International Journal of Research
Available at
https://journals.pen2print.org/index.php/ijr/

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 07 Issue 03
March 2020

Assessment of Heavy Metals Contamination in Soil and Plant (*Talinum triangulare*) Leaf around Selected Industrial Areas in Ogun State, Nigeria

Ibrahim Aderemi Salaudeen; Azeezat Ayannike Rasheed-Adeleke; Kamor Temitope Olanrewaju

Department of Chemistry, The Polytechnic, Ibadan, Oyo State, Nigeria

Main Author's E-mail: ibrahim.aderemi77@gmail.com

ABSTRACT

Heavy metal accumulations in plant and soil from anthropogenic sources with subsequent consequences constitute major environmental problem. This present study investigated the pollution load of heavy metals in the soil and plant from selected industrial estates, Ogun State, Nigeria. Twenty soil and plant samples were collected from four selected industrial areas in Agbara, Sango-ota, Ewekoro, and Sagamu Ogun State, Nigeria. Also, five soil and plant samples were collected from Epe town, located in the outskirts of Ogun where there are no industrial activities to serve as control. The concentration of selected heavy metals in the soil and plant samples were determined by atomic absorption spectrometry. The mean concentration of heavy metal in the soil shows Fe ranged from 50.00 to 1964.00 mg/kg, Zn ranged from 136.00 to 1862.80 mg/kg; Cu ranged from 4.12 to 122.40 mg/kg, Cd ranged from ND to 12.48 mg/kg, and Mn ranged from 16.76 to 60.60 mg/kg. Also, mean concentration of Fe in the vegetable samples ranged from 118.00 to 579.20 mg/kg, Zn ranged from ND to 1687.00 mg/kg, Cu ranged between 5.72 to 32.16 mg/kg, Cd ranged from 1.12 to 12.16 mg/kg while Mn ranged from 13.00 to 32.60. Analysis of variance revealed significant ($p<0.05$) variation in the concentrations of the heavy metals in soil and plant samples among the sites which is an indication of extent of metal contamination. Positive correlation was found in some of the metals in soils and plants samples indicating common contamination source. Zn, Cu and Cd concentrations in the soils from some of the locations exceeded WHO permissible limit. The impact of industries on surrounding environmental media was observed, it is therefore necessary for the authorities to enforce stricter measures on the release of contaminants into the environment by industries to forestall health crisis.

Keywords: *Industrial areas, Pollution, Heavy metal, Atomic absorption spectrometry, natural and anthropogenic sources*

1. INTRODUCTION

Due to industrial activities, several countries have attained sustainable development with some degree of environmental degradation. These activities in the environment, however tend to produce pollutants that may include gases, acids, oils, cooling water, and so on *(*Lawal *et al.*, 2017). When there is no serious concern for the environment or measures to contain these problems, several issues (such as indiscriminate dumping of waste, illegal mining, oil spillage, and evolution of poisonous gases) often make untreated wastewater and pollution inevitable *(*Cooper. *et al.*, 2006*).* These issues can be more prevalent in less developed countries, to the extent that industries are located without due regard to physical planning (Cooper *et al.*, 2006). Resulting pollutants are distributed by several means such as atmosphere within a distance and transported up to several kilometers away from their sources and transferred to the soil through wet or dry deposition (Tsafe, *et al.*, 2012*).* Soil contamination had become a serious problem in all industrialized areas of the country **(**Srinivasa *et al.,* 2010). Soil is regarded as the ultimate sink for the pollutants discharged into the environment (Shokoohi *et al.*, 2009). Most plants and animals depend on soil as a growth substrate for their growth and development. In many instances the sustenance of life in the soil matrix is adversely affected by the presence of deleterious substances or contaminants (Babyshakila, 2009). The entry of the organic and inorganic form of contaminants results from disposal of industrial effluents (Gowd *et al.*, 2010). The sources of organic and inorganic elements of the soil of contaminated area are mainly from unmindful release of untreated effluents in to the ground *(*Shetty and Rajkumar, 2009*).*

