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PHYSICO-CHEMICAL STUDIES OF SOIL ALONG THE BANKS OF MILI SHALLOW STREAM IN NNEWI, ANANMBRA STATE OF NIGERIA FOR EVIDENCE OF INDUSTRIAL POLLUTION

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ABSTRACT

The physico-chemical properties of soils along the banks of Mili shallow stream in Nnewi, Anambra State of Nigeria was investigated for possible evidence of industrial pollution. The parameters investigated include pH, chloride, nitrate, sulphate, phosphate, Hydrocarbon, alkaline and heavy metal contents of the soil extracts and digests. The data were compared with those of two control stations at Nza Ozubulu and Uzoakwa Ihiala of the neighboring towns. The pH of soils from banks of the Mili stream sampling stations have values less than 5, indicating that soil acidity is wide spread along the banks of Mili stream. Hydrocarbon and lead contamination of soil along some parts of the banks of Mili stream was found to have occurred. Thus, a mean lead concentration of 11.9 ±9.0 mg/kg was recorded. Hygrocarbon concentration as high as 30.1 mg/kg of soil was recorded around Resources Improvement and Manufacturing Company Limited (Rimco). Statistical analysis was carried out on the data and is concluded that there is evidence of soil contamination along the banks of Mili Ele and Rimco industrial parts of the Mili stream.

KEY WORDS: Industrial pollution, monitoring, physico-chemical parameters, soils, Nnewi

INTRODUCTION

Industrial pollution of our environment from industrial waste disposal is becoming a serious environmental issue globally. The phenomenon is also a topical issue in present day Nigeria and in many developing countries of Africa. Chemical wastes from industrial activities are the main source of industrial pollution (Hodgson 1963) and they are generated mainly from chemical manufacturing industries such as fertilizer, agro-chemical and allied products. Others include industries manufacturing or assembling auto spare parts, tyres, fan belts, engine oil formulation and other accessories. Environmental pollution can also occur from runoffs of excessive fertilization of farm lands (White-Head 1964). Species such as chloride, phosphate (Egball et al., 1996), sulphate (David et al., 1982, Stevenson 1986), nitrates (Stevenson 1986) and heavy metal ions (Magdoff and Barlett 1980) have been detected in the aquatic and land bodies surrounding places where industrial activities are actively taking place. Alteration of soil acidity (Kunishi and Vickers 1980, Magdoff and Barlett 1985) and buffering capacity (Holford 1976) by industrial wastes have also been reported.

Nnewi in the Eastern part of Nigeria has witnessed a tremendous growth in the establishment of industries within the last two decades. These industries specialize in soap and vegetable oil production, formulation of auto-engine oil, automobile spare parts production such as fan belts, types, manufacturing of batteries and other accessories. However, there is no established programme for the displosal of wastes generated by these industries. The Mili shallow stream at the moment is a convenient recipient body of the domesic effluents discharged by tenants of houses that are eracted along the bank of the stream, and industrial effluents from industries that are sited at the bank up stream. A report has already been made (Orisakwe et al., 1999) that these industrial activities are responsible for polluting the surrounding land surface in Nnewi. Therefore, soil contamination by industrial discharges is an emerging problem in Nnewi town. Mili shallow stream flows across Umudim Nnewi and discharges into the Eze river in Nnewi.

The aim of this study is to determine the organic and inorganic characteristics of surface soil along the banks of the Mili shallow stream from Mili Ele (Up stream) to Mili Ofia (down stream) all in Nnewi. The results of this study will reveal the extent of pollution from domestic and industrial effluent disposals across the length and breath of the banks of the stream. On the other hand, if no pollution had occurred, the investigation will provide the baseline data that will enable us monitor the pollution status of the soil along the banks of the soil along the banks of the Mili shallow stream.

