ISSN 2350-1049

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 10, Issue 3, pp: (25-31), Month: July - September 2023, Available at: www.paperpublications.org

OIL EXPLOITATION AND HEAVY METALS CONTENT IN ORHOIKE KOKORI SOIL DELTA NIGERIA

Ogwu, C.[1], Awowede, M.[2], A. Onuelu J.E.[3]

[1] Department of Environmental Management and Toxicology, Delta State University of Science and Technology, Ozoro

[2] Department of Vocational Education, Delta State University, Abraka

[3] Department of Pharmacology, Delta State University, Abraka

DOI: https://doi.org/10.5281/zenodo.8220428

Published Date: 07-August-2023

Abstract: **This study investigated the heavy metals content of Orhoike-kokori soil to ascertain the environmental health. It was an ex-post facto research that answered 3 research questions and tested a hypothesis. To achieve these, the study area Orhoike-Kokori was mapped out into sampling grids (SG) and soil samples were collected from 5 spots in each sampling grid with soil sampling auger at the depth of 15cm. The samples were bulked, composite taken and wrapped with aluminium foil for analysis. The analytical standard adopted was USEPA 200.7 and the instrument of determination used for detecting the concentration of the metals was Agilent GFAAS modele 240z and 280z. The mean results obtained were as follow: Cd, 09±0.10mg/kg, Cu, 38.0±0.21 mg/kg, Pb, 87.8±0.11 mg/kg, Ni, 38.3±0.12 mg/kg and Cr, 108.4±0.13 mg/kg. The mean concentrations of the heavy metals investigated were subjected to test of significance with ANOVA using SPSS model 29 at 0.05 level of significance. The *p*-value was 0.48 thus rejecting H_0. The study concludes that Orhoike-Kokori soil is polluted above maximum permissible limits by the metals measured. It thus recommends that crop production should be suspended in Orhoike-kokori soil forthwith, the impacted environment should be remediated and the monitoring agencies NESREA and NOSDRA should increase their surveillance and enforcement obligations.**

Keywords: **oil exploitation, heavy metals, soil contamination crop production, bioaccumulation, health.**

1. INTRODUCTION

Nigeria was an agrarian country with agriculture accounting for 95 percent of its gross domestic product and 85 percent of its export earnings (Ruwani, 2021, Oteriba 2021, Abegunde, 2022). Agriculture accounted for varying landmark developments in pre and post-colonial Nigeria and provided for the infrastructural and education institutional developments (Onwubiko, 2016, Tajumiola, 2017, Fehintola, 2019). Nigeria had a robust economy with a very convenient gross domestic product and outstanding foreign exchange earning (Babatunde, 2019, Osunde, 2018, Sodiq, 2019). The value of Nigeria currency was higher than United States dollars and at par with British pounds (Okpanya, 2020, Ogagaoghene, 2019, Okudu, 2019).

The discovery and extraction of oil in the 70s marked a turning point in Nigeria as it came with stupendous wealth which engendered tastes for foreign goods and relegated agriculture to the back burner (Adewale, 2017, Ogunjobi, 2015, Spiff, 2019). Nigeria thus became an oil producing and exporting country becoming a member of the Organisation of petroleum exporting country in 1971 (OKonkwo, 2020, Asuquo, 2021, Adokiye, 2021). It is today the eleventh greatest oil producer globally and the highest in Africa position being challenged by Libya and Angola (Emeronye, 2021, Abubakar, 2020, National Bureau of Statistics, 2020, Ope, 2022). Nigeria with 205.5 trillion cubic feet (tcf) of proven gas reserve

(pricewaterhourse, 2022) occupies global 7th position thus making it one of the world remarkable world hydrocarbon hub (OPEC, 2022).

