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Benthic Algae and Banana (*Musa* spp.) as Bio-monitors of Heavy Metals Pollution in Alaro River, Oluyole Industrial Estate

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Abstract
Alaro River is the main receiving water body for industrial effluents from Oluyole Industrial Estate. Previously, studies on environmental monitoring of heavy metals pollution in Alaro River have focused on the levels of heavy metals in sediment samples, water samples and fishes. However, studies on bio indicators of heavy metal pollution such as algae and banana (*Musa spp*.) plant, which are commonly found within/around the river, are still lacking. This study was therefore conducted to determine the concentrations of selected heavy metals in algal biomass and banana plant in order to establish the feasibility of using the two indicators in phytoextraction and bio-monitoring of environmental quality. Algae samples, banana leaves and roots, and soil samples were collected at different sampling points along the course of the river and analysed for heavy metals. Translocation factor for banana and pollution index for soil samples were determined. Analysis of algal biomass showed that zinc was the most accumulated with values ranging from 133.27 ± 6.36 to 299.98 ± 130.13 mg/kg. Copper, lead and chromium were also detected in varying concentrations while cadmium was not detected in all the samples. Similarly, copper (10.90 ± 3.22 - 11.96 ± 1.98 mg/kg), zinc (50.59 ± 15.14 - 88.52 ± 32.73 mg/kg) and chromium (10.28 ± 5.98 - 12.13 ± 6.32 mg/kg) were detected in the roots of banana while only zinc (17.69 ± 2.92 - 29.02 ± 10.01 mg/kg) and copper (5.07 ± 0.86 - 10.10 ± 5.98 mg/kg) were detected in the leaves. Copper (0.49) was the most translocated metal for banana plant. The potential to bio-concentrate metals were in the order of zinc (1.24), copper (1.12) and chromium (0.44). The mean soil pollution load index was determined to be 0.62. From the results of the study, it can be concluded that algae and banana (*Musa spp*.) plant have potential as aquatic bio-filter plants for phytoextraction and bio-monitoring of heavy metals pollution in Alaro River.

Les Algues Benthiques et des Bananes (*Musa* spp.) En Tant Que Indicateurs Biologiques de la Pollution par les Metaux Lourds dans la Riviere Alaro, Zone Industrielle D' Oluyole

Résumé
La rivière Alaro est la principale masse d'eau réceptrice des effluents industriels de la zone industrielle d'Oluyole. Jusqu'à présent, les travaux

de recherche sur la surveillance environnementale de la pollution par les métaux lourds dans la rivière Alaro se sont concentrés sur les niveaux de métaux lourds dans les échantillons de sédiments, les échantillons d'eau et les poissons. Cependant, les études sur les bio indicateurs de la pollution par les métaux lourds tels que les algues et les bananiers (Musa spp.), que l'on trouve couramment dans/autour de la rivière, font encore défaut. Cette étude a donc été menée pour déterminer les concentrations de métaux lourds sélectionnés dans la biomasse algale et le bananier afin d'établir la possibilité d'utiliser les deux indicateurs en phytoextraire et en bio surveillance de la qualité environnementale. Des échantillons d'algues, de feuilles et de racines de bananier et des échantillons de sol ont été collectés à différents points d'échantillonnage le long du cours de la rivière et analysés pour les métaux lourds. Le facteur de translocation pour le bananier et l'indice de pollution pour les échantillons de sol ont été déterminés. L'analyse de la biomasse algale a montré que le zinc était le plus accumulé avec des valeurs allant de 133,27 ± 6,36 à 299,98 ± 130,13 mg/kg. Le cuivre, le plomb et le chrome ont également été détectés à des concentrations variables tandis que le cadmium n'a pas été détecté dans tous les échantillons. De même, le cuivre (10,90 ± 3,22 - 11,96 ± 1,98 mg/kg), le zinc (50,59 ± 15,14 - 88,52 ± 32,73 mg/kg) et le chrome (10,28 ± 5,98 - 12,13 ± 6,32 mg/kg) ont été détectés dans les racines de bananier tandis que seuls le zinc (17,69 ± 2,92 - 29,02 ± 10,01 mg/kg) et le cuivre (5,07 ± 0,86 - 10,10 ± 5,98 mg/kg) ont été découverts dans les feuilles. Le cuivre (0,49) était le métal le plus transloqué pour le bananier. Le potentiel de bioconcentration des métaux était de l'ordre du zinc (1,24), du cuivre (1,12) et du chrome (0,44). L'indice moyen de charge de pollution du sol a été déterminé à 0,62. D'après les résultats de l'étude, on peut conclure que les algues et les bananiers (Musa spp.) ont un potentiel en tant que plantes aquatiques de bio filtré pour la phytoextraire et la bio indicateur de la pollution par les métaux lourds dans la rivière Alaro.