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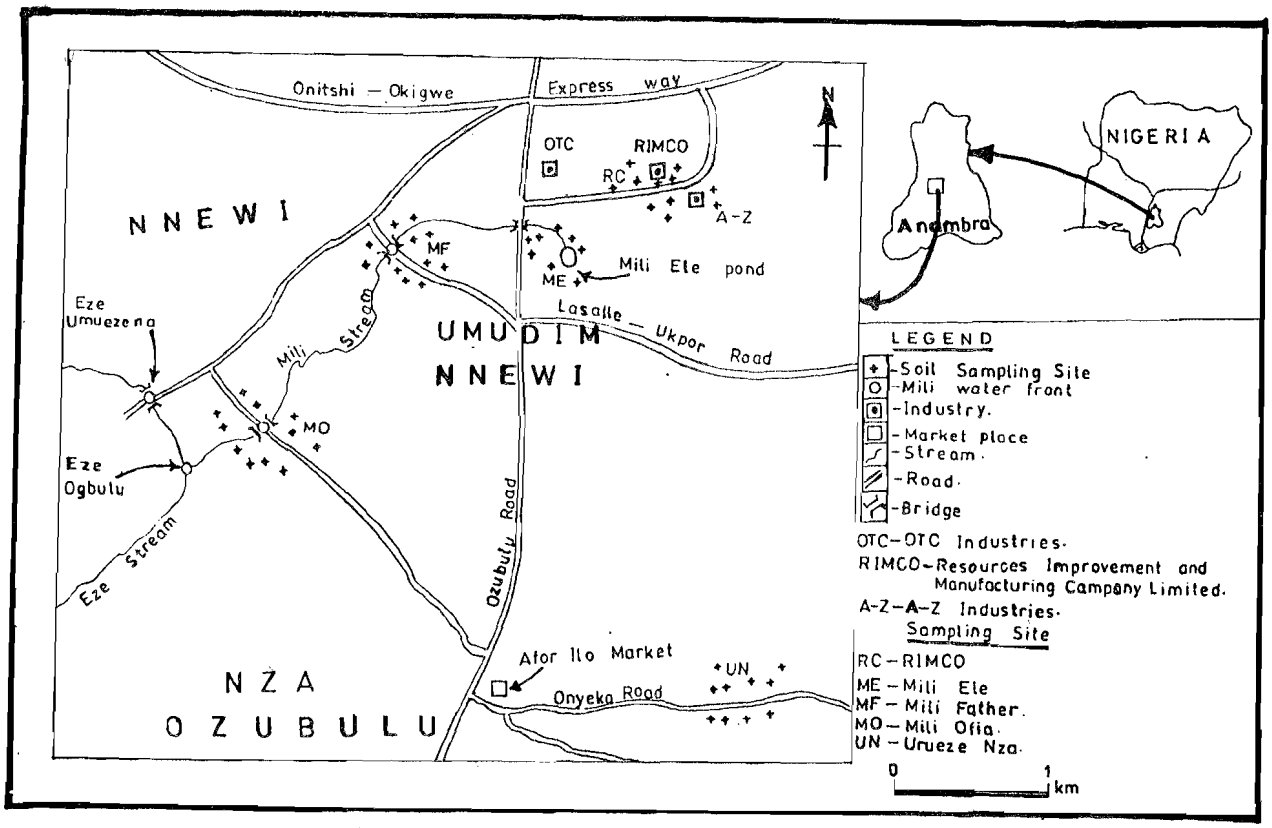

Fig 1 Map showing sites in Nnewi and Ozubulu towns of Nigeria.

MATERIALS AND METHODS

Area of Study

The Mili stream is a short shallow stream that runs across Umudim Nnewi in Anambra State of Nigeria. The bank of the stream stretches a short distance of about 3 km and covers an area of about 2-3 km^2. although the width of the stream is about 0.3 – 6m, the sandy beach that lines the route of the stream extends the width to between 5 – 15m wide and hence, presents an attractive site for industrial and domestic waste disposal. The locations of the study area are shown in Figure 1. The Mili Ele part of the stream, is a pond about 300 m in length and 100 m in width that is situated up stream with depths of about 200 – 500cm. After Mili Ele the stream becomes very shallow from Mili father to Mili Ofia with about 15 – 50 cm in depth. Large scale industrial waste disposal along the beaches of the Mili stream was not observed during the time of the study. The study area are coded as follows: ME (Mili Ele), RC (Rimco), MF (Mili Father), MO (Mili Ofia). The area is subjected to two seasons, consisting of rainy season that runs from April to September and dry season that runs from October to March with an average daily temperature of 29-32°C.