Oil and gas exploration and exploitation are prone to environmental degradation (Yap et al., 2010, Yanbali et la., 2014, Suleiman & Hanzah, 2018, Singh et al., 2017). Environmental devastation of oil activities are occasioned by oil spillages resulting from equipment failure and pipeline corrosion (Sheded et al., 20006, Shah et al, 2013), wellhead blowout, sabotage (Sangwan et al., 2014, Basaq et al., 2015). Pipeline vandalism, tankwash (Panda & Chaudwury, 2003, Oliveira, 2012). Petroleum is a complex compound whose elemental make ups include carbon hydrogen oxygen, nitrogen, sulphur and varying percentages of heavy emtals (Ogunsesi et al., 2017, Nwineewu & Neeka, 2017, Moradi et al., 2013, Mee-Young et al., 2013). There are 24 metals that are classed heavy due to their high atomic weight (Luo et al., 2012, Kacholi & Sahu, 2018, Idodo Ume & Ogberbu, 2010). Heavy metals occur in the soil in known percentages and any occurrence at higher concentration is anthropogenic (Ogwu 2021, Ogwu et al., 2022, Hindi et al., 2014). Contamination of soil by heavy metals result in bioaccumulation and biomagnification of the metals in crops and animals (Ogwu et al., 2021, Ogwu et al., 2022, Hajar et al., 2014), and consumption of heavy metals contaminated foods result in varying health complications; such as cardiovascular diseases (Ogwu et al., 2023, Fosu-Mensah et al., 2017, Elbagemi et al., 2013, Boke et al., 2015). Osteoporosis, lung cancer (Benson et al., 2016), memory loss, brain damage (Ogwu et al., 2020, Ogwu et al., 2022) muscular tremor and death (Ogwu et al., 2021, Ali et al., 2013, Ahmad & Ashraf, 2011).

This study is charged with the assessment of heavy metals in the soil of Orhoike-Kokori an oil producing community Delta State Nigeria. The heavy metals investigated are: Cd, Cu, Pb, Ni, and Cr.

The study was guided by research questions as follows:

1. what are the concentrations of Cd, Cu, Pb, Ni and Cr. In Orhoike-Kokori oil producing community soil?
2. are the concentration of the heavy metals within World Health Organisation maximum acceptable levels for the metals in soil?
3. are crops be grown in the soil fit for human consumption?

This study was guided by a hypothesis as below:

H_0: there is no significant difference between the concentrations of the metals investigated in Orhoke-Kokori soil and wHO MPC for the metals in soil.

Study Area

Figure 1: Map of kokori

Source: Goggle map, 2023

ISSN 2350-1049

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 10, Issue 3, pp: (25-31), Month: July - September 2023, Available at: www.paperpublications.org

Orhoike Kokori is in quarter in Kokori Agbon clan in Ethiope east local government area Delta state. It is located within geographical coordinates of latitude 5°37',52''N and longitude 6°2'6''E (google 2023) with a population of 28,897 (National Population Commission, 2006) and a land area of 196sq kilometres (google map, 2023). Orhoike-Kokori people are farmers with number of them being petty traders (due to the influx of non-indigenes into the settlement because of oil production) some Kokori people work in the oil firms while others are civil servants teaching in the primary and secondary schools and some of the people work in the village health centre.

2. MATERIALS AND METHODS

Grid soil sampling technique was adopted in this study. Orhoke Kokori oil bearing community was mapped into 5 sampling grids tagged A, B, C, D, E (Ahmad & Shraf, 2011). From of the grids soil samples were collected from 5 spots using soil sampling auger at 15cm depth. The samples from each sampling grids were bulked and composites drawn, which were wrapped in aluminium foil for analysis.

Analysis

The analytical standard deployed in this study is United States environmental Protection Agency Method 200.7.

