal of wastes. Disposal of wastes from these industries is mainly through effluent discharges into surrounding shallow streams and dumping on fallow land. Orisakwe et al (1999) have reported that effluent discharges are responsible for polluting many parts of Nnewi, a rapidly growing industrial town where the Resources Improvement and Manufacturing Company Limited (Rimco) is situated.

The aim of this study is to monitor the monthly variation of the physicochemical properties of effluent wastes which the Resources Improvement and Manufacturing Company Limited (Rimco) discharged throughout the year into the shallow down stream end of the Mili Ele pond.

MATERIALS AND METHODS

Area of Study

The Resources Improvement and Manufacturing Company Limited (Rimco) situated at Akwu Uru Industrial Estate, Umudim Nnewi, Anambra State of Nigeria is the manufacturer of Life Vegetable Oil that is used for cooking purposes in the Eastern part of Nigeria. Other industries situated within the same vicinity of the Akwu Uru industrial Estate are Uru industries of OTC Group, specializing in the manufacturing of automotive cables and hoses, A-Z industries that produce various engine oil formulation and allied petroleum products.

The effluent studied consisted of the waste water runoff that resulted from the cold water that was used for cooling the heat exchange columns of the edible oil production lines and other waste water that were generated during production in

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Table 1. Monthly variations in the physicochemical properties of Rimco Industrial effluents