Leafy vegetables occupy a very important place in the human diet (Mudipalli *et al.*, 2005), but unfortunately constitute a group of constituents which contribute maximally to nitrate and other anions as well as heavy metals consumption, an example of this is waterleaf (*Talinum triangulare*). Waterleaf (*Talinum triangulare*) is one of the most common leafy vegetables in Nigeria. It is a perennial herbaceous plant widely grown and consumed as a vegetable (Wilberforce, 2016). Studies have shown that waterleaf contains important nutrients and phytochemicals such as flavonoids and polyphenols, crude protein, lipids, essential oils, cardiac glycosides, omega -3-fatty acids, minerals, soluble fibres and vitamins (Swarnaj and Ravindhran, 2013, (Guillén, *et al.*, 2017). The availability and nutritional composition make it one of the most sought vegetables (Aja *et al.*, 2010). Heavy metals such as lead (Pb), cadmium (Cd) and mercury

(Hg) are natural constituents of the environment like air, water, and soil (Fagmin *et al.*, 2006). They are produced from anthropogenic activities and have gained importance as contaminants *(*Taha *et al.*, 2013*)*. They have no beneficial role in living organisms, but are very toxic to humans *FAO/WHO,* 2002. They are only tolerated at extremely low concentrations and excesses are associated with many adverse health effects (*Abiona et al.,* 2016). This study covers the evaluation of heavy metals contamination in soil and plant (*Talinum triangulare*) leaf samples around selected industrial areas in Ogun state, Nigeria.

1. METHODS

Twenty soil and plant samples were collected from four selected industrial areas (Agbara, Sango-ota, Ewekoro, and Sagamu) Ogun State, Nigeria (Figure1). Also, additional five soil and plant samples were collected from Epe town, located in the outskirts of Ogun, where there are no industrial activities to serve as control. The plant samples were washed with tap water and then distilled water to eliminate unwanted particles air dried at room temperature to remove moisture; thereafter blended into powdery form using an electric blender to obtain uniform particle size while the soil samples were thoroughly mixed to form a composite sample; air-dried, grounded and sieved to get uniform particle size. Each sample was labelled and stored in a dry plastic container that had been pre-cleaned with concentrated nitric acid to prevent contamination prior to the analysis with Atomic Absorption Spectroscopy (AAS). For each of the soil and plant sample, 5g was weighed and digested with 20ml of Aqua regia at the ratio 3:1 (HCl: HNO_3) and heated at 100^0C on a hotplate for 20minutes until effervescence subsidized giving a clear white fume (Abiona *et al*., 2016). The cooled solutions were filtered from the digestates, then 20ml of the filtrate was standardized with distilled water in 100ml standard flask and transferred into a sampling bottle for further analysis (Abiona *et al*., 2016).

Atomic Absorption Spectrometry Analysis

Experimental analysis of both soil and waterleaf samples were carried out using Atomic Absorption Spectrophotometer (AAS) at Central Research laboratory, Chemistry Department, The Polytechnic of Ibadan, Nigeria. The heavy metals were analyzed using Model 210 VGP of the Buck Scientific AAS series with air-acetylene gas mixture as oxidant. Filtrates from digestion above were aspirated and the equipment calibrated for each element *(APHA, 2005)*. The results were recorded as mg/l of solution and were calculated to mg/kg of sample using the weight of sample taken as a denomination of the digest volume (100ml) *(APHA, 2005).*

Calculation:

International Journal of Research
Available at
https://journals.pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 07 Issue 03
March 2020