The soil samples were oven dried using Agilent door oven for 1 hour 30 minutes (1½ hours) to expel the moisture and organic matters (Yilmaz et la., 2005). 5g of each of the samples were weighed out and into beakers and digested with perchloric and nitric acid at ratio 1:1. The mixtures were then heated for another 30 minutes at 200 degree Celsius (200°C) and allowed to cool for another 1½ to 2 hours. Heavy metals investigated were determined using Agilent graphite furnance atomic absorption spectroscopy (AAS) model 240z and confirmed with mosel 280z (GFAAS 240z and 280z)

3. RESULTS

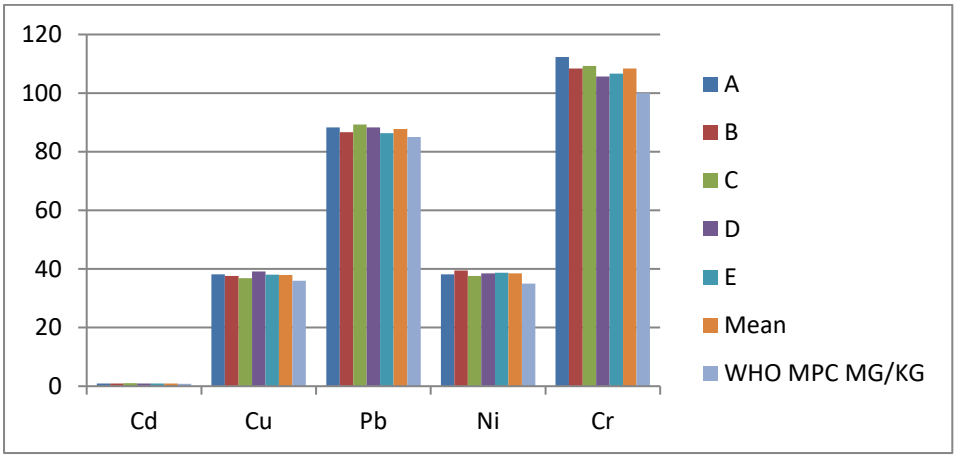
The results of the analysis of the heavy metals in Orhoike Kokori soil are as in Table I.

Table 1: results of the heavy metals content in Orhoike Kokori soil and WHO MPC for heavy metals in soil in mg/kg

Parameters	A	B	C	D	E	X	WHO MPC MG/KG
Cd	0.9	0.92	0.99	0.94	0.95	0.94	0.8
Cu	38.2	37.6	36.9	39.2	38.1	38.0	36
Pb	88.3	86.7	89.3	88.3	86.3	87.8	85
Ni	38.2	39.5	37.6	38.5	38.7	38.5	35
Cr	112.3	108.4	109.3	105.7	106.6	108.4	100

The heavy metals content of Orhoike-Kokori were was presented in graph as in Figure 2.

Figure 2: result of the heavy metals content in Orhoike-Kokori soil and WHO MPC in mg/kg.



The mean contents of the metals investigated were subjected to test significance with analysis of variance deploying special package for social sciences (SPSS) model 29. The p-value was 0.48 thus rejecting H_0.

4. DISCUSSION

The analysis of the Orhoike Kokori soil for the heavy metals content presented varying concentrations of the heavy metals investigated. The concentration of Cd in Orhoike-Kokori soil the analysis revealed was between 0.90 mg/kg in sampling grids A(SG "A") to 0.99 mg/kg in SG "C" with a mean concentration of 0.94 mg/kg. The WHO MPC for Cd in soil is 0.80 mg/kg. The deviation from acceptable limit is man induced degradation. High content of Cd in food resulting in bioaccumulation and biomagnification is associated with in health complications such as damaged to the lungs and death (Weber et al., 2013, Ogwu et al., 2023) cancer of the lungs, blood and sinus (Ogwu et al., 2023, Yilmaz et al., 2005, Yilmaz et al., 2010). Report of high content of Cd in soil was in Waakes, 2000, Ogwu et al., 2021).

The analysis of the soil of Orhoike showed that the Cu content was between 38.1 mg/kg in SG "E" to 39.2 in SG "D" with a mean concentration of 38.0 mg/kg. The high concentration of Cu recorded is attributed to oil exploitation activities. Similar report of high Cu in soil was in (Ogwu et al., 2023, Voight, 2004). Food contamination by Cu results in various health complications including diarrhoea, kidney failure (Tuzen, 2003); Dizziness and throat irritation (Ogwu et al., 2022, Turkmen et al., 2005).