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
Temperature (°C)	32.2 ± 0.1	34.6 ± 0.2	35.1 ± 0.2	34.0 ± 0.2	30.0 ± 0.2	32.5 ± 0.2	32.8 ± 0.1	31.4 ± 0.2	32.8 ± 0.1	32.2 ± 0.2	31.4 ± 0.1	28.8 ± 0.2	32.3 ± 1.8
pH	5.88 ± 0.02	8.38 ± 0.05	6.71 ± 0.05	5.70 ± 0.02	6.68 ± 0.04	7.38 ± 0.05	6.54 ± 0.03	5.25 ± 0.03	4.84 ± 0.02	5.56 ± 0.02	5.45 ± 0.04	6.45 ± 0.03	6.24 ± 0.99
Electrical conductivity (μS/cm)	28.5 ± 0.5	2,070 ± 10	75.0 ± 0.5	33.5 ± 0.6	104.0 ± 1.0	89.3 ± 0.5	37.1 ± 0.3	49.2 ± 0.2	44.3 ± 0.2	55.7 ± 0.7	54.8 ± 0.4	110.0 ± 1.0	229.3 ± 580.3
Discharge rate (10^3 cm^3/sec)	21.8 ± 0.5	3.7 ± 0.4	4.3 ± 0.5	7.6 ± 0.5	1.4 ± 0.4	9.7 ± 0.6	11.1 ± 0.8	8.4 ± 0.4	8.0 ± 0.8	7.7 ± 0.4	6.4 ± 0.5	1.4 ± 0.3	7.6 ± 5.43
Dissolved Oxygen (mg/L)	3.8 ± 0.15	4.6 ± 0.08	3.0 ± 0.15	4.0 ± 0.05	3.4 ± 0.20	2.7 ± 0.13	3.6 ± 0.16	3.2 ± 0.09	4.4 ± 0.05	3.7 ± 0.09	3.4 ± 0.10	3.9 ± 0.06	3.6 ± 0.55
Biochemical Oxygen Demand (mg/L)	1.5 ± 0.5	9.4 ± 0.2	1.1 ± 0.7	2.1 ± 0.5	2.3 ± 0.8	1.6 ± 0.3	1.9 ± 0.7	1.3 ± 0.6	2.2 ± 0.8	2.0 ± 0.7	1.0 ± 0.2	2.2 ± 0.4	2.4 ± 2.3
Turbidity (NTU)	80 ± 35	4,000 ± 400	12 ± 4	80 ± 16	20 ± 4	60 ± 12	56 ± 12	120 ± 25	140 ± 35	85 ± 16	72 ± 20	72 ± 12	400 ± 1,134
Total Hydrocarbon content (mg/L)	13.9 ± 2.3	123.7 ± 5.8	2.6 ± 0.4	6.6 ± 1.0	11.2 ± 1.2	9.0 ± 0.7	14.3 ± 1.1	11.5 ± 1.9	8.5 ± 0.7	10.5 ± 1.0	12.4 ± 0.8	15.3 ± 1.3	20.0 ± 32.9
Total Dissolved Solid (mg/L)	15.3 ± 0.7	1,450 ± 180	40.2 ± 0.6	20.3 ± 1.3	58.2 ± 1.5	46.1 ± 0.7	19.9 ± 0.3	26.4 ± 0.9	23.7 ± 0.4	30.5 ± 0.5	30.3 ± 0.2	61.9 ± 2.1	151.9 ± 409.1
Total Hardness (mg $CaCO_3$/L)	15 ± 2	20 ± 2	41 ± 3	14 ± 1	35 ± 3	20 ± 2	88 ± 5	12 ± 1	28 ± 2	24 ± 3	11 ± 1	25 ± 2	28 ± 21
Alkalinity (mg $CaCO_3$/L)	34.0 ± 1.0	46.5 ± 1.2	50.0 ± 2.5	112.5 ± 2.5	120.0 ± 2.5	73.0 ± 1.4	26.0 ± 1.0	31.5 ± 1.1	20.0 ± 0.9	25.5 ± 0.9	21.5 ± 1.2	86.3 ± 1.6	53.9 ± 35.6
Surfactant (mg/L)	0.69 ± 0.22	1.88 ± 0.29	0.23 ± 0.15	0.26 ± 0.15	0.23 ± 0.18	0.38 ± 0.21	0.56 ± 0.18	0.50 ± 0.18	0.36 ± 0.09	0.76 ± 0.12	0.55 ± 0.08	0.43 ± 0.10	0.57 ± 0.45
Total Hydrocarbon content (mg/L)	13.9 ± 2.3	123.7 ± 5.8	2.6 ± 0.4	6.6 ± 1.0	11.2 ± 1.2	9.0 ± 0.7	14.3 ± 1.1	11.5 ± 1.9	8.5 ± 0.7	10.5 ± 1.0	12.4 ± 0.8	15.3 ± 1.3	20.0 ± 32.9
Chloride (mg/L)	4.6 ± 0.1	461.0 ± 3.6	10.8 ± 0.3	10.3 ± 0.7	13.5 ± 0.6	11.7 ± 0.6	12.8 ± 0.4	9.6 ± 0.4	5.0 ± 0.2	6.8 ± 0.3	8.2 ± 0.3	4.4 ± 0.2	46.6 ± 130.6
Sulphate (mg/L)	2 ± 1	14 ± 2	5 ± 2	5 ± 2	5 ± 2	5 ± 2	15 ± 3	20 ± 4	3 ± 1	12 ± 3	15 ± 2	15 ± 3	10 ± 6
Nitrate (mg/L)	0.8 ± 0.1	0.7 ± 0.1	1.6 ± 0.1	2.7 ± 0.2	0.6 ± 0.1	2.3 ± 0.2	3.8 ± 0.5	3.0 ± 0.1	11.6 ± 0.2	3.2 ± 0.4	2.1 ± 0.1	2.5 ± 0.1	2.9 ± 2.9
Phosphate (mg/L)	0.29 ± 0.04	0.48 ± 0.10	0.21 ± 0.08	0.34 ± 0.05	0.65 ± 0.09	1.12 ± 0.10	0.17 ± 0.02	0.35 ± 0.03	0.06 ± 0.01	0.32 ± 0.06	0.79 ± 0.04	0.46 ± 0.05	0.44 ± 0.30

the Rimco industries. The waste water emerging from the Rimco industries are channelled into a single shallow gutter measuring about 70 – 80 cm in depth and 55-60 cm in width and constitute the Rimco effluent being studied. The shallow gutter carrying the effluent runs through a distance of about 600 m before discharging its content and debris at a confluence with a stream coming from the downstream end of the Mili Ele pond.

Effluent Sample Collection

The effluent samples were collected at the point where it is discharged into the shallow stream that flows from the Mili Ele pond. The samples were collected once every month starting from January 2001 and ending in December 2001. Sample collection took place between the hours of 9 am and 11 am on the day of sampling. Four samples were collected at the point of discharge, at least 10 cm apart from each other and pooled together to form the composite sample for the month.

Three different sampling containers were used for sample collection for Biochemical oxygen demand, metal ion content and other physicochemical parameters respectively, and are preserved appropriately (Uzoukwu 2000). Temperature, dissolved oxygen, discharge rate and odour were measured in the field before the samples were transported to the laboratory for analysis of other physicochemical parameters.