Introduction

Environmental pollution, particularly that emanating from industrial sources remains one of the notable problems faced by many countries around the world. Industrial activities often create waste water laden with various contaminants among which are heavy metals that is often discharged into surface water bodies without any form of treatment. Heavy metals from different industries, such as textiles, pigments, plastics, mining, electroplating, metallurgical processes, etc., are frequently released into different environmental media (Han *et al*., 2006; Lyer *et al*., 2005). This heavy metals are considered to be persistent environmental pollutants because they cannot be destroyed or degraded (Montazer-Rahmati *et al*., 2011). Owing to their harmful effects and the propensity to accumulate in the food chain, the toxicity of heavy metals is an important issue with severe ecological and human health implications. It is therefore important to develop and implement strategies for monitoring and their removal from industrial waste water. Oluyole Industrial Estate in Ibadan is an area with a high concentration of industries that produce various goods. Among these, food and beverage processing factories and chemical processing factories are prominent. Such factories produce a lot of waste containing heavy metals, which as effluents and pollutants are released into the immediate environment. In these effluents and emissions, metals that may be present include lead, zinc, cadmium and nickel, which are environmental pollutants of priority. Therefore, the assessment of the pollutant status of wastewater from Oluyole Industrial Estate is of great importance.

In Nigeria, the Alaro River is noteworthy and is situated on the North−East side of Ibadan, with a water depth of less than 10 metres. The river originates from Ijokodo and flows South-East along the Ibadan-Lagos expressway through the Oluyole Industrial Estate into Ona River. Hotels, camping sites, restaurants, entertainment or event centres and schools are close to river channel, especially downstream of the Oluyole Industrial Estate. Taking into account the ongoing activities around the Alaro River, the river serves the dual purpose of providing recreational facilities that affect people's social lives and contributes to water supply for small-scale industries. It also receives effluent discharges from factories, which result in the accumulation of contaminants in the sediment. Food and beverages, pulp and paper, chemical and pharmaceutical including publishing industries, which do not have effective effluent treatment plants, are concentrated in the area (Fakayode, 2005; Tyokumbur and Okorie, 2011). Alaro River situated in Oluyole Industrial Estate has been reported to be contaminated by untreated industrial effluents discharged into it by various factories (Adeogun, 2012).

Owing to their toxicity and bioaccumulation ability in animals, heavy metals are major ecological and public health issues (Adeniyi, 2008). As demonstrated by the chronic and acute toxicity of fish and other aquatic species, the concentration and persistence of heavy metals in the aquatic environment is dangerous to biological life (Haiyan and Stuanes, 2003). The majority of heavy metals are well-known toxic and carcinogenic agents which pose a significant threat to the human population as well as to the fauna and flora of the water bodies receiving them (Lyer *et al*., 2005). Heavy metals have a significant propensity to bio-accumulate and end up as permanent environmental additions. As waste water is discharged to water sources without the removal of heavy metals, since they are non-degradable and permanent, heavy metals may be toxic to both human and marine life.