Nature of Industrial Activities in the Area

The land surfaces along the entire route of the stream are used mainly for agricultural purposes. However, at places such as Umuezena Umudim in Nnewi where Mili Ofia water front is located, the land surfaces contain large deposits of stones and the main occupation of the local populace is stone querying. The main industries sited along the banks of Mili stream are found close to the bank of Mili Ele, up stream. They are situated within 100 – 500 m to the Mili Ele water pond. The industries include Uru industries of OTC Group specializing in automotive cables and horses, Resources Improvement and Manufacturing Company Limited (Rimco) industries producing edible vegetable oil and domestic soap, A-Z industries producing various auto-engine oil formulation and allied petroleum products.

Soil Sample Collection

The soil samples were collected from lands situated within 5 – 100 m to the Mili stream and along the banks of the stream starting from Mili Ele up where the stream started, to Mili Ofia where the stream discharges into Eze river all in Nnewi. The sampling sites along the banks were chosen from paces already overgrow.. with

shrubs and were adjudged to be uncultivated in the past four agricultural seasons. Places that were evidently agricultural farmlands or portray evidence of being cultivated within the past two agricultural seasons were not sampled. The sampling sites were extended to places around the Rimco, Uru, Culvan and A – Z industries that are situated within 100 – 500 m to the route of the Mili stream. All the samples are coded accordingly and the places from where the samples were collected are shown in Figure 1. The sample codes are ME, RC, MF and MO.

Soil samples were collected during the dry season, on the 27th of January 2001, 1st and 2nd of February, 2001, between 9 am and 5 pm on each day. At each station, ten – composite samples were collected at least 10 m apart from each other and pooled together to form the sample for a station. Samples were also collected from Nza Ozubulu in Ekwusigo Local Government Area and Uzoakwa Ihiala in Ihiala local Government area both of Anambra State, and used as controls. Nza Ozubulu is situated at about 3-5 km from the nearest Mili water front, while Uzoakwa Ihiala is situated at about 30 km from the nearest Mili water front. Soil samples were taken from depth of 0-30 cm into clean black polythene bag and transported to the laboratory for analyses.

Chemical Reagents Used.

Chemical reagents of analytical grade were used in this work without further purification. The pH and electrical conductivity measurements were carried out with a consort C531 pH conductivity meter. All colorimetric measurements were performed with a Bioblock Scientific UV-Visible spectrophotometer. Metal concentrations were determined using a Buck scientific atomic Absorption/Emission spectrophotometer 200A.

Soil Analyses

The physico-chemical parameters of the soil samples determined include pH, electrical conductivity, chloride, nitrate, phosphate, sulphate and total hydrocarbon content. All methods used are in accordance with standard