Four sediment samples were collected by scooping the deposit with a beaker, at the point of discharge, at least 10 cm apart from each other and pooled together to form the composite sediment sample in June 2001.

Effluent Analyses

The physicochemical parameters of the effluent samples determined included pH, electrical conductivity, colour, odour, turbidity, discharge rate, depth, dissolved oxygen (DO), biochemical oxygen demand (BOD), chloride, nitrate, phosphate, sulphate, surfactant, alkalinity, total hardness, total hydrocarbon content and metal ions. All methods used are in accordance with standard methods for the analysis of water and waste water (Greenberg, 1992, Allien *et al.*, 1974). Alkalinity, total hardness and chloride ion were determined using appropriate titrimetric methods. A Consort C531 pH and electrical conductivity meter was used for the determination of both the pH and electrical conductivity of the samples. DO and BOD were analysed electroanalytically using an OxyScan Light oxygen measuring meter. Sulphate ions and turbidity were analysed using the turbidometric method. Total dissolved solid (TDS) was determined by weighing the deposit after evaporation of a known volume of filtrate of the sample. Discharge rate was determined by measuring the speed of a light foam object floating on the effluent. A chloroform extract of a known volume of the sample was evaporated and the deposit used for estimating the total hydrocarbon (THC). Phosphate ions were determined using the molybdenum blue method while nitrate was determined following the brucine method. Surfactant was determined using the methylene blue method (Uzoukwu, 2000). Nitrite and sulphite ions were not detected in the effluents. The colour and odour of the effluents were determined empirically. All colorimetric analysis were carried out using a Bioblock Scientific UV-visible spectrophotometer. The metal ions were analysed by direct aspiration of the samples into a Buck Scientific 200A atomic absorption spectrophotometer (Bosnak and Grosser, 1996, Latino and Grosser, 1996).

Sediment Analyses

A 1:1 suspension of the sediments in water was prepared and used for measuring the pH and electrical conductivity values of the sediments. A 1 g portion of the dried sediment was digested with concentrated HNO_3:$HClO_4$ (5:1) and the 50 mL solution obtained from it with water was used for analysis of the metals using atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

Presented on Table 1 is the monthly variations in the physicochemical properties of Rimco industrial effluents monitored from January 2001 to December 2001. Table 2 contains the monthly variation in the concentrations of metal ions detected in the effluent for the same period of time. Aluminium was detected only in the month of February (3.13 mg/L) while lead was detected in March (0.05 mg/L) and April (0.02 mg/L) only. The following metal ions were not detected in the effluent at any time of the year: Cu, Co, Cd, Ba, Ni, Cr, V, Mo, Hg and As. Table 3 contains data on the pH, electrical conductivity and concentrations of metal ion content (mg/kg) in sediments of the Rimco effluent. Dark grey sediments were collected. The following metals not listed on the Table (apart from Pb) were not detected in the sediments. They include V, Mo,

Table 2. Monthly variations in the metal ion content (mg/L) of Rimco Industrial effluents

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
Na	5.2	706.0	9.5	5.3	8.4	20.3	7.1	6.8	7.2	7.2	7.4	14.2	67.1
	± 0.05	± 4.0	± 0.1	± 0.2	± 0.2	± 0.9	± 0.1	± 0.1	± 0.1	± 0.1	± 0.1	± 0.8	± 201.3
K	2.17	24.40	1.32	0.23	1.89	1.79	1.68	0.75	0.45	0.88	2.25	2.88	3.39
	± 0.05	± 0.70	± 0.06	± 0.05	± 0.04	± 0.04	± 0.05	± 0.03	± 0.05	± 0.03	± 0.06	± 0.07	± 6.66
Fe	0.01	13.26	0.29	0.10	1.38	1.11	0.45	0.46	0.46	0.44	0.30	3.06	1.78
	± 0.01	± 0.15	± 0.05	± 0.02	± 0.05	± 0.07	± 0.05	± 0.07	± 0.02	± 0.03	± 0.03	± 0.27	± 3.71
Zn	0.01	0.55	0.03	0.03	0.03	0.08	0.04	0.20	0.02	0.04	0.05	0.06	0.10
	± 0.00	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.02	± 0.01	± 0.01	± 0.01	± 0.01	± 0.15
Mg	0.21	1.15	0.39	0.16	0.51	0.39	0.23	0.18	0.21	0.21	0.46	1.24	0.45
	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.37
Ca	0.74	11.00	3.29	1.72	6.61	5.59	1.46	1.32	1.40	1.67	2.99	8.20	9.94
	± 0.05	± 2.10	± 0.11	± 0.08	± 0.13	± 0.15	± 0.08	± 0.05	± 0.05	± 0.06	± 0.12	± 0.44	± 20.42
Mn	nd	0.09	0.02	0.01	0.03	0.01	nd	nd	0.01	0.01	0.01	0.06	0.02
		± 0.01	± 0.01	± 0.01	± 0.01	± 0.01			± 0.01	± 0.01	± 0.01	± 0.01	± 0.03