The removal of heavy metals from waste water has recently become a matter of significant concern (Nagajyoti *et al*., 2010). Wastewater contaminated with heavy metals can be treated before being released into the aquatic ecosystem; however the treatment is very expensive. Cancer (Amaranemi, 2006) and reproductive impairments (Iwegbu, 2007) are possible long-term harmful effects of heavy metals on humans. This makes effective monitoring and control measures imperative. In view of the adverse effects of heavy metals on waterbodies, it has become very important to determine their accumulation in the dominant and economically viable organisms. This would reflect the spatio-temporal impact of the process and will also determine the potential impacts on health and services of the ecosystem (Baiomy, 2016).

In environmental monitoring, due to variability in water discharge and low residence time, the use of pollutant status in water as a sole ecosystem assessment index is incomplete. For the measurement of heavy metals, biomonitors have more advantages than water samples, particularly when economic considerations preclude the use of highly sensitive water analysis methods, and/or when seasonal or spatial concentration variations need to be considered, as in the case of trace metals (Díaz *et al*., 2001). In addition, assessment of pollution by traditional water or sediment analysis alone is often cumbersome and unreliable (Topcuo'lu *et al*., 2003), due to either very low concentrations (due to regular contaminant tidal fluxes) or large concentrations (due to inadequate tidal flux) (Chaudhuri *et al*., 2007). In this respect, by reporting observable bioavailable concentrations of pollutants, biomonitors such as algae are efficient. They also have the benefits of accumulating pollutants without being seriously impacted or destroyed by levels present in the ecosystem. Sediments serve as the sink of several contaminants including heavy metals (Clements, 1992). Although the concentration of heavy metals in the sediment is not a toxicity reagent unit (Perera, 2004), algae species are one of the valid methods for estimating the occurrence of heavy metals and their availability in the aquatic setting (Karadede-Akin and Unlu, 2007; Vicente Martorell *et al*., 2009). Thus, it has been pointed out that it is preferable to investigate the presence of metals in the environment by determining metal concentrations in algae species such as *Spirogyra* rather than direct water measurements (Karadede-Akin and Unlu, 2007; Vicente Martorell *et al.* , 2009). In addition, benthic *spirogyra* is actively in contact with marine habitat sediments and therefore aggregate heavy metals within their bodies. In marine environments, this may also contribute to suggestions for heavy metal bioremediation.

Banana (*Musa spp*.) is also a potential bio monitor of heavy metals pollution. Quiterio *et al.* (2004) reported that banana leaves can be used to detect and track environmental contamination. An enrichment of aluminum and manganese concentrations was observed in banana leaves exposure to total suspended particles (TSP) and airbone particulate matter contaminated with these elements. Monitoring heavy metals aggregation in dominant and commercially productive organisms such as algae in the river and banana (*Musa* spp) on the bank has become very important in view of the adverse effects of heavy metals on water bodies. This would help in determining the future impacts on health and service of the environment (Baiomy, 2016).This study investigated the presence of heavy metals (Cu, Zn, Cr, Pb and Cd) in the algae in Alaro River and assessed the metal contamination of soil and banana (*Musa* spp) in Oluyole Industrial Estate in order to establish the feasibility of using these two bio indicators in phytoextraction remedial activities and bio-monitoring of environmental quality. The specific objectives of the study were to determine the level of metals accumulated in the algae collected from the river, assess the distribution of heavy metals in the leaf and root of banana (*Musa* spp) and determine the pollution status of the soil.

Materials and Methods

Site Description and Sampling

The study is an observational cross-sectional study. The study area is the Alaro Stream ecosystem between latitude 7 ° 21" N-7 ° 22' and longitude 3 ° 50' E-3 ° 52' E in Oluyole Industrial Estate in Ibadan, Nigeria. Oluyole Industrial Estate is situated in Ibadan South West Local Government Area of Oyo State. The choice of the stream was influenced by the fact that most industries in Ibadan are located very close to the stream, which serves as a means of disposing their wastewater. This has made the stream unacceptable for domestic use. This is influenced by detection of trace metals in the river (Ogedengbe and Akinbile, 2004).

Sampling was carried out twice between the month of March and October. Four sampling points were purposively selected based on presence of wastewater discharge points and samples species. Sampling points had different levels of human impact, where heavy metals inputs were mainly due to untreated industrial wastewaters, farming, run-offs and improper excretion practices. The locations of sampling points are as given in Table 1.