Kg/ sample = Digest Concentration x Dilution factor

$$DF = \frac{volume\ of\ digest \times aliquot}{weight\ of\ sample}$$

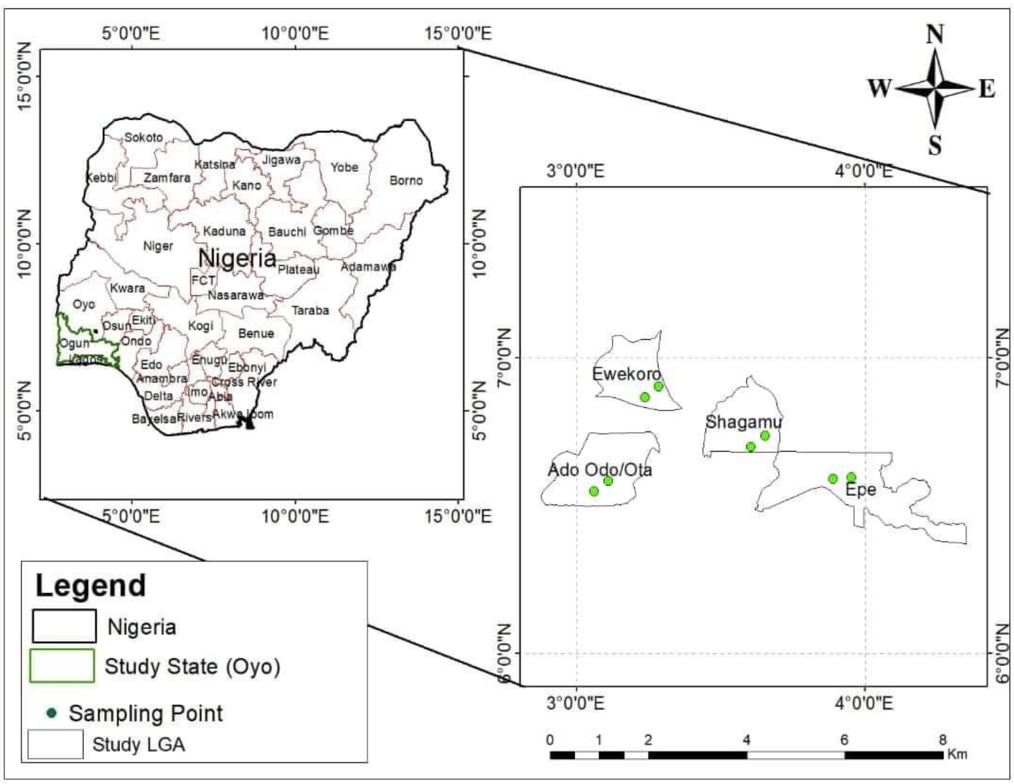
Digest concentration = Analyte reading on A.A.S.

Volume of digest = final volume of digested or extracted sample

Aliquot = ratio of sample to distilled water (when diluted further)

Statistical Analysis Data were subjected to statistical analysis using the QED statistics software. The heavy metals' levels among the plants and soils samples were compared using the One-Way Analysis of Variance (ANOVA) and the means were compared using Tukey's post hoc test at adequate significance level.

2. RESULTS AND DISCUSSIONS



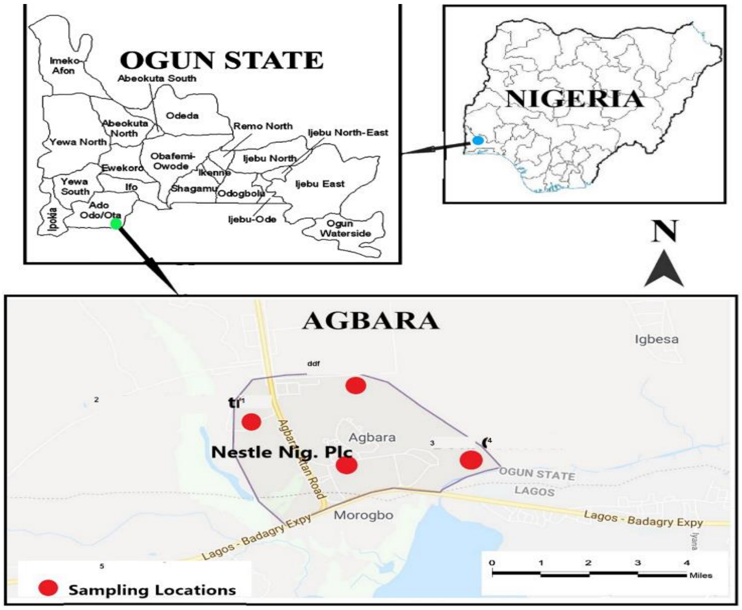


Fig. 1: Map of the study area and sampling point

Table 1: Mean Heavy Metals Concentration (mg/kg) in soils samples from selected industrial sites in Ogun State

Sampling site	Fe	Zn	Cu	Cd	Mn
Sango Ota	1298.40±1069.43[b]	1101.20±935.99[a]	122.40±4.36[c]	12.48±1.64[c]	60.60±12.39[c]
Ewekoro	1964.00±328.97[b]	1862.80±513.88[a]	9.08±4.12[a]	5.68±1.42[b]	32.64±6.62[b]
Agbara	1143.20±787.35[b]	1211.40±710.61[a]	29.32±9.33[b]	11.20±5.46 [c]	16.76±2.91[a]
Sagamu	1292.00±375.85[b]	1488.60±758.05[a]	4.12±1.20[a]	ND[a]	55.92±9.21[c]
Epe	50.00±22.63[a]	136.00±83.44[a]	9.20±5.37[a]	ND[a]	60.60±3.96[c]
WHO	5000	300	100	3	2000

ND – Not detected; mean values with same subscript are not significantly different ($p>0.05$)