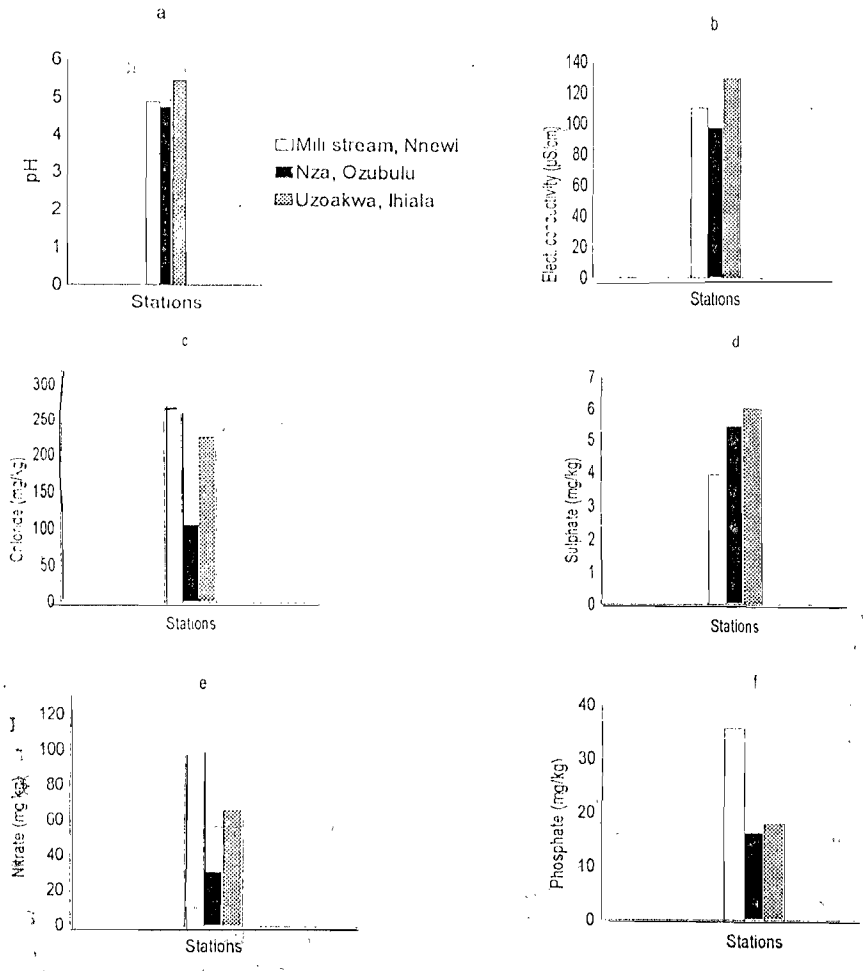

Figure 2 Mean values of pH, electrical conductivity, chloride, sulphate, nitrate and phosphate for Mili stream and two control stations at Nza Ozubulu and Uzoakwa Ihiala

Table 1 Physico-chemical results of soil samples from banks of Mili stream in Nnewi, Anambra State

S/N	Soil Sample	pH	Electrical Conductivity (μS/cm)	Cl (mg/kg)	NO_3^- (mg/kg)	SO_4^{2-} (mg/kg)	PO_4^{3-} (mg/kg)	Total Hydrocarbon (mg/kg)
1	ME	4.85	155.1	261 7	66.6	6.2	18.4	<0.01
2	RC	4.91	85 6	178.9	155.9	<2.0	46.6	30.10
3	MF	4.79	143.0	297.0	56.8	5.6	46.4	<0.01
4	MO	4.83	58 0	324.1	120.8	<2.0	30.7	<0.01
	Mean of Mili	4.85 ± 0.05	110.4 ± 46.3	265.4 ± 63 1	100.0 ± 46.7	3.9 ± 2.3	35.5 ± 13.6	7.53 ± 15.05
5	*UN	4.73 ± 0.12	97.1 ± 2.7	105.6 ± 15.0	30.7 ± 5.8	5.4 ± 0.2	16.2 ± 6.4	<0.01 ± 0.00
6	*UI	5 44 ± 0 34	129.0 ± 5.2	225.7 ± 17.1	65.8 ± 8.4	6.0 ± 0.3	17.9 ± 6.0	<0.01 ± 0.00

*Result is for mean of four replicate results.

Legend

Code	Soil samples from the banks of Mili shallow stream in Nnewi	Distance from water front
ME	Mili Ele Nnewi	5-100 m from Mili Ele
RC	Rimco Nnewi	100-500 m from Mili Ele
MF	Mili Father Akabo	5-100 m from Mili Father
MO	Mili Ofia Umuezena	5-100 m from Mili Ofia
	Samples from two control points	
UN	Uhueze Nza Ozubulu	3,000-5,000 m from the nearest Mili stream
UI	Uzoakwa Ihiala	30,000 m from the nearest Mili stream

methods for the analysis of soil (Allien et al., 1974, Piper 1994). A ground portion of the soil sample was thoroughly mixed with water in the ratio of 1:1 by weight and used for determining the pH and electrical conductivity of the soil. A weighed amount of the soil (5-10g) was extracted with 50 mL of 0.005 M HNO_3 or HC1 solution and the extract used for determining the extractable metal ions anions. Chloride was determined by the argentometric method. Sulphate was analyzed using the turbidometric method (Allien et al., 1974). Phosphate was determined using the molybdenum blue method while nitrate was determined following the brucine method. A known portion (1-5g) of the soil was extracted with 10 mL chloroform and used for determining the total hydrocarbon content spectrophotometrically.

Another dry I g portion of the soil was digested with $HC1O_3/HNO_3$ (1:5) and the filtrate made up to 100 ml with water and used for the determination of the metal content of the soil using atomic absorption spectrophotometric method (Allien et al., 1974, Burell 1974).