Table 1: Locations of sampling points

Sampling point	GPS reading
1	7°21’52”N3°51’06”E
2	7°21’48”N3°51’07”E
3	7°21’37”N3°51’04”E
4	7°21’36”N3°51’08”E

During sampling, environmental conditions were stable; specifically, days were sunny, not windy, without recent rains, with calm and regular water flow.

At each sampling site, two algae samples, two composite soil samples, two leaf samples along the whole length of the midrib and two roots samples around the corm of two different banana crops were collected. Soil samples were taken from the vicinity of the collected plants at a depth of 0-10 cm from within a circular area having a radius of around 0.5 m and with the collected plant located at its centre. To avoid contamination by metals, the plant samples were rooted out with stainless steel tools. After collection, the plants were delicately shaken to remove large soil particles and then placed in airtight well-labelled plastic bags.

Sample Preparation and Analysis

The algae samples were scooped into water bottles along with the freshwater using a plastic water jug. In order to protect the samples, Lugol's solution (prepared by dissolving one gram of iodine crystals and two grams of potassium iodide in 300ml of water) was used. For algae identification, all observable soil particles were extracted by washing the collected strains thoroughly with tap water and then finally washing with distilled water. These algae were examined under a microscope and then identified taxonomically using published literature (Prescott, 1962).

At each sampling point, the soil samples were thoroughly mixed to create a composite sample. At each sampling site, two composite soil samples were collected. Similarly, at the sampling points, the leaf along the entire midrib and the roots on the corm of the banana plants were collected using scalpel and placed in well-labelled polythene bags.

Plant samples (samples of algae and banana crops) were first washed to remove large particles under running tap water and then rinsed with purified water to remove any remaining fine adhering or residual content. In order to prevent the unwanted effects of higher temperatures on the analytical results for some of the heavy metals, plant samples were then dried to a constant weight at room temperature. Once dry, plant samples were grinded and homogenized in an agate mortar in preparation for samples digestion. The soil samples were homogenized, air-dried, ground using a pestle and mortar into a very fine powder, and sieved using a 2 mm mesh scale. It was preserved for further study in airtight polyethylene bags. Samples were digested as described by Ehi-Eromosele *et al.*, (2012). The samples were analysed for cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb) and zinc (Zn) using Flame Atomic Absorption Spectrometer 240 FS AA.

Analysis

Determination of Bio concentration and Translocation

Bio concentration and translocation factors were calculated using equations 1 and 2 to element mobility in the study species.

$$Bioconcentration\ factor\ (BCF) = \frac{C_{root}}{C_{soil}} \ldots\ldots\ldots\ Equation \quad 1$$

Where,

C_{soil} is the concentration of a particular element in the soil (mg kg^{-1} DW).

C_{root} is the concentration of a particular element in the root of the study species (mg kg^{-1} DW).

The efficiency of a plant species to absorb from the sediment and store a particular element in its tissues is expressed by BCF. Higher BCF values mean a greater potential for bioaccumulation (EPA, 2007).

$$Translocation\ factor\ (TF) = \frac{C_{leaf}}{C_{root}} \ldots\ldots\ldots\ Equation \quad 2$$

Where,

C_{leaf} is the concentration of a given element in the leaves (mg kg^{-1} DW)

C_{root} is the concentration of a given element in the roots (mg kg^{-1} DW).

Translocation factor represents the mobility of a given element within the plant species, where higher TF values mean higher translocation capacity (Deng *et al.*, 2004).

Contamination Indices

Determination of Geo-Accumulation Index

For the evaluation of soil pollution around the sampling sites, a geo–accumulation index (I_{geo}) was used. This was determined using equation 3.

$$I_{geo} = \log_2\left(\frac{C_n}{1.5B_n}\right) \ldots\ldots\ldots\ Equation \quad 3$$

Where,

C_n is the measured concentration of the element in the soil sample fraction

B_n is the geochemical background value.