Table 2: Variation in Heavy metals concentration (mg/kg) in *Talinum triangulare* leaf at different sites in the study area

Sampling Site	Fe	Zn	Cu	Cd	Mn
Sango Ota	296.40±594.92^{a}	729.75±159.21^{b}	32.16±55.34^{a}	12.16±2.00^{c}	13.00±2.48^{a}
Ewekoro	310.40±266.65^{a}	1687.00±124.44^{c}	5.72±3.19^{a}	5.04±3.17^{ab}	43.92±17.20^{b}
Agbara	579.20±396.62^{a}	881.80±240.30^{b}	23.24±15.61^{a}	8.16±4.13^{bc}	25.40±9.12^{ab}
Sagamu	361.20±77.66^{a}	630.00±61.18^{b}	8.48±1.53^{a}	1.12±1.54^{a}	32.60±16.21^{ab}
Epe	118.00±45.25^{a}	ND^{a}	11.50±0.14^{a}	1.20±1.70^{a}	25.80±19.52^{ab}

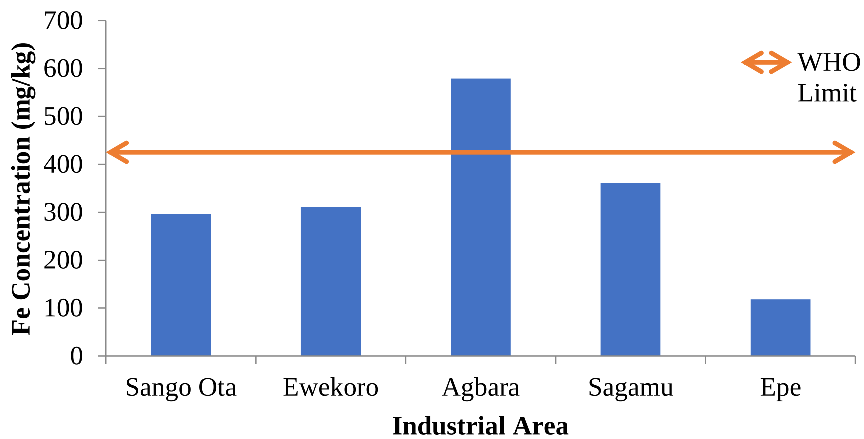


Fig. 2: Comparison of Iron Accumulation by Plants with W.H.O Standards

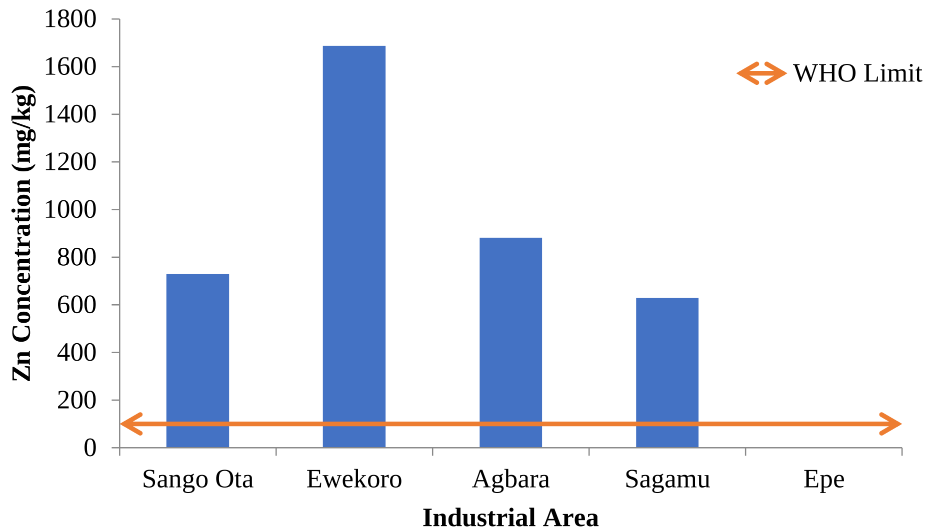


Fig. 3: Comparison of Zinc Accumulation by Plants with W.H.O Standards

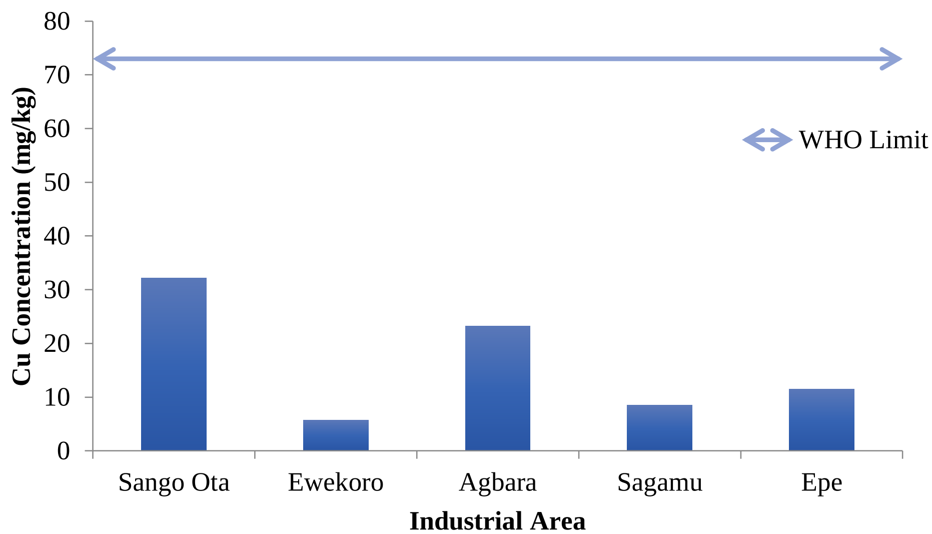


Fig. 4: Comparison of Copper Accumulation by Plants with W.H.O Standards

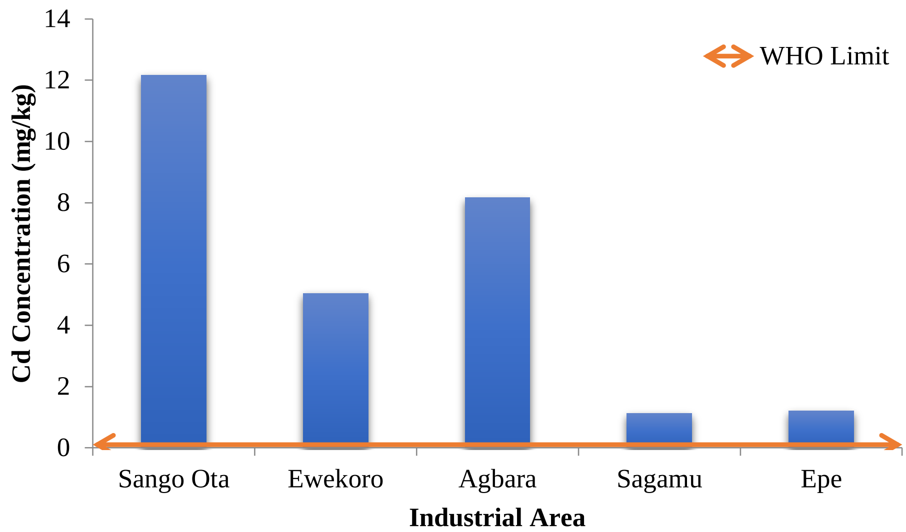


Fig. 5: Comparison of Cadmium Accumulation by Plants with W.H.O Standards

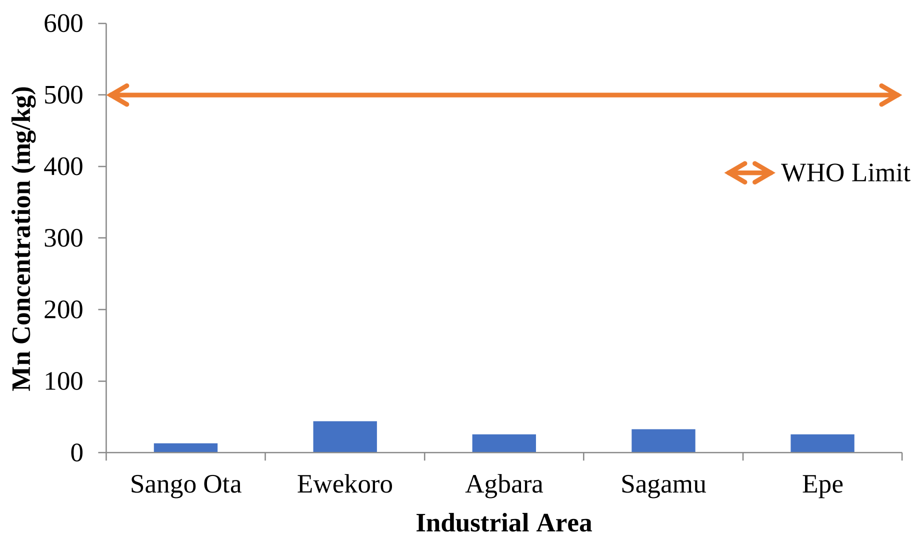


Fig. 6: Comparison of Manganese Accumulation by Plants with W.H.O Standards

3. Discussion

The mean concentrations of heavy metals (Fe, Zn, Cu, Cd and Mn) analyzed in the soil samples collected from selected industrial areas in Ogun State are represented in Table 1. The mean concentration of Fe ranged from 50.00-1964.00 mg/kg; Zn ranged from 136.00-1862.80 mg/kg; Cu ranged from 4.12-122.40 mg/kg; Cd ranged from ND-12.48 mg/kg; and Mn