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Impact of Effluents from Cable Manufacturing Plant on Food, Water and Soil Qualities in Nnewi, Nigeria

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Abstract: The present study investigated the impact of the chemicals arising from cable manufacturing plant on the environment, with a view of compiling an ecotoxicolgical data of Nnewi. Soil, tap water, cassava water as well as food (cassava tuber) samples were collected from cable manufacturing industry and control site about five kilometers from the industry. Heavy metals namely Cd, Pb, Zn, Ni, Cu, Fe, were analysed in the samples using atomic absorption spectrophotometer. Ammoniun and nitrate contents were also analysed. Volatile and non-volatile solids, pH, electrical conductivity, biological oxygen demand and salinity of tap water and cassava water were analysed. The biological integrity and microbial loads of the soil were determined. Cd (0.001 - 0.002), Pb (1.302-7.454), Ni (0.00-0.186), Cu (0.000-0.680), Fe (0.000-0.030) ppm were present in the soil samples. The food sample contained Cd 0.01, Pb 0.48, Cu 0.01 and Fe 0.02 ppm. While tap water had Pb 3.08, Ni 0.24 and Cu 0.14. None of the samples contained Zn and there was a trace of Fe in the control water sample only. Other parameters: NH_4^+, $N0_3^-$, pH, salinity, electrical conductivity, biological oxygen demand, biological integrity, volatile and non volatile solids, bacterial and fungal loads of the soil sample were found to be within the WHO recommended levels. There were elevated soil, water and food lead levels in around the factory site. Since there were elevated soil, water and food lead levels, we recommend a control measure to reduce lead exposure to the adjoining communities. There is a need for a follow up study by research toxicologists of the blood lead levels of the adults and children in this community.

Key words: Effluent, food quality, soil and water quality, heavy metal, cable manufacturing plant

INTRODUCTION

In the last few decades, man has modified his environment beyond limits as a result of enormous technological advancement[1]. The disposal of industrial wastes poses a serious problem due to their diverse composition. Interaction of these components further increases their complexity. Industrial wastes may contain many contaminants such as alkalis, metallic ions, phenols cyanides, pesticides and many other organic and inorganic substances, which have become a pervasive threat to the natural ecosystems. Environmental contaminants have toxic effects on different types of organisms and affect biological processes at cellular, population, community and ecosystem levels of organization[2].

Nnewi usually referred to as the Japan of Nigeria because of its high industrialization has about thirty giant manufacturing plants and over a hundred cottage industries. According to the 1991 national census the population is about two hundred and one thousand, two hundred and sixty three people. There is no defined industrial estate as most of these industries are located in residential quarters.

The present study investigated the impact of the chemicals arising from cable manufacturing plant on the environment, with a view to compiling an ecotoxicolgical data of Nnewi.

MATERIALS AND METHODS

Sample collection: Soil, water and food samples were collected for analysis from a cable manufacturing plant in Nnewi, Nigeria. Three soil samples A, B, C, from adjacent farmlands to the factory and one sample D from the factory yard (all 30 cm deep) were used for the study. The

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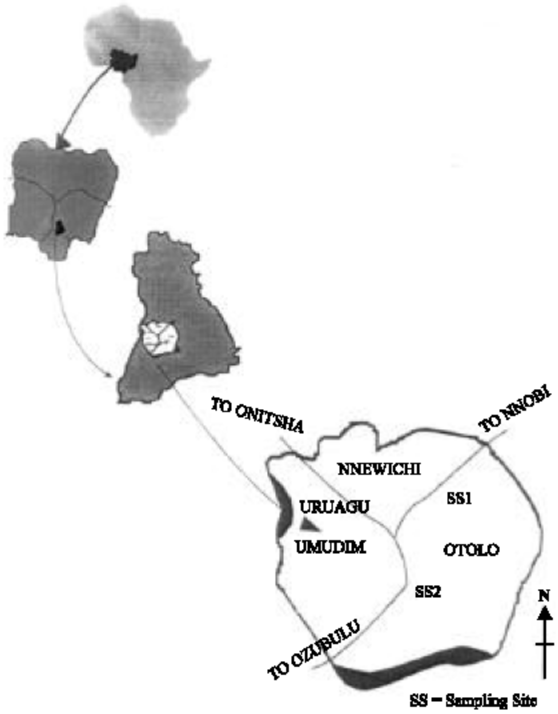

Fig. 1: Map of Nnewi showing sampling sites. SS1 = Factory (Test) Site, SS2 = Control Site

water samples were the potable tap water from the factory yard and water from the food sample, cassava. Food sample was cassava (the staple food of the local population) tuber harvested from adjoining farmland. Control samples were collected from a residential quarter about five kilometers away from the factory site where it was thought that no manufacturing outfit existed. Figure 1 shows Nnewi where samples were collected.