Values from a controlled sample from Olapiti Village an area free from industrial influence was used as background for this study which was previously used by Isibor (2016). The background values were copper (16.5), lead (23.4), zinc (89), chromium (49) and cadmium (0.09). The constant 1.5 allows for measurement of natural fluctuations in the content of a given substance in the environment and very small anthropogenic influences.

Determination of Contamination Factor

Contamination factor was determined using equation 4.

$$C_f = \frac{C_n}{B_n} \quad \text{...... Equation 4}$$

Where,

C_n is the measured value of the heavy metal in the soil

B_n is the background values for heavy metals in soil.

Determination of Pollution Index (PLI)

Pollution index was determined using the equation 5

$$PLI = (C_{f1} \times C_{f2} \times ... \times C_{fn})^{\frac{1}{n}} \quad \text{...... Equation 5}$$

Where,

n is the number of metals

According to Mohiuddin *et al.* (2011), if *PLI* is greater than 1, pollution occurs and otherwise there is no metal contamination.

Results

Algae Identification

The algae collected from Alaro River were identified under microscope as *Spirogyra sp.* They were found at the edge or where water flow is impeded or sluggish. Their chloroplasts were band-shaped and spirally arranged in the cell. They had slippery bodies with thread made up of tiny filaments bounded by layer of slime. They were attached to the benthic zone of the river by means of root-like filament structures.

Heavy Metal Concentration in Algal Biomass

Mean heavy metal concentrations at the different sampling points for the two sampling periods are indicated in Table 2. Copper concentration was in the order of sampling points 3>1>2>4 with highest concentration of 45.29 mg/kg while zinc concentration was in the order of sampling points 1>3>2>4 with maximum concentration of 299.98 mg/kg. The results also revealed that zinc was the most abundant among the heavy metals observed in the algal biomass. For chromium concentration, the observed concentration was in the order of sampling points 3>4>1>2 with maximum concentration of 42.99 mg/kg.

Heavy Metal Concentration in Soil, Banana Root and Banana Leaves

Mean copper concentrations in soil, banana root and banana leaves are shown in Figure 1a. Generally, the concentration was highest in the soil and was followed closely by the root at all sampling points except at sampling point 4.

Moreover, leaves had the least copper concentrations at all sampling points. For all sampling points, copper concentrations were higher in root than in the leaf while soil recorded highest concentration except at sampling point 4.

For zinc concentration (Figure 1b), the concentration was highest in the root followed by the soil at all sampling points except at sampling point 2 while leaf had the least concentration at all points. The highest concentration was in the order root (88.5 mg/kg)>soil (69.0 mg/kg)>leaf (29.0 mg/kg) at sampling points 4, 3 and 4, respectively.

Chromium concentrations are shown in Figure 1c. Chromium was not detected in banana

Table 2: Heavy metal concentration at different sampling points

Sampling point	Cu (mg/kg)	Zn (mg/kg)	Cr (mg/kg)	Pb (mg
1	44.3 ± 10.7*	300.0 ± 130.1	39.8 ± 0.00	31.2 ± 7.3
2	36.3 ± 8.3	225.0 ± 115.9	36.7 ± 1.6	28.9 ± 2.2
3	45.3 ± 3.3	282.9 ± 12.7	43.0 ± 5.5	44.3 ± 5.4
4	28.1 ± 4.2	133.3 ± 6.4	41.5 ± 10.9	21.8 ± 6.1

*Values are means ± standard deviation (n = 2) leaf. Soil had higher concentration at all sampling points when compared with banana root. Highest concentration (30.1 mg/kg) was recorded in the soil at sampling point 2. Soil recorded higher chromium concentrations at all points.