ranged from 16.76 - 60.60 mg/kg. Analysis of variance (ANOVA) revealed a significant ($p<0.05$) variation in the concentrations of the heavy metals among the sites which is an indication of the extent of metal contamination in the soils (Table 1). It is an established fact that soils may become contaminated through the accumulation of heavy metals from the emissions of the rapidly expanding industrial areas, disposal of high metal wastes, sewage sludge, atmospheric deposition, leaded gasoline and paints and a host of other sources, these in turn may contaminate food crops that comes in contact with such soil (Khan *et al.*, 2008). The concentration of iron in the soil shows that the control soil had the least concentration of heavy metals which is significantly lower ($p<0.05$) than the levels obtained from the other areas, predominant concentration of Fe was found in Ewekoro industrial area, this level is however, comparable with the levels obtained in the other industrial areas. The concentration of Fe in the industrial soil was found to be within the WHO permissible limit of 5000 mg/kg for Fe in the soil (WHO, 2007). The highest concentration of Zn in the industrial areas was observed in Ewekoro, though, there is no significant difference ($p>0.05$) in the Zn concentration across all the locations. Comparison of the Zn concentration in the soil across the studied sites revealed that the soil samples from all the locations exceeded the WHO permissible limit of 300 mg/kg for Zn except in the control sample. The range of Fe and Zn concentrations obtained in this study is higher when compared with those reported in the industrial areas in Libya (Elbagermi *et al.*, 2013). The highest concentration of Cu was found in Sango Ota; this level is significantly higher ($p<0.05$) than those of the other industrial areas and the control, it also exceeded the WHO permissible limit of 100 mg/kg for Cu in soil (WHO, 2007**)** while the other areas were within the recommended limit. The range of Cu concentration found in this study is comparable with those reported by Ramesh Kumar and Anbazhagan, (2018) in industrial areas in India. The concentration of cadmium within the study areas showed that Sango ota had significantly higher level which is comparable to the levels presented by Agbara. Cadmium was not detected in the control area and Sagamu industrial area. The levels detected in the other areas were found to exceed the WHO permissible limit of 3 mg/kg for cadmium in soil. **(**WHO, 2007**).** The level obtained in some of the locations where Cd was detected is similar to those reported in other industrial areas outside Nigeria (Tahar and Keltoum, 2011). Significant difference exists in the manganese concentration of the soil samples obtained from different industrial areas, the levels are however, within the permissible limit of 2000 mg/kg for Mn in soil (WHO, 2007). This range of values corresponds with those previously reported for manganese in soil from an industrial area in West Algeria (Tahar and Keltoum, 2011).