The results of the analysis of soil of Orhoike for the content of Pb revealed that the concentrations of Pb is between 88.3 mg/kg in SG "A" to o89.3 mg/kg in SG "C" with a mean content of 87.8 mg/kg. The WHO MPC for Pb in soil is 85.0 mg/kg. This result of high Pb in Orhoike Kokori soil is similar to (Tari and Rohascincy, 2013, Ogwu et al., 2023). The health complications resulting from bioaccumulation and biomagnification of Pb in food include nausea, abdominal pains and gastroenteritis (Papagiams et al., 2004, Oguzie, 2003).

The laboratory analysis of Orhoike-Kokori soil for Ni presented Ni concentrations of between 37.6 mg/kg in SG "C" to 37.5 mg/kg in SA "B" with a mean of 38.5 mg/kg. The critical point established for Ni in soil by WHO is 35.0 mg/kg. The elevated Ni is associated to oil exploitation and drilling activities in the community. High content of Ni in soil was in (Obadohan equavoen 2008, Ogwu et al., 2023, Ogwu et la., 2021). The presence of Ni above threshold stipulated will lead to bioaccumulation of Ni in food which will give rise to health complications; cardiovascular diseases, nasal cancer (Ogwu et al., 2023) epigenic effects, lung cancer (Obasohan et al., 2006).

The content of Cr contamination in Orhoike-Kokori soil the laboratory analysis reveals range from 105 mg/kg as SG "D" to 112 mg/kg in SG "A" with a mean concentration of 108.4 mg/kg. The WHO MPC for Cr in soil is 100 mg/kg. The increased Cr in Orhoike soil is oil activities related. This report of high Cr in soil was in (Nussey et al., 2000, Ogwu et al., 2023, Noor-syuhasah et al., 2014, Noor-Syuhadh & Rohashney, 2011). Contamination of food by Cr will give rise to health challenges such bronchitis and cardiovascular diseases (Karadede et al., 2004), renal damage, gastroenteritis and death (Ogwu et al., 2021, Ogwu et al., 2023, Oguzie, 2003).

5. CONCLUSION

Nigeria is an oil dependent country as oil is its economic mainstay. Oil activities is associated with degradation of the soil, water and reduction of air quality. Oil is highly beneficial to the country as it the current "blood in its veins", but its activities should be carried out with utmost concern for the environment and human health.

The result of the analysis of the Orhoike-Kokori soil revealed that the soil environment have been impacted upon which is antithesis to the health of the inhabitants of Orhoike-Kokori and other people who buy produce from Orhoike farmers.

Against this backdrop of this result, the study recommends the following:

1. crop production should be suspended in Orhoike soil.
2. the impacted soil should be remediated.
3. the monitoring agencies; National Environmental Standards Regulation and Enforcement Agency (NESREA) and National Oil Spill Detection and Response Agency (NOSDRA) should increase their surveillance on the oil companies operating in Orhoike Kokori to ensure their compliance to environmental standards and world best practices in all their operational activities.

REFERENCES

[1] Ahmad, M. S. & Ashraf, M. (2011).Essential roles and hazardous effects of nickel in plants. Revolution in Environmental Contamination and Toxicology, 214:125-67.

[2] Ali, S., Farooq, M. A., Yasmeen, T., Hussain, S. &Arif, M. S. (2013). The influence of silicon on barley growth, photosynthesis and ultra-structure under chromium stress. Ecotoxicology & Environmetal Safety, 89: 66-72.

[3] Benson, N. U., Enyong, P. A. & Fred-Ahmadu, O. H. (2016). Trace Metal Contamination Characteristics and Health Risks Assessment of Commelinaafricana L. and Psammitic Sand flats in the Niger Delta, Nigeria. Applied and Environmental Soil Science, Volume 2016, Article ID 8178901, 14 pages. http://dx.doi.org/10.1155/2016/8178901

[4] Boke, A., Megersa, N. &Teju, E. (2015). Quantitative Determination of the Heavy Metal Levels in the Wild Edible Plant Parts and their Corresponding Soils of the Central and Western Regions of the Oromia State, Ethiopia. Journal of Environmental and Analytical Toxicology, 5:5. DOI: 10.4172/2161- 0525.1000299.