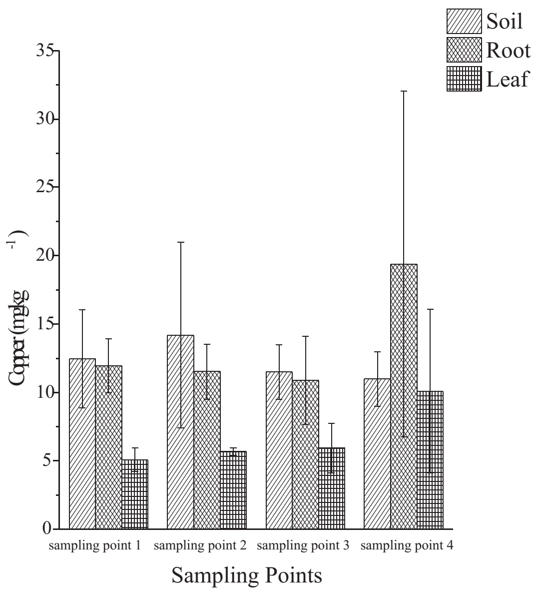

Figure 1a: Copper concentrations in soil, banana root and leaf

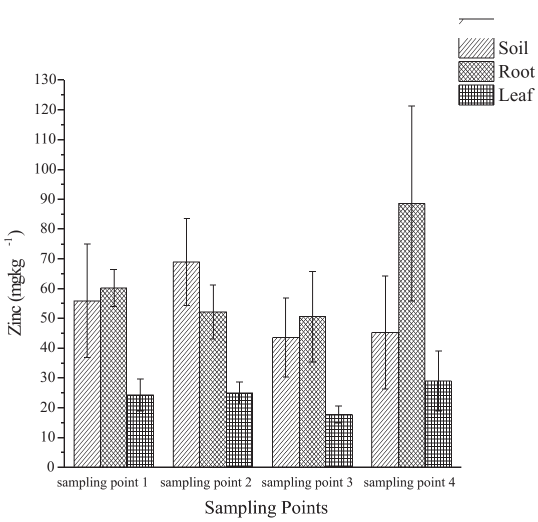

Figure 3.1b: Zinc concentrations in soil, banana root and leaf

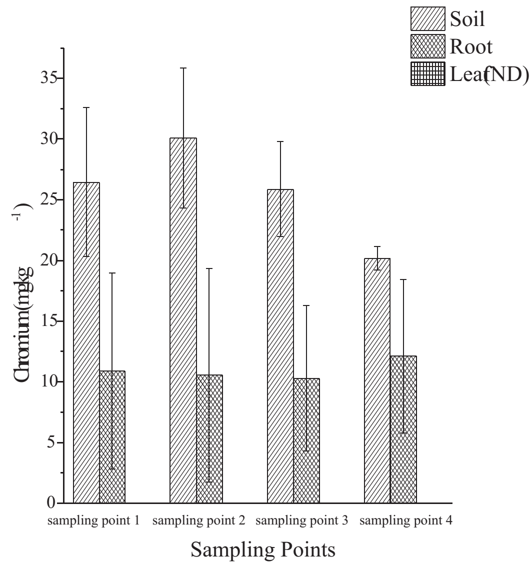

Figure 3c: Chromium concentrations in soil, banana root and leaf

Bio concentration and Translocation Factors in Banana

Bio Concentration Factor (BCF) is the ratio of heavy metal content in root part of plant to the sample in respective soil samples. It is an important parameter to know the transfer capability of a metal from a soil into a plant. The BCF that is greater than 1 indicates that the plant is an accumulator for metal being analysed (Baker, 1981). The BCF was generally less than 1 for Cu and Cr at all sampling points except at sampling point 4 where BCF for Cu was 1.76. Conversely, BCF for Zn was greater than 1.0 except at sampling point 2. The mean BCF from all the sampling points can be ranked in the order of decreasing magnitude as Zn (1.24)>Cu (1.12)>Cr (0.44). This indicates that *Musa spp*. was an accumulator of Zn and Cu.

Translocation Factor (TF) in the banana leaf and root (Table 3) expresses the mobility of a given element within the plant species, where higher TF values result in a greater translocation capability (Deng *et al.*, 2004). The mean TF from all the sampling points can be ranked in the order of decreasing magnitude as Cu (0.49)> Zn (0.39). This indicates that Cu was the most translocated metal for banana plant.