RESULTS

The man values of pH and electrical conductivity of soil suspension, and those of chloride, sulphate, nitrate, phosphate and total hydrocarbon of the extracted soil samples of the study area and two control sampling stations are

presented on Table 1. The Tables shows that soils from banks of Mili stream generally have pH values lower than 5. Hence, they are slightly acidic than the uzoakwa control sample which recorded an average pH values of 5.44. Statistical analysis with student's t-test at 95% confidence level shows that the mean pH values of the study area are significantly lower than that of the Uzoakwa control but not significantly different from the mean pH value of 4.73 ± 0.12 recorded for control samples from Nza. There is slight variation in the mean electrical conductivity of soil samples from Mili stream stations (110.4 µS/cm) when compared with the value recorded for Nza Ozubulu (97.µS/cm). This is an indication that ionic content of soil samples along the bank of Mili stream is higher than that of Nza Ozubulu, a place that is situated just 3-5 km away. Although Uzoakwa Ihiala recorded a mean value of 129.0 µS/cm. data collected from Nnewi shows that samples from ME (Mili Ele) where most of the industries are situated and Mili Father (MF) where many residents are found have values of 155.1 µS/cm and 143.0µS/cm respectively. These values are higher than the mean value for Uzoakwa. The course of the relatively high soil electrical conductivity recorded for soil from the banks of Mili stream may have been explained by the level of chloride, nitrate and phosphate values which are relatively higher than those of Nza Ozubulu and uzoakwa Ihiala control stations. It is obvious from Figure 2 and results on Table 1 that the level of total hydrocarbon content is very high in soil samples collected from and around OTC, Rimco and A-Z industries coded as RC. Generally the hydrocarbon contamination of soils along the banks of Mili stream is not wide spread except in the industrial area (RC).

The mean levels of alkaline and trace metal ions in the soil extract from the various locations studies are presented on Table 2. Slight variations were observed between the mean levels of extracted sodium, potassium, calcium and magnesium in samples of the Mili stream and those of Nza Ozubulu and Uzoakwa Ihiala. In all three different stations the mean mg/kg level of calcium extracted from the soil was found to be the highest followed by those of potassium and sodium. The data also showed detectable levels of extractable lead, chromium and cadmium in soil sample collected from Mili Ele. Chromium and lead were not found in samples from other stations along the bank of Mili stream and those of Nza and Uzoakwa controls. Cobalt, copper vanadium, molybdenum, mercury, barium and arsenic were not detected in soil extracts from any of the sampling stations.

Data on the metal content of the digested soil samples from the various sampling stations and controls are presented on Table 3. It shows that none of the soils contained detectable levels of mercury, vanadium, molybdenum or barium. Copper that was not detected in the extracts, was however detected in the digests of all the sampling stations. Although, cobalt was detected in some soil samples from banks of Mili stream, it was not detected in the soil digest from the two controls. Table 3 shows that the mean level of lead in soils from Mili stream is 11.9 mg/kg while those of the controls recorded 2.5 mg/kg for both Nza and Uzoakwa. With a lead concentration of 25.0 mg/kg Table 3 shows that the lead content in digested soil samples from Mili Ele sampling station is relatively high.

Figure 2 presents the histograms showing

Table 2 Metal ion content (mg/kg) of extracted soil samples from banks of Mili stream in Nnewi, Anambra State

S/N	Soil Sample	Na	K	Ca	Fe	Zn	Mg	Ni	Cu	Co	Cd	Cr	Al	Pb	Mn
1	ME	27.1	35.0	160.7	0.86	2.77	0.89	0.03	<0.01	<0.01	0.01	0.51	6.52	0.77	5.61
2	RC	11.9	29.2	173.3	0.19	1.35	12.97	0.08	<0.01	<0.01	0.01	<0.01	0.77	<0.01	2.77
3	MF	11.9	29.7	88.5	0.22	41.16	0.88	0.02	<0.01	<0.01	<0.01	<0.01	5.92	<0.01	8.94
4	MO	14.7	26.9	94.1	0.19	0.49	1.17	0.03	<0.01	<0.01	<0.01	<0.01	9.64	<0.01	19.55
	Mean of Mili	16.4 ± 7.3	30.2 ± 3.4	129.1 ±44.1	0.37 ±0.33	11.44 ± 19.83	3.98 ± 6.00	0.04 ±0.03	<0.01 ±0.00	<0.01 ±0.00	0.01 ±0.00	0.14 ±0.25	5.71 ±3.68	0.20 ±0.38	9.22 ± 7.34
5	*UN	8.9 ± 1.6	19.7 ± 2.7	123.6 ± 9.8	1.16 ±0.05	1.25 ±0.05	1.14 ± 0.09	0.05 ±0.01	<0.01 ± 0.00	<0.01 ±0.00	<0.01 ±0.00	<0.01 ±0.00	7.45 ± 1.06	0.07 ±0.01	9.10 ± 1.03
6	*UI	19.3 ± 2.9	34.3 ± 2.6	175.7 ± 1.1	0.75 ±0.03	0.42 ± 0.01	1.94 ± 0.03	0.05 ±0.01	<0.01 ±0.00	<0.01 ± 0.00	<0.01 ±0.00	<0.01 ±0.00	2.25 ±0.98	0.08 ±0.02	12.99 ± 1.58