[5] Elbagermi, M. A., Edwards, H. G. M. & Alajtal, A. I. (2012). Monitoring of heavy metal content in fruits and vegetables collected from production and market sites in the Misurata Area of Libya. Analytical Chemistry, Volume 2012, Article ID 827645, 5 pages, doi:10.5402/2012/827645.

[6] Fosu-Mensah, B. Y., Emmanuel Addae, E., Yirenya-Tawiah, D. & 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

[7] Hajar, A. W. I., Sulaiman, A. Z. B. & Sakinah, A. M. M. (2014). Assessment of heavy metals tolerance in leaves, stems and flowers of Steviarebaudiana plant. Environmental Sciences, 20: 386 – 393.

[8] Hind S. J., Mushrifah, I., Aminah, A. & Kadhum, A. A. H (2014).Determination of Heavy Metals in Soil and Different Parts of Diplaziumesculentum (Medicinal Fern). AIP Conference Proceedings, 1614, 713 – 718, https://doi.org/ 10.1063/1.4895289.

[9] Idodo-Umeh, G. & Ogbeibu, A. E. (2010). Bioaccumulation of the Heavy Metals in Cassava Tubers and Plantain Fruits Grown in Soils Impacted with Petroleum and Non-Petroleum Activities. Research Journal of Environmental Sciences, 4 (I): 33-41.

[10] Jabatan Ukur dan Pemetaan Malaysia (JUPEM). (2002). eMap peta elektronik Kelantan. Kuala Lumpur: JUPEM.

[11] Kacholi, D. S. & Sahu, M. (2018). Levels and health risk assessment of heavy metals in soil, water and vegetables of Dar es Salaam, Tanzania. Journal of Chemistry, Volume 2018, Article ID 1402674, 9 pages

[12] Karadede H, Oymak S A and Ünlü E. (2004). Heavy metals in mullet, Liza abu, and catfish, Silurus triostegus, from the Ataturk Dam Lake (Euphrates) Turkey. Environment International 30: 183–188.

[13] Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z. & Zhu, Y. G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environmental Pollution, 152(3): 686-692.

[14] Luo, X. S., Yu, S., Zhu, Y. G. & Li, X. D. (2012). Trace metal contamination in urban soils of China. Science and Total environment, 421: 17 – 30.

[15] Mee-Young, S., Young-Eun, C., Chana, P., Ho-Yong, S. & JaeHwan, L. (2013).The Contents of Heavy Metals (Cd, Cr, As, Pb, Ni, and Sn) in the Selected Commercial Yam Powder Products in South Korea. Preview in Nutrition and Food Science, 18(4):249- 255

[16] Moradi, A., Honarjoo, N., Fallahzade, J. &Najafi, P. (2013). Assessment of heavy metal pollution in soils and crops of industrial sites, Isfahan, Iran. Pakistan Journal of Biological Sciences, 16(2): 97-100.

[17] Noor Syuhadah S and Rohasliney H. (2011). A preliminary study on batik effluents in Kelantan state: A water quality perspective. In P S Sandhu and N Delcoure (eds.). International Conference on Management, Social Sciences, Biology & Pharmaceutical Sciences (ICMSSBPS) 2011. First Hotel, Bangkok, Thailand, 23– 24 December 2011. Bangkok: Planetary Scientific Research Centre.

[18] Noor Syuhadah S, Rohasliney H and Noor Zuhartini M M. (2014). Heavy metal analysis of batik industry wastewater, plant and soil sample: A comparison study of FAAS and HACH colorimeter Analytical capabilities. In A Z Aris, T H Tengku Ismail, R Harun, A M Abdullah and M Y Ishak (eds.). From Sources to Solution. Proceedings of the International Conference on Environmental Forensics 2013. Marriot Hotel, Putrajaya, Kuala Lumpur, 12–13 November 2013. London: Springer, 285–289.

[19] Nussey G, Van Vuren J H J and Du Preez H H. (2000). Bioaccumulation of chromium, manganese, nickel and lead in the tissues of the moggel, Labeo umbratus (Cyprinidae), from Witbank Dam, Mpumalanga S. Africa. Water SA 26(2): 269–284.