Soil digestion: Five grams of each of the oven dried soil sample was added to 15 mL of a mixture (ratio 3:1) of concentrated HCl and HNO_3 and allowed to stand for 30 min. This was heated over an open flame for 1 h 30 min. The heated sample was made up to 100 mL with distilled water after cooling, filtered and kept in a clean plastic container. The digested samples were subsequently used for heavy metal analysis.

Determination of heavy metals: Heavy metals (Cd, Pb, Ni, Cu and Fe) in soil, water, cassava water and tuber were analysed using atomic absorption spectrophotometer[3].

Determination of NH_4^+ and NO_3^-: Five milliliters of each of the samples was mixed with 2 mL of NaOH and 5 mL of a mixture of H_2SO_4 and salicylic acid. NH_4^+ was analysed spectrophotometrically at 530 nm. For NO_3^-, 1 mL of dilute HCl was added to 10 mL of each of the samples and the ion analysed at 220 nm using spectrophotometer.

Determination of pH, Electrical Conductivity (EC), Salinity (SAL) and Biological Oxygen Demand (BOD): The pH meter, digital meter and digital conductometer were used to determine the pH, SAL and EC, respectively for each of the samples. The BOD was determined electrometrically[4].

Determination of total hardness (TH): The TH of the tap water and cassava water was analysed as mg $CaCO_3$/l by complexiometric method[4].

Determination of volatile and non-volatile solids: Volatile and non-volatile solids were determined by weighing a beaker containing a known volume of the water samples and evaporating the content. After evaporation, the beaker was weighed again together with the residue. The amount of volatile and non-volatile solids was then calculated from the weights of the beaker alone the beaker and the contents and sample volume.

Soil microbiology: The presence of macro organisms alive and dead was recorded by direct observation or by soaking the soil sample in water before noting the presence of macro organisms[5]. Microbial loads (bacterial and fungal) were determined using the method of Postgate[6].

RESULTS

The metal levels ranged from 0.00-7.454 ppm in the test soil samples, with Pb having the highest concentration of 7.454 ppm, while Fe had the highest level (16.754 ppm) in the control soil sample. The ranges of the entire non-metallic ions were NO_3^- 4.4-4.6 mg L^{-1} and NH_4^+ 1.4-1.6 mg L^{-1} (Table 1).

Pb level in the test samples was highest in the tap water (3.08 ppm) and least in the cassava tuber (0.48 ppm), whereas in the control samples, it was least in the tap water (< 0.01 ppm) and highest in the food sample (2.0 ppm). There were only traces of Ni and Cu in the tap water (Table 2).

The pH, EC, SAL, TH, BOD and volatile and non-volatile solids are shown in Table 3. The percentage of volatile and non-volatile solids are in the trace amounts and salinity was nil for the tap water. The bacterial and fungal colonies ranged from 100-130 and 4-6, respectively while the pH of the soil was 6.18-6.91 (Table 4). Water

Table 1: Metal, NH_4^+ and NO_3^-, levels in soil samples

Analyte	Soil samples A	B	C	D	Control
Cd^{2+} (ppm)	0.002	0.001	0.002	0.002	2.20
Pb^{2+} (ppm)	4.144	7.454	1.302	2.462	4.54
Ni^{2+} (ppm)	0.186	0.000	Nil	Nil	12.65
Cu^{2+} (ppm)	0.680	0.350	0.300	0.000	108.76
Fe^{2+} (ppm)	0.000	0.000	0.000	0.030	16754.00
NH_4^+ (mg kg^{-1})	1.600	1.500	1.600	1.400	NA
NO_3^- (mg kg^{-1})	4.400	4.600	4.400	4.500	NA

NA = Not Analysed

Table 2: Metal NH_4^+ and NO_3^- levels in water and food samples

Analyte	Water sample: Tap water	Cassava water	Food: Cassava
Cd^{2+}(ppm)	Nil	0.001	0.01
	(Nil)	(<0.001)	(<0.001)
Pb^{2+}(ppm)	3.08	2.08	0.48
	(<0.01)	(0.04)	(2.0)
Ni^{2+}(ppm)	0.24	0.18	Nil
	(<0.01)	(0.08)	(6.32)
Cu^{2+}(ppm)	0.14	0.50	0.01
	(<0.01)	(0.43)	(4.87)
Fe^{2+}(ppm)	Nil	0.02	0.02
	(<0.01)	(2.91)	(65.78)
NH_4^+ (mg L^{-1})	0.13	6.34	NA
	(NA)	(NA)	(NA)
NO_3^- (mg L^{-1})	0.14	6.03	NA
	(NA)	(NA)	(NA)

NA = Not Analysed, Values in parentheses represent control values

Table 3: Determination of pH, electrical conductivity (EC), salinity (SAL), total hardness (TH), biological oxygen demand (BOD) and volatile and non-volatile solid of water samples

Analyte	Tap water	Cassava water
pH	6.60	3.20
	(4.79)	(NA)
EC (µs)	11.60	0.73
	(15.51)	(NA)
SAL (%)	Nil	8.4
	(0.03)	(NA)
TH (ppm)	0.40	8.30
	(1.0)	(NA)
BOD (mg L^{-1})	12	33
	(1.20)	(NA)
Volatile solids (%)	0.027	0.006
	(NA)	(NA)
Non-volatile solids (%)	0.054	0.042
	(NA)	(NA)

NA = Not Analysed, Values in parentheses represent control values

Table 4: Determination of pH values and bacterial and fungal colonies of soil samples

Parameters	Soil samples (cfu/g) A	B	C	D
pH	6.89	6.18	6.91	6.76
Bacterial colony	130.00	100.00	160.00	140.00
Fungal colony	4.00	5.00	6.00	6.00

sample from control site showed no growth. There was an absence of live and dead macro-organisms in the soil samples.