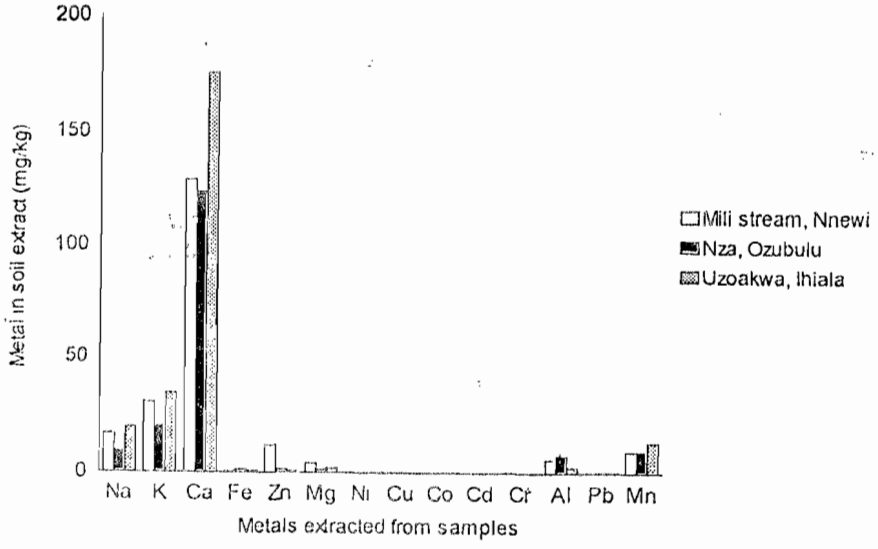

Figure 3 Mean concentration of metal ions extracted from soils from Mili stream and two control stations at Nza Ozubulu and Uzoakwa Ihiala

the relative levels for the mean values of pH, electrical conductivity, chloride, sulphate, nitrate, phosphate and total hydrocarbon content of samples from Mili stream, Nza Ozubulu and Uzoakwa Ihiala sampling stations. The mean concentration of metal ions found in extracted and digested soil samples for the sampling stations are presented on Figures 3 and 4 respectively.

DISCUSSION

The data on pH gave the following values: 4.85 (ME), 4.79 (MF) and 4.83 (MO) indicating that soil acidity is wide spread along the banks of Mili stream. The mean pH of soil from Mili stream is slightly lower than that of the Uzoakwa Ihiala control (5.44). The pH of soils from banks of Mili stream are however similar to that of Nza Ozubulu (4.73) indicating that soil acidity is wide spread from Mili stream to Nza Ozubulu, two stations that are about 3-5 km apart. Within experimental error it could be observed that soil pH is fairly constant from upstream (ME, 4.85) of the Mili stream to the downstream (MO, 4.83). A mean electrical conductivity value of 110.4 µS/cm recorded for Mili stream station is slightly higher than that of Nza. This may have been reflected in the relatively higher mean chloride level of 265.4 mg/kg in soils from Mili stream. A closer observation of Table I shows that sampling stations like MO and MF recorded chloride levels of 324.1 mg/kg and 297.0 mg/kg respectively, an indication that a fair amount of chloride ion in soil is wide spread along the banks of the Mili stream. Compared with 105.6 mg/kg and 225.7 mg/kg recorded fro Nza and Uzoakwa respectively it is hereby being suggested that domestic waste disposal or spillage may be the major contributor to the higher chloride ion content of soils along the banks of the Mili stream. This may have explained the source of the relatively high mitrate (100.03 mg/kg) and phosphate (35.51 mg/kg) concentrations recorded for soils from Mili stream station when compared with 30.74 mg/kg and 16.16 mg/kg recorded for Nza and 65.78 mg/kg and 17.88 recorded for Uzoakwa stations respectively. Statistical analysis (95%) shows that the chloride and nitrate levels from the Mili stream sampling station are significantly higher than those of the Nza Ozubulu control station. The results on Table 1 shows that sulphate ion is not widely distributed in soils along the banks of the Mili stream. In some cases concentrations as low as <2 mg/kg was recorded. This shows that the source of anionic contamination of banks along the Mili stream may not have contained sulphate ion contaminants. Even the 6.15 mg/kg recorded for ME that is prone to industrial waste disposal is close to the 5.42 mg/kg and 6.01 mg/kg recorded fro Nza and Uzoakwa stations respectively. It also suggests that sulphate found in Mili stream sampling stations may have been due to the inherent soil chemistry of the area or may have been introduced into the soils of the three areas by similar sources of domestic, waste disposal. Statistical analysis showed that there is no significant difference (95% confidence limit) between the mean sulphate concentration levels of soils from Mili stream sampling station and those of Nza and Uzoakwa control stations.