nd = not detected. Metals that were not detected also are Al, Pb, Cu, Cr, Co, Cd, Ni, Ba, V, Hg, As, and Mo

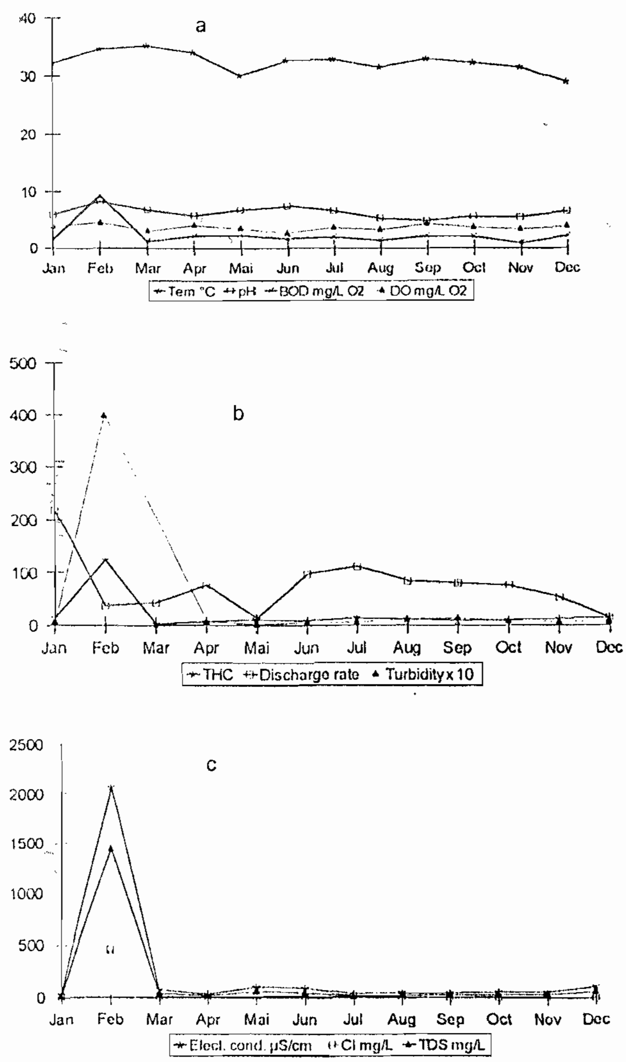
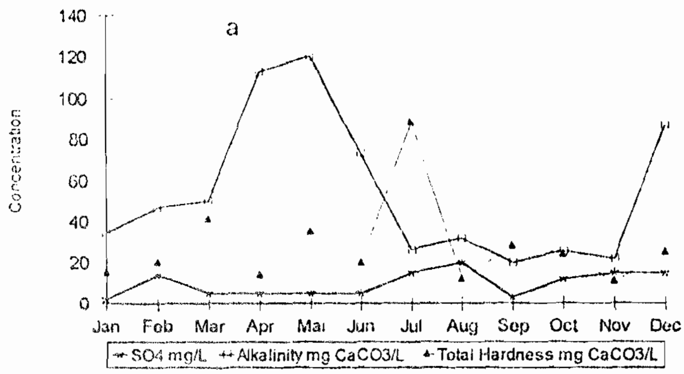


Fig. 1 Monthly profiles of some physicochemical parameters of Rimco effluents: (a) plot of temperature (°C), pH, biochemical oxygen demand (mg O_2/L), dissolved oxygen (mg O_2/L), (b) plot of total hydrocarbon content (mg/L), discharge rate (10^2 x cm^3/sec), turbidity (10 x NTU) and (c) plot of electrical conductivity (µS/cm), [Cl^-] (mg/L) and total dissolved solid (mg/L) values vs months.