The variation in mean concentrations of heavy metals (Fe, Zn, Cu, Cd and Mn) analyzed in the *Talinum triangulare* leaf samples collected at the various sampling sites around industrial areas in Ogun State was summarized in Table 2. In the table, mean concentration of Fe in the samples ranged from 118.00 to 579.20 mg/kg; Zn ranged from ND to 1687.00 mg/kg; Cu ranged from 5.72 to 32.16 mg/kg; Cd ranged from 1.12 to 12.16 mg/kg and Mn ranged from 13.00 to 32.60. The trends in the heavy metal accumulation into *Talinum triangulare* plant growing around the study areas showed variation but comparable trend in Fe accumulation in the plants where the highest level of Fe accumulated into the plant was observed in the *Talinum triangulare* growing in Ewekoro industrial area. Only the plant samples from Agbara industrial area was found to exceed the recommended limit (Figure 2). Correlation analysis showed slightly but insignificant positive relationship (correlation coefficient: 0.47) between the Fe in the soil and the levels in the plant. The concentration of Zn observed in the plant showed that predominant levels was found in the plants from Ewekoro industrial area; this level is significantly higher ($p<0.05$) than those of other industrial areas. Lower level have been found to be accumulated in some plants around potentially contaminated sites (Fosu-Mensah *et al.*, 2017); conversely, high levels of zinc has been reported in some edible plants like grape and pepper (Tahar and Keltoum, 2011), this trend was similarly observed in this study where high levels of Zn was accumulated into the edible *Talinum triangulare* leaf in all the studied industrial sites. The levels accumulated were found to exceed the recommended standard for heavy metals in Zn (Figure 3). Results from correlation analysis suggested a significant ($p<0.05$) positive relationship between the Zn levels in the soil and those in the plants. This may imply direct uptake from the soil even though metal accumulation in the plant may come from several sources. Copper accumulation into the *Talinum triangulare* leaf shows similar levels which are not significantly different from each other; the highest level was accumulated in the plant sample from Sango Ota industrial area, the levels accumulated by all the plants were within WHO permissible limit for Cu in vegetable (Figure 4). The levels accumulated into the plant compared with those accumulated in grape and pepper under heavy metal contaminated soil area as reported by Tahar and Keltoum, (2011) and also in some common vegetation around contaminated sites (Fosu-Mensah *et al.*, 2017). Results from the correlation analysis also suggested direct relationship between the Cu levels in soil and plants with a significant ($p<0.05$) correlation coefficient of 0.89. The accumulation of cadmium into the plant was significantly highest in the plant samples from Sango Ota, however, the concentration of Cd in all the site showed that they exceeded the WHO permissible limit for heavy metal in plants (Figure 5), therefore, suggesting possible Cd contamination within the study location. The correlation analysis result showed a significantly positive relationship between the Cd levels in the soil and those in the plants with a correlation coefficient of 0.97, this suggested common source of Cd pollution. Manganese levels in the plants shows a comparably predominant concentration in the *Talinum triangulare* leaf from Ewekoro industrial area, the concentration of Mn in the sample from the location were found to be within the WHO permissible limits (Figure 6), while a slight positive but insignificant correlation (0.38) was found between the Mn in soil and plant levels also compares with those previously reported (Tahar and Keltoum, 2011).

From the foregoing, the impact of industries on the surrounding soils and edible plants have been demonstrated, variable concentration of heavy metals such as Zn, Cu and Cd exceeded permissible levels in soil were observed across the study locations, while, others too contain appreciable levels though within the recommended limits. Significant concentration of heavy metals was found in the water leaf samples from the studied area, some (Zn and Cd) of which exceeded the permissible limits were observed. Hence, the concentrations of metals in plants appear to be dependent on the levels in soil where the source metal contamination is from the neighboring industries.

4. RECOMMENDATION

It is apparent that the contamination of soil and plants with heavy metals continue to have detrimental influences on plant growth, water purification, and food safety; the industrial areas appear to have an impact on the metal concentration in the soil and plants from the study location which differs greatly from those of the control area; also, the inherent risk of accumulation of metals into the body parts of edible plants cannot be overemphasized from the food safety point of view, it is therefore necessary for the authorities to apply stricter measures on the release of contaminants into the environment by industries to forestall public health crisis. Also, food safety should be ascertained through constant assessment of vegetables sold in the market to prevent situations where they are possibly harvested for sale from contaminated areas.

5. ACKNOWLEDGEMENT

The author acknowledge the management of The Polytechnic Ibadan Oyo State Nigeria for their support in providing enabling environment for us to conduct research in their laboratory.

6. REFERENCES.

Abiona, D. L., Salaudeen, I. A. and Kelani, A. (2016). Assessment of Cadmium, Chromium and Lead in Some Common Anti-Malaria Drugs in Ibadan North Local Government Area, Ibadan, Oyo State, Nigeria. IOSR Journal of Applied Chemistry, 1-20.

Babyshakila P. (2009). Effect of Diluted Effluent on Soil Properties and Plant Growth. Advanced Studies in Biology, 1(8); 391-398

Babayemi, J.O., Olafimihan, O.H. and Nwude, D.O. (2017). Assessment of Heavy Metals in Waterleaf from Various sources in Ota, Nigeria Department of Chemical Sciences, Bells University of Technology, Ota.

Cooper F.K., Davey N.T. and Dunwell N.M. (2006). Environment and development. International Development Abstracts. Norwich, Elsevier. 170.