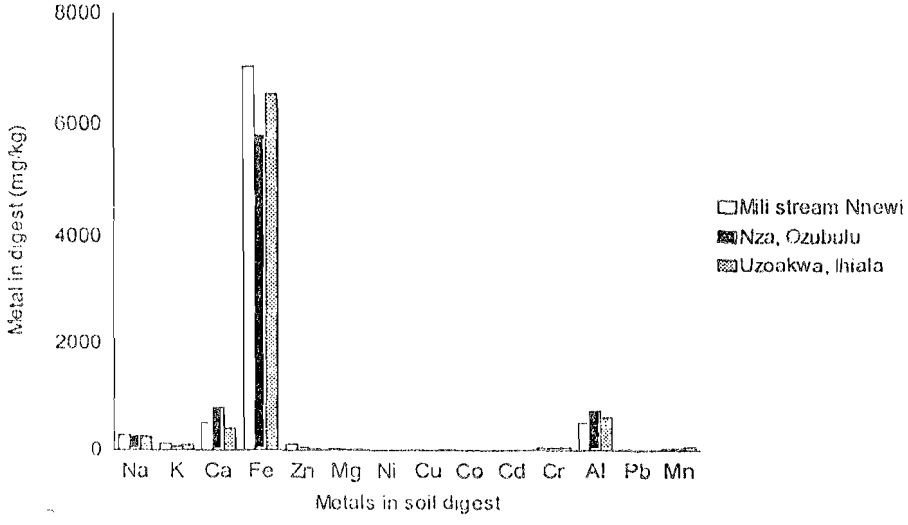

Figure 4 Mean concentration of metal ions in soil digests from Mili stream and two control stations at Nza Ozubulu and Uzoakwa Ihiala

The results show that there is little or no hydrocarbon pollution along the banks of the Mili shallow stream except around the RC sampling station. Since the following industries OTC, Resources Improvement and Manufacturing Company Limited and A-Z industries are located around RC, with a total hydrocarbon content of 30 mg/kg the investigation is showing that industrial activities in the area (RC) has led to hydrocarbon contamination of the soil of the area. The amount of hydrocarbon allowed by Federal Environmental Protection Agency (FEPA 1991) in Nigeria for disposal by any category of industry into our soil environment is 20 mg/L. Hence, the hydrocarbon content of soil samples from areas around the RC sampling station is above acceptable limit, hence there is hydrocarbon contamination of soil of the area.

The mean values recorded for metal ions extracted from soil of the three sampling stations indicate that calcium is the metal with the highest mg/kg concentration. Table 2 and Figure 3 show that the trend in abundance of extractable metals from the soils follows the sequence Ca> K> Na, and this trend is the same in all the three sampling stations. A similar observation (Uzoukwu and Onomake 2002) has been recorded from another study on soils from Nnewi. Manganese and aluminium follow these metals in abundance of extractable metals. The results suggest that leachates from the three sampling stations will have a high probability of containing calcium as the metal with the highest mg/kg concentration. Table 2 shows that extractable lead and chromium are not wide spread along the banks of Mili shallow stream. Apart from Mili Ele

Table 3 Metal ion content (mg/kg) of digested soil samples from banks of Mili stream in Nnewi, Anambra State