Hg, As and Pb (< 0.05 mg/kg). It is significant to observe that although the following metals Cu, Cd, Co, Cr, Ba and Ni were not detected in the effluent samples they appeared in detectable concentrations in the sediments.

The monthly profiles of some physicochemical parameters of the Rimco effluents are presented in Fig. 1. The plot (Fig. 1(a)) shows that the temperature is fairly constant throughout the year, ranging from 30-35 °C and less than the 40 °C limit set by FEPA for effluent discharge into our environment. Rimco effluent, hence, can not be associated with thermal pollution at the point of discharge into the downstream part of Mili Ele. With a pH range of 6-9 set by FEPA Table 1 shows that for the months of January, April, August and September the effluent discharges have pH values less than 5 which are outside the FEPA limit. This is an indication that for about half of the year the effluent discharges may be having adverse effect on the pH levels of the recipient Mili Ele stream. Fig. 1(a) also shows that apart from the month of February where a remarkable value of 9.4 mg O_2 /L was recorded for BOD the Rimco effluent for the rest of the year can be characterized as being fairly anaerobic with a BOD level that ranged from 1.0 – 2.3 mg O_2 /L. The result presented in Fig.



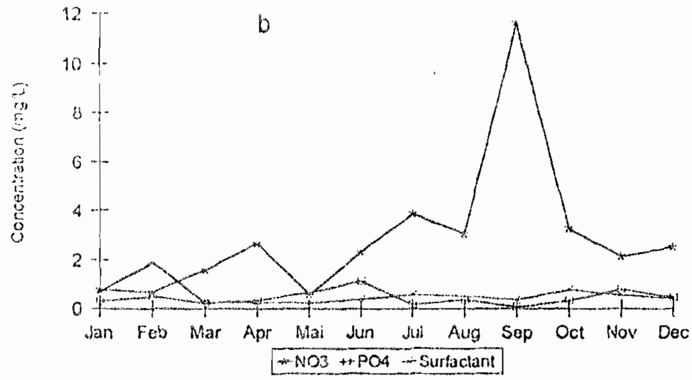


Fig. 2. Monthly profiles of some major components and anionic content of Rimco effluents: (a) plot of sulphate, alkalinity, total hardness and (b) plot of nitrate, phosphate and surfactants values vs months.

1(b) contained the three parameters: total hydrocarbon content (THC) (mg/L), discharge rate ($10^2 \times cm^3/sec$), and turbidity (NTU). The investigation showed that (Table 1) apart from the months of March, April, June and September the total hydrocarbon content in the Rimco effluent discharged into the environment ranged from 10 – 124 mg/L. This is above the 10 mg/L limit set by FEPA. Fig. 1(b) shows that the THC concentration profile rose to the highest level of 123.7 mg/L in February. The cause may probably be due to a clean up of a large scale of spillage in the industry that was channelled into the shallow gutter without observing any proper waste clean up practice. The investigation shows that Rimco effluent is polluting the downstream part of the recipient Mili Ele water body and its environs with hydrocarbon and the level of pollution rose to a maximum in February. There is no visible effluent waste control and management facility put in place by the industry. It is also important to report that the investigation found that the effluent is turbid, milky coloured and had a strong odour of decaying vegetable/palm kernel oil waste throughout the twelve months of study. The odour can be perceived from a distance of about 10 m away. The profiles for other parameters: electrical conductivity, chloride ion content and total dissolved solid presented in Fig. 1(c) followed a similar pattern to that of the THC by rising to a maximum in February and falling in all other months. Fig. 1(b) shows that the discharge rate of the effluent dropped drastically from 2.18×10^4 cm^3/sec in January to 0.37×10^4 cm^3/sec during the month of February, probably due to the heavy load of vegetable oil debris contained in the effluent. The discharge rate rose to 1.11×10^4 cm^3/sec in the month of July before falling gradually to 0.14×10^4 cm^3/sec during the month of December. When compared with the relatively lower THC content of the Rimco effluent for the period August to December the fall in effluent discharge rate is attributable to obstruction from dead organic debris from weathering plants that littered the route of the effluent. This period is