[20] Nwineewii, J. D. & Neeka, J. B.(2017). Heavy metal concentrations in sediments from Eleme creeks in relation to the Eleme (Indorama) petrochemicals company, Rivers State, Nigeria. International Journal of Chemical Studies, 5(5): 377-380.

[21] Obasohan E E and Eguavoen O I. (2008). Seasonal variations of bioaccumulation of heavy metals in a freshwater fish (Erpetoichthys calabaricus) from Ogba River, Benim City, Nigeria. African Journal of General Agriculture 4: 153–163.

[22] Obasohan E E, Oronsaye J A O and Obano E E. (2006). Heavy metal concentrations in Malapterurus electricus and Chrysichthys nigrodigitatus from Ogba River in Benin City, Nigeria. African Journal of Biotechnology 5(10): 974–982.

[23] Ogunlesi, M., Okiei, W., Adio-Adepoju, A. & Oluboyo, M. (2017). Electrochemical determination of the levels of cadmium, copper and lead in polluted soil and plant samples from mining areas in Zamfara State, Nigeria. Journal of Electrochemical Science and Engineering, 7(4): 167-179.

[24] Oguzie F A. (2003). Heavy metals in fish, water and effluents of lower Ikpoba River in Benim City, Nigeria. Pakistan Journal of Science and Industrial Research 46(3): 156–160.

[25] Ogwu, C., Abvbunudiogba, R. E., Ogune, P., Aloamaka, T. A. (2023). Analysis of the heavy metals content of Lagos Lagoon Lagos Nigeria. International Journal of Recent Research in Physics and Chemical Sciences, 10(1), 1-6.

[26] Ogwu, C., Obi-Okolie, F. and bvbunudiogba, R. E. (2023). Quantification of the heavy metals in the groundwater of Ikeja industrial estate, Ikeja Lagos. Quest Journal of Research in Environmental and Earth Science 9(3), 69-73.

[27] Ogwu, C., Ossai, A. C., Ejemeyovwi, D. O. & Unuafe, S. E. (2023). Characterisation of the heavy metals in the aquifer of Matori Industrial estate Lagos Nigeria. Quest Journal of Research in Environmental and Earth Science 9(3), 20-26.

[28] Ogwu, C., Ossai, A. C., Ejemeyovwi, D. O. and Unuafe, S. E. (2023). IOSR Journal of Environmental Science, Toxicology and Food Technology. 17(issue 3, sir 1), 01-06.

[29] Ogwu, C., Ukpene, A. O., Ekpe, I. N. and Aregbor, O. (2023). Bioaccumulation of heavy metals in the tissues of some fishes species in selected wetlands in Lagos Nigeria. Journal of Innovation 72, 1407- 1418.

[30] Ogwu, C., Ukpene, A. O., Ekpe, I. N., Umukoro B. O. J. and Onuelu, J. E. (2023). Quantification of heavy metals and metalloid in cassava roots (manihot esculenta crantz; family: Euphorbiaceae) grown in oil bearing communities of the Niger Delta. Innovation Journal, 73, 89-101.

[31] Oliveira, H. (2012). Chromium as an Environmental Pollutant: Insights on Induced Plant Toxicity. Journal of Botany, Volume 2012, Article ID 375843, doi:10.1155/2012/375843.

[32] Panda, S. K., Chaudhury, I. & Khan, M. H. (2003) Heavy metals induce lipid peroxidation and affect antioxidants in wheat leaves. Biological Plantarum 2: 289-29

[33] Papagiannis I, Kagalou I, Leonardos J, Petridis D and Kalfakakou V. (2004). Copper and zinc in four freshwater fish species from Lake Pamvotis (Greece). Environment International 30(3): 357–362.

[34] Rasaq, A. O., Oladipo, A. L., Gregory, O. A., Olumayowa J. O. &Owolabi, M. S. (2015). Concentration of heavy metals in root, stem and leaves of Acalyphaindica and Panicum maximum jacq from three major dumpsites in Ibadan metropolis, South West Nigeria. American Journal of Chemistry, 5(1): 40-48.