S/N	Soil Sample	Na	K	Ca	Fe	Zn	Mg	Ni	Cu	Co	Cd	Cr	Al	Pb	Mn
1	ME	339	133	459	8,415	64 5	31 0	3.50	4 5	1.75	0.01	33 3	569	25.0	34.4
2	RC	248	122	357	6,981	21 5	24 3	3.50	5.0	0.88	0.02	41.6	300	10.0	27.2
3	MF	271	116	944	2,805	325.0	8.6	2.63	2.0	0.88	0.09	33 3	488	7.5	23.1
4	MO	272	137	306	9,913	39.5	22.6	1.75	3.5	1.75	<0.01	66 6	656	5 0	23.8
	Mean for Mili	283 ± 39	127 ± 10	517 ± 292	7,029 ± 3,060	112.6 ± 142.7	21 6 ± 9.4	2.85 ± 0 84	3.8 ± 1 3	1.35 ± 0.50	0.03 ± 0.04	43.7 ± 15.8	503 ± 152	11.9 ± 9.0	27 1 ± 5 2
5	UN	263 ± 5	71 ± 9	791 ± 78	5,802 ± 460	56.2 ± 4.8	12 1 ± 1.7	1.75 ± 0.05	2.5 ± 0.1	<0.01 ± 0.00	<0.01 ± 0.00	50.0 ± 2.1	738 ± 55	2 5 ± 0.1	35 6 ± 4.9
6	UI	260 ± 8	98 ± 10	408 ± 106	6,535 ± 869	23.5 ± 4 6	13 4 ± 2.5	2.63 ± 0.12	2.5 ± 0.4	<0.01 ± 0.00	0.01 ±0.00	50 0 ± 5.9	613 ± 51	2.5 ± 0 2	60.0 ± 5.4

station where 0.77 mg/kg of lead and 0.51 mg/kg of chromium were extracted from the soil, other samples recorded little (less than 0.01mg/kg) or no amount of these metals. The results show that leachates of soils from the Mili Ele sampling station may contain detectable levels of lead and chromium ions. Copper and cobalt were not detected in any of the extracts of soils from the Mili stream sampling station.

The results presented on Table 3 and Figure 4 show that the abundance of metal in soil digests from the three sampling stations follow the trend Fe > Ca > Na> Al > K. It shows that the soils from the three stations studied are ferrous. However, the mean iron content of soil along the banks of Mili stream is higher than those of the two control stations. The very high iron content (9,913 mg/kg) recorded for soil from Mili Ofia sampling station is due to the large stone deposit that is found there. It has been observed earlier that K was found to be more abundant in the soil extract than Na. Table 3 shows that the trend has reversed with the level of Na becoming higher than that of K in the soil digest. The higher abundance of K in the soil extract than Na is attributable to the unguided domestic disposal of palm bunch ash in soils in all the three sampling stations. A similar observation had been made in another study (Uzoukwu and Onomake 2002). Palm bunch ash contains K as its major metal component and domestic disposal of the palm bunch either as the ash or bunch is a common practice in the three sampling stations. Table 3 shows that chromium is wide spread in soil samples along Mili stream and the two control stations. Although the mean lead content of Mili stream station was found to be 11.9 mg/kg, a lead concentration as high as 25 mg/kg was recorded for soils collected from Mili Ele sampling station. When compared with 2.5 mg/kg recorded for each of the control stations the investigation suggests that there is lead contamination of soils from Mili Ele sampling station. The other metals that were detected in the soils of the Mili stream sampling station but were not detected in either of the control stations are Co and Cd. This is an indication of contamination of soils along the banks of the Mili stream by these two metals as a result of waste disposal. Barium, Vanadium, Molybdenum, Mercury and Arsenic were not detected in both the soil extracts or soil digests from Mili stream station or any of the two control stations.

CONCLUSION

The pH of soils from Mili stream sampling station have values less than 5 indicating that soil acidity is wide spread along the banks of Mili stream. The levels of chloride ions found in soils of the Mili stream and the relatively high nitrate and phosphate levels suggest that anionic contamination of the soil may have taken place as a result of domestic waste disposal. The investigation has shown that hydrocarbon pollution is not wide spread along the Banks of the Mili show stream, however hydrocarbon contamination of soils around the Rimco, OTC and A-Z sampling stations has been revealed. There is evidence of lead contamination of soil in the Mili Ele sampling station. The presence of cobalt and cadmium in soils from Mili stream sampling station which were not detected in either of the two control stations has been attributed to soil contamination by waste disposal.

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