Table 3: Bio concentration Factors in Banana Plant

Heavy metals	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4
Cu	0.96	0.81	0.95	1.76
Zn	1.08	0.76	1.16	1.95
Cr	0.41	0.35	0.40	0.60
Pb	-	-	-	-
Cd	-	-	-	-

Table 4: Translocation Factors (Leaf/Root) in Banana Plant

Heavy metals	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4
Cu	0.42	0.49	0.54	0.52
Zn	0.41	0.48	0.35	0.33
Cr	-	-	-	-
Pb	-	-	-	-
Cd	-	-	-	-

Contamination Indices

The geo-accumulation indices (Igeo) for the sampling points are presented in Table 4. Soil with Igeo ≤ 0 is classified as practically uncontaminated (Muller 1969). The results in Table 4 thus indicated that the soil at all the sampling points were practically uncontaminated. Contamination factor (CF) is the ratio between the concentration of each metal in soil samples and the background value. The background values adopted were from Olapiti Village used as control point by Isibor (2016). The CF is classified as low contamination when CF<1 (Hakanson, 1980). The CFs for the tested heavy metals were less than 1 (Table 5), which indicated low contamination by the tested heavy metals. The pollution indices (PLI), which give an assessment of toxicity status of samples and the contribution of each metal to the pollution, are presented in Table 5. The PLI<1 indicates that there is no metal pollution in the site; otherwise there is no pollution (Varol, 2011). The results showed that there was no metal pollution.

Discussion

The present study was conducted to determine the level of metals accumulated in the algae so as to determine its potential as aquatic bio-filter

Table 5: Geo-accumulation index ratio of soil across the sampling points

Heavy metals	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4
Cu	-0.99	-0.80	-1.11	-1.17
Zn	-1.26	-0.95	-1.61	-1.56
Cr	-1.47	-1.29	-1.51	-1.86
Pb	-	-	-	-
Cd	-	-	-	-

Table 6: Contamination Factor and Pollution Load Index of soil

	Contamination Factor						
Sampling Point	Cu	Zn	Cr	Cd	Pb	PLI	Pollution degree
1	0.76	0.63	0.54	-	-	0.64	No metal pollution
2	0.86	0.77	0.61	-	-	0.74	No metal pollution
3	0.70	0.49	0.53	-	-	0.57	No metal pollution
4	0.67	0.51	0.41	-	-	0.52	No metal pollution

plant for phytoextraction and bio-monitoring of heavy metals pollution in Alaro River. The algae samples were found to be *Spirogyra spp* which are green algae capable of photosynthesizing food due to the presence of chlorophyll. They are visible on the water body as green filaments covered in slime by the edge or at the point of sluggish flow of water due to obstruction by debris. The relative abundance of heavy metals in the algae decreases in the order Zn> Cr> Cu > Pb. This order is close to that reported by Akcali and Kucuksezgin (2011) who conducted a biomonitoring study with macroalgae in the Eastern Aegean coastal areas which decreases in the order Fe > Zn > Cu > Cr > Cd > Hg > Pb. The abundance of heavy metal in algae biomass can be attributed to heavy metal pollution in the Alaro River. Tyokumbur *et al.*, (2014) who conducted an experiment to assess heavy metals in the fish (*Hemisynontis membraneeous*) in Alaro stream concluded that the fishes were contaminated and that the sediments are greatly polluted by heavy and trace metals. This shows that the sampled algae have potential to be used as aquatic bio-filter plant for phytoextraction activities and bio-monitoring of heavy metals pollution in Alaro River.