[35] Rohasliney H. (2010). Status of river fisheries in Kelantan, Peninsular Malaysia, Malaysia. World Academy of Science, Engineering and Technology 65: 829–834.

[36] Sangwan, P., Kumar, V. & Joshi, U. N. (2014). Effect of Chromium(VI) Toxicity on Enzymes of Nitrogen Metabolism in Clusterbean (Cyamopsistetragonoloba L.). Enzyme Research, 784036.

[37] Shah, A., Niaz, A., Ullah, N., Rehman, A., Akhlaq, M., Zakir, M. & Khan, M. S. (2013). Comparative Study of Heavy Metals in Soil and Selected Medicinal Plants. Journal of Chemistry, Volume 2013, Article ID 621265, 5 pages, http://dx.doi.org/10.1155/2013/621265.

[38] Sheded, M., Pulford, I. and Hamed, A. (2006).Chromium. Journal of Arid Environments, 66 (2): 210-217.

[39] Singh, M., Kumar, J., Singh, S., Singh, V. P., Prasad, S. M. & Singh, M. P. V. V. B. (2015). Adaptation Strategies of Plants against Heavy Metal Toxicity: A Short Review. Biochemistry and Pharmacology, (Los Angel) 4, 161. doi:10.4172/2167- 0501.1000161.

[40] Singh, S., Zacharias, M., Kalpana, S. & Mishra, S. (2012). Heavy metals accumulation and distribution pattern in different vegetable crops. Journal of Environmental Chemistry and Ecotoxicology, 4(10):170–177.

[41] Sulaiman, R. F. & Hamzah, H. A. (2018).Heavy metals accumulation in Suburban roadside plants of a tropical area (Jengka, Malaysia). Ecological Processes, 7: 28. https//doi.org/10.1186/s13717-018-0.09-3.

[42] Tan P Y and Rohasliney H. (2013). Status of water quality subject to sand mining in Kelantan River, Kelantan. Journal of Tropical Life Sciences Research 24(1): 19–34.

[43] Türkmen A, Türkmen M, Tepe Y and Akyurt İ. (2005). Heavy metals in three commercially valuable fish species from İskenderun Bay, Northern East Mediterranean Sea, Turkey. Food Chemistry 91(1): 167–172.

[44] Tüzen M. (2003). Determination of heavy metals in fish samples of the middle Black Sea (Turkey) by graphite furnace atomic absorption spectrometry. Food Chemistry 80(1): 119–123.

[45] Voigt H R. (2004). Concentration of mercury and cadmium and the condition of some coastal Baltic fishes. Environmentalica Femnica 21: 1–26.

[46] Weber P, Behr E R, Knorr C D L, Vendruscolo D S, Flores E M M, Dressler V L and Baldisserotto B. (2013). Metals in the water, sediment, and tissues of two fish species from different trophic levels in a subtropical Brazilian river. Microchemical Journal 106(1): 61–66.

[47] Yabanlı, M., Yozukmaz, A. &Sel, F. (2014). Heavy metal accumulation in the leaves, stem and root of the Invasive submerged macrophyte Myriophyllumspicatum L. (Haloragaceae): An example of Kadın Creek (Mugla, Turkey). Brazilian Archives of Biologyand Technology, 57(3): 434-440.

[48] Yap, C. K., Fitri, M. M., Mazyhar, Y. & Tan, S. G. (2010).Sains Malaysiana 39 (3): 347-352.

[49] Yilmaz A B, Sangün M K, Yağlıoğlu D and Turan C. (2010). Metals (major, essential to non-essential) composition of the different tissues of three demersal fish species from İskenderun Bay, Turkey. Food Chemistry 123(2): 410–415.

[50] Yilmaz F, Nozdemir N, Demirak A and Tuna A L. (2005). Heavy metal levels in two fish species Leuciscus cephalus and Lepomis gibbosus. Food Chemistry 100(2007): 830–835.