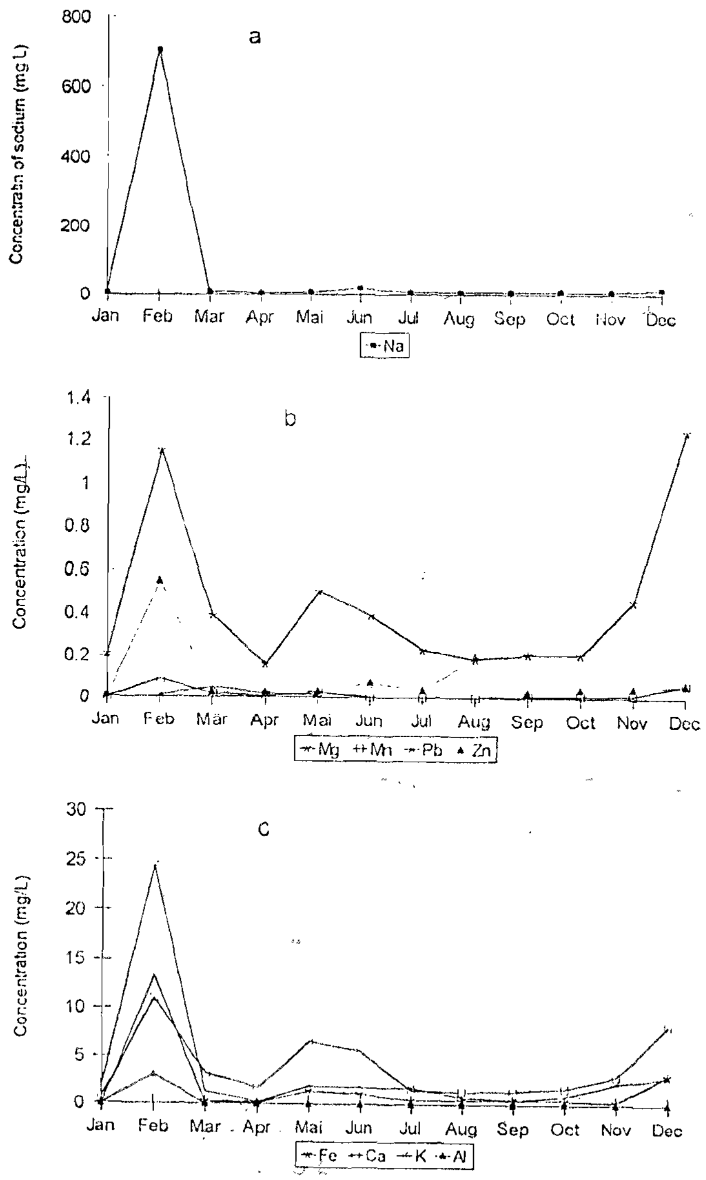


Fig. 3. Monthly profiles of some major metal ion content detected in the Rimco effluents: (a) plot of concentrations of sodium, (b) plot of concentrations of magnesium, manganese, lead, zinc and (c) plot of concentrations of iron, calcium, potassium and aluminium vs months.

Table 4 Ratio of mean annual metal concentration in effluent to that of the metal concentration in sediment

Metal	$[C]_{effluent}/[C]_{sediment}$
Na	0.048
Ca	0.014
K	0.011
Zn	0.0075
Mg	0.0058
Mn	0.0038
Fe	0.0019

Table 3. Data on pH, electrical conductivity and concentration of metal ion content (mg/kg) in sediments from Rimco effluent

Code	Colour	pH	EC (µS/cm)	Na	K	Ca	Mg	Fe	Zn	Pb	Mn	Cu	Al	Ni	Cd	Co	Cr	Ba
Rimco	Dark grey	5.38 ±0.05	319 ±10	1,385 ±20	302 ±10	687 ±15	75 ±2	928 ±10	12.44 ±0.10	nd	7.65 ±0.15	9.57 ±0.15	nd	7.65 ±0.15	10.72 ±0.20	7.65 ±0.10	44.01 ±0.50	38.27 ±0.50

also the time that the dry season sets in in the area.

The monthly profiles of some major anionic and other water quality parameters are presented in Fig. 2. All the parameters throughout the year, are within the FEPA limit for the discharge of effluents from industries into surface water bodies. They include sulphate, chloride