The distribution of heavy metals in the soil, banana leaf and root samples were analysed. Zinc concentration was the highest in all the samples. Zinc concentration decreased in the order of root > soil > leaf. Copper concentration followed the same order as zinc (root > soil > leaf). However, chromium concentration differed as concentration in soil was higher than in root sample. Chromium was not detected in the leaf samples. The metals concentration in the leaves are almost similar to that recorded in banana leaves also collected from Industrial Area in Rio de Janeiro by Flores *et al.*, (2018). The concentration measurements for heavy metal contents in the study were as follows Cd (0.09 ± 0.05 mg/kg), Cu (5.86 ± 2.34 mg/kg), Pb (1.54 ± 0.90 mg/kg), and Zn (50.81 ± 13.90 mg/kg). It can also be observed that zinc had the highest concentration in the leaves than copper which is in complete harmony with findings in this study. The results of copper, zinc and chromium obtained from this study are within closed range to that reported by Isibor (2016) who earlier conducted assessment of soils within the industrial estate. The result obtained by Isibor (2016) who also assessed the heavy metals concentration in soils around Oluyole Industrial Estate showed the mean value increased in the order Mn>Cr>Zn>V>Pb>Cu>Ni>Sr>Co>Sc>As>Mo>Cd. The critical elements needed for normal plant growth and metabolism are Co, Cu, Fe, Mn, Mo, Ni and Zn, but these elements can easily lead to poisoning if their concentration is greater than the optimum value. The possibility of moving heavy metals from soil to humans should be a matter of concern, given the edible portion of the plant in most vegetable species (Jordao *et al.*, 2006). A possible hazard to animal and human health is the uptake of heavy metals by plants and subsequent accumulation along the food chain (Sprynsky *et al.,* 2007). Therefore, the determination of bio concentrations of selected heavy metals in sampled banana is desirable for food safety.

Bio concentration factor infers the efficiency of a plant species to take up and accumulate a specific element in its tissues from the soil. From the result, it can be concluded that banana (*Musa spp*) has higher bio accumulation capacity (from soil to root) for copper and zinc than chromium.

The translocation factor is a measure of the mobility of an element within the plant. The higher the TF values the greater the translocation capability (Deng *et al.,* 2004). Translocation factor could not be calculated for chromium as chromium was not detected in leaf. Plant root absorption is one of the key routes of entry of heavy metals into the food chain The absorption and accumulation of heavy metals in plant tissue depends on several variables, including temperature, humidity, organic matter, pH, and the availability of nutrients (Jordao *et al.,* 2006). These probably explain the differences in TF values recorded in this study.

The geo-accumulation factors for copper, zinc and chromium in the soil were all below zero. It can, therefore be concluded that the areas covered in the study were practically uncontaminated by copper, zinc and chromium. The geo accumulation index is in close relation with that of Isibor (2016) who reported practically uncontaminated to moderately contaminated sites for Cu, Zn and Cr. Copper contributed mostly to the pollution index of the study site, followed by zinc and chromium. The pollution load index which is an assessment of the overall toxicity of the metals and their contribution to the pollution status of the area, across all the sampling point was less than 1. This implies that the study sites seem not to be polluted by heavy metals. However, it important to state here that with pollutant discharges still ongoing and no investment in pollution tracing and control in the study area, the situation as reported in this study may be transient. Soil pollution by heavy metals is a well-known environmental problem (Hinojosa *et al.,* 2004). In addition to having adverse effects on different parameters concerning plant quality and yield, heavy metal contamination often induces changes in the size, composition and behavior of the microbial community (Yao *et al.,* 2003). Chen *et al.* (2010) reported that heavy metals in polluted soils caused a decline in the richness of bacterial species and a relative increase in soil actinomycetes or even a decrease in both the biomass and diversity of the bacterial populations.

Conclusion

This study supports growing evidence that Alaro River is actively accumulating heavy metals that are likely traceable to discharges from industrial activities. It also indicates that algae have the potential to accumulate Zn, Cu, Cr and Pb. It can thus be used to assess the level of pollutants, which can be a reflection of heavy metal pollution in the river. Consequently, algae can be used in the phytoextraction process of heavy metals in wastewater effluents. Zinc, copper and chromium were detected in *Musa spp* roots while only zinc and copper were found in the leaves. Results of bio concentration factor of *Musa spp* indicate that the plant is an accumulator for copper and zinc but not for chromium. Translocation factor of elements between the roots and leaves of *Musa spp* indicates that copper has higher mobility than zinc. Values of geo-accumulation and pollution load index indicate soil quality is practically uncontaminated.

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