DISCUSSION

The awareness of the relationship between pollutants and the atmosphere has created the necessity for identification and measurement of heavy metal contaminants in the environment. The scope of the present work is to detect the presence of heavy metals in industrial effluents and other pollutants with a view to using the World Health Organization (WHO) guidelines to know the trace metal and other pollutant concentrations that are in excess. Since there has also been accumulation over the years, this survey was undertaken to initiate a routine monitoring of the heavy metal concentration in the industry.

This study has provided data on Cd, Ni, Pb, Cu, Fe, Zn, nitrate, ammonium of soil samples, BOD, EC, volatile and non-volatile solid, pH, TH of the water samples, biological integrity and bacterial and fungal loads of soil and water samples. The pH of different soil samples from the cable manufacturing plant ranges from 6.76-6.91 with the tap water's pH as 6.60. Although these indicate slight acidity of both the soil and water samples, they are within the recommended range (6.5-8.5) specified by WHO. The low level of ammonium and nitrite in water sample is also in agreement with WHO's recommendation of 10 mg L^{-1}. In all the samples, Cd, Cu and Fe are within the recommended limits of WHO. The bacterial and fungal colonies ranged from 100-130 and 4-6, respectively. The composition of the effluent which was analysed in this study must have been responsible for the reduced microbial population. Water sample from control site showed no growth. There was an absence of live and dead macro-organisms in the soil samples.

Cadmium was not found in the tap water. Drinking water normally does not significantly contribute to Cd intake as some other foodstuffs. Observations from the present study shows that cadmium was in trace amounts in cassava and its water extract. Soil contaminated by environmental toxicants such as cadmium constitute a potential risk for human health. Human exposure to contaminants in soil may occur through the inhalation of dust derived from soil at a contaminated site, through dermal absorption of contaminated soil, by direct ingestion of soil and dust particles due to the hand to pathway, or by secondary exposure through the food chain routes in which initial ingestion uptake occurred in animals and agricultural crops used for food production[7]. Cadmium intake in relatively high amounts can be detrimental to human health. Over a long period of continuous intake, cadmium may accumulate in the kidney and liver and because of long half -life may lead to kidney damage. Food is the major source of cadmium intake and cadmium is present in most foods in low concentrations. Guidelines proposed by the WHO recommend a provisional tolerable weekly concentration of 490 μg cadmium for a person who weighs 70 kg[8].

Cu is an essential element in human diet and has to be present in excessive concentration (20 mg L^{-1}) to create health problems[9]. The WHO 1971 International Standard recommended 0.1 mg L^{-1} Fe as the highest desirable level for total Fe and 1.0 mg L^{-1} as the maximum permissible level. The iron was several orders higher in the control cassava food as compared to the samples collected from the plant. It was also observed that the copper and nickel from the control sample were higher than the samples collected at the cable plant and the environs. These are indications of wide scale pollution of the environment in the event of bioaccumulation due to indiscriminate dumping of wastes from unregistered manufacturing outfits.

Lead level in soil samples ranged from 1.302-7.454, 3.08 and 0.48 ppm in water and food samples respectively. These values are considered high when compared to 0.2 ppm acceptable level in body and 0.1 ppm WHO standard[10]. The principal source of contamination has been the use of Pb compounds in the manufacture of storage batteries as well as the use of Pb based agricultural insecticides[11]. The most important non-occupational sources are food, water, Pb based paints of housing, tobacco and alcohol consumption. Studies suggest that relatively high occupational exposure to Pb as indicated by blood Pb (BPb) levels, can reduce human semen quality[12]. The daily intake of Pb from drinking water for an adult is usually 15-20 mg, where domestic Pb plumbing is still in use and water is soft and acidic. The WHO recommended limits for Pb is 100 mg dm^{-3} for municipal water supplies.

The TH in water has been classified into soft water, moderately soft water and hard water. Soft water is water with total hardness less than 60[13]. The tap water from this factory yard can be classified as soft and slightly acidic. Another observation of public health concern from this study is that the tap water from the control site was found to be more acidic than tap water from the cable plant.

The high levels of lead indicate a direct relation between exposure and accumulation.

Since there were elevated lead soil, water and food lead levels from the cable plant, we recommend a control measure to reduce lead exposure to the adjoining communities. There is a need for a follow up study by research toxicologists of the blood lead levels of the adults and children in this community.

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