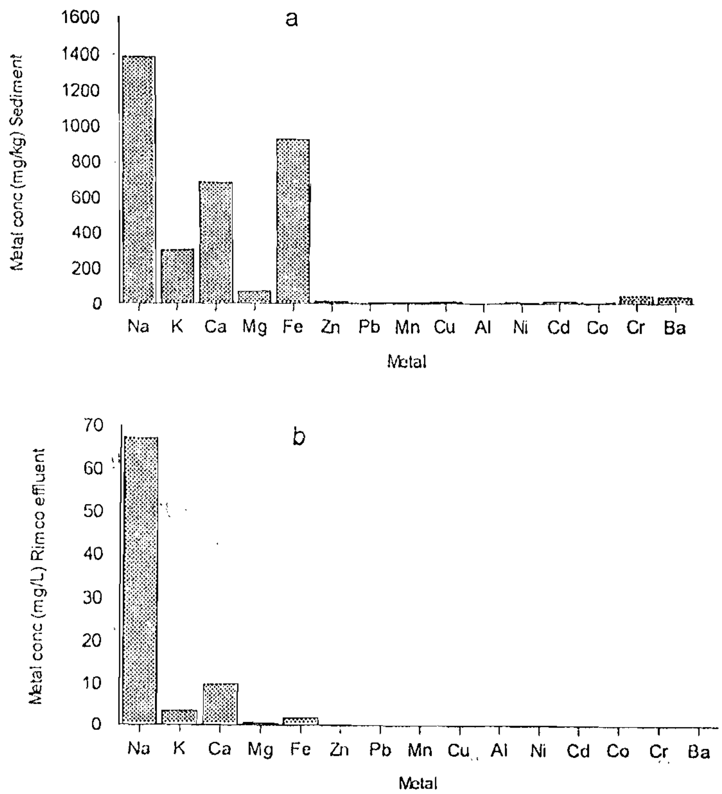


Fig. 4 Histogram plots comparing the metal ion concentrations in the (a) sediments (mg/kg) with those of the (b) mean annual metal concentration (mg/L) in the effluent.

(Fig. 1(c)), alkalinity, total hardness, nitrate, phosphate and surfactants. No similarity could be observed between the pattern of the concentration profiles of parameters in Fig. 2 with that of THC (Fig. 1(b)). This suggests that some other environmental factors other than the Rimco effluent waste, may be playing vital roles also. In contrast however, the monthly profiles of some major metal ion contents detected in the Rimco effluents presented in Fig. 3 showed a trend that is similar to that of THC. Apart from lead which recorded its highest concentration level of 0.05 mg/L in March, the concentration level of each of the metals in the effluent was highest in the month of February as follows: Na (706 mg/L), K (24.40 mg/L), Ca (11.00 mg/L), Mg (1.15 mg/L), Mn (0.088 mg/L), Zn (0.550 mg/L) and Fe (13.26 mg/L), and Al (3.13 mg/L). Aluminium was not detected in the samples in any other month. The concentration levels of all the metals, however, are within acceptable limits set by FEPA for discharge of industrial effluents into surface water.

Analytical data on the metal content of the sediments of the Rimco effluent presented in Fig. 4 shows that many metal ions that are undetectable in the effluent accumulate over a long period of time to make them detectable in the sediment. The metals include Cu, Ni, Cd, Co, Cr and Ba. A comparative analysis of the histograms (a) and (b) of Fig. 4 shows that to some extent the concentration levels of the metals in the sediment is related to its mean annual level in the effluent. The calculated ratio of mean annual metal concentration in effluent to that of the metal concentration in sediment, $[C]_{effluent}/[C]_{sediment}$, for metals with concentrations > 0.01 mg/L presented in descending order in Table 4 shows that the alkali and alkaline metals (Na, Ca, K) occupy the upper part of the Table with relatively higher ratio while the transition metals (Fe, Mn, Zn) occupy the lower part of the Table. This is an indication that these heavier metals are more likely going to be found in sediments of the Rimco effluent than the lighter metals Na, K and Ca if the effluent has the quality so determined quantitatively during this investigation.

CONCLUSIONS

The investigation has shown that for the months of January, April, August and September the effluent discharges have pH values less than 5 which is outside the FEPA limit. This is an indication that for about half of the year the effluent discharge is slightly acidic. With a BOD level that ranged from 1.0 – 2.3 mg O_2/L the Rimco effluent for most part of the year can be characterized as being fairly anaerobic. Rimco effluent contains hydrocarbon at a level above 10 mg/L. This is unacceptable and is polluting the Akwu Uru and downstream Mili Ele areas in Nnewi with hydrocarbon and odour of decaying vegetable/palm kernel oil waste. The level of hydrocarbon released into the environment is highest during the month of February. Most metals were not detected in the effluent at toxic level, therefore Rimco effluents do not contribute to metal pollution of the environment.

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