Fangmin, C.Z., Ningchun, X. and Haiming (2006). "Cadmium and lead contamination in japonica rice grains and its variation among the different locations in southeast China," Science of the Total Environment, vol. 359, (1–3), 156–166. View at Publisher · View at Google Scholar · View at Scopus

Elbagermi, M. A., Edwards, H. G. M. and Alajtal, A. I. (2013). Monitoring of Heavy Metals Content in Soil Collected from City Centre and Industrial Areas of Misurata, Libya. International Journal of Analytical Chemistry, Article ID 312581.

FAO/WHO, (2002). Codex Alimentarius General Standards for Contaminants and Toxins in Food. Schedule1. Maximum and Guideline Levels for Contaminants and Toxins in Food, Joint FAO/WHO Food standards programme Reference CX/FAC 02/16, Codex Committee, Rotterdam, Netherlands.

Bilo, F.L., Borgese, D., and Cazzago (2014). "TXRF analysis of soils and sediments to assess environmental contamination"

Environmental Science and Pollution Research, vol. 21(23),13208–13214. View at Publisher · View at Google Scholar

Fosu-Mensah, B. Y., Addae, E., Yirenya-Tawiah, D. and Nyame, F. (2017). Heavy Metals Concentration and Distribution in Soils and Vegetation at Korle Lagoon Area in Accra, Ghana. Cogent Environmental Science,3:1405887. https://doi.org/10.1080/23311843.2017.1405887

Gowd, S.S., Reddy, M.R.M. and Govil, P.K. (2010), Assessment of heavy metal contamination in soil at Jajmau (Kanpur) and Unnao Industrial areas of the Ganga plain, Uttar Pradesh, India, Journal of Hazardous materials, 174:113-121

Guillén, J., Baeza, A., Salas, A., Muñoz-Muñoz, J.G. and Muñoz-Serrano, A. (2017). Factors Influencing the Soil to Plant Transfer of Radiocaesium. In: D.K. Gupta, C. Walther (eds.), Impact of Cesium on Plants and the Environment. Springer International Publishing, Switzerland; 19-3.

K. K. Taha, I. M. Shmou, H. M. Osman, and M. H. Shayoub (2013), "Soil-plant transfer and accumulation factors for trace elements at the Blue and White Niles," Journal of Applied and Industrial Sciences, vol. 1, 97–102. View at Google Scholar.

Mendil, D., Tuzen, M., Yazici, K. and Soylak, M. (2005). Heavy metals in lichens from Roadsides and an industrial zone in Trabzon, Turkey. Bull. Environ. Contam. Toxicol., 74: 190- 194.

Salaudeen I.A., Sonibare O.O., Sojinu S., and Ekundayo O. (2017). Polycyclic aromatic Hydrocarbons in air from industrial areas in Lagos and Ogun State Nigeria, pollution Autumn 3(4): 561-573.

Shetty, R. and Rajkumar, S., (2009). Biosorption of copper by metal resistant Pseudomonas sp.Int. J. Environ. Res., 3(1):121-128.

Shokoohi, R., Saghi, M.H., Ghafari, H.R. and Hadi, M. (2009). Biosorption of iron From Aqueous solution by dried biomass of activated sludge. Iran Journal of Environmental Health Science and Engineering, 6(2):107-114

Srinivasa, S., Gowd, M., Ramakrishna, R., and Govil, P. K. (2010). "Assessment of heavy metal contamination in soils at Jajmau (Kanpur) and Unnao industrial areas of the Ganga Plain, Uttar Pradesh, India," Journal of Hazardous Materials, vol. 174 (1–3): 113–121.

Swarna, J., and Ravindhran, R. (2013). Pharmacognostical and phytochemical evaluation of Talinum triangulare (jacq.) willd. International Journal of Pharmacy and Pharmaceutical Sciences 5 (2): 249-256.

Tahar, K., and Keltoum, B. 2011. Effects of Heavy Metals Pollution in Soil and Plant in the Industrial Area, West Algeria. Journal of the Korean Chemical Society, 55(6): 1018-1023.

Tsafe, A. I., Hassan, L. G., Sahabi, D. M., Alhassan, Y and Bala, B.M. (2012).

Evaluation of Heavy Metals Uptake and Risk Assessment of Vegetables Grown in Yargadama of Northern Nigeria, Journal of Basic and Applied Scientific Research, 2(7):6708-6714.

WHO (2007). Health risks of heavy metals from long-range transboundary air pollution. Copenhagen, World Health Organization Regional Office for Europe (http://www.euro.who.int/document/E91044.pdf).