

Lead Removal from Contaminated Water by Corn and Palm Nut Husks

ABSTRACT:

This study evaluates the efficacy of using two local, cheap, and abundant waste materials such as charred husks from corn and palm nut for the remediation of lead contaminated water. The study was conducted for the development of a very cheap, natural, easy to prepare, and effective technology for the rural natives to remove lead contaminant from water as there was a concern that the dust and soil lead contamination that killed over 500 people in Nigeria could contaminate the water resources. Charred husks from corn cob and palm nut were respectively exposed to 50 ml of 102 ppm of aqueous lead nitrate solution for 48 hours at room temperature without agitation. The mixture was filtered and the filtrate was analyzed for residual lead concentrations using atomic absorption spectrophotometer (AAS). The results indicated that the two biosorbents were very effective in removing lead from contaminated aqueous solution with 92-99% removal efficiency. The study concluded that charred palm nut and corn cob husks can be used as cheap and safe bioremediators of lead contaminated water.

Keywords: Cornhusk, palm nut husk, bio-remediation, adsorption, lead, biosorption

1. INTRODUCTION:

Contamination of soil, water and air by heavy metals, especially lead, poses a detrimental threat to our environment, human health, aquatic and terrestrial animals and plants. Lead uptake, transport, and accumulation by plants and animals as well as the potential for its propagation into the food chain exacerbate its toxic health effects. Lead does not undergo degradation or decomposition. It is estimated to persist in the soil for 5000 years [1]. Thus, its long persistence in the environment contributes to its lingering health and toxic effects. Historical lead pollution results from a variety of human activities such as past practices of lead-related industrial processes, smelting, and combustion of coal [2-3]; mining activities [4], use of lead based paints and automotive exhaust fumes [5], manufacture and use of agricultural fertilizer, insecticides, and pesticides [6]. Agwaramgbo [7] reported that natural disaster such as hurricanes and flooding may exacerbate or increase the redistribution of lead in the environment. Research by Mielke *et al* [5] suggests that the ingestion of lead contaminated water and food and inhalation of lead dust are the most important and serious routes of lead exposure and entry in the human body. Studies have shown that there is a strong correlation between chronic lead exposure to children and impaired cognitive skills, intellectual impairment [8], reduced IQ, physical and mental retardation, and neurotoxicity [9].

Similarly, exposure to adults has health consequences that have been linked to damage to the neurological, reproductive, central nervous and renal systems respectively. [10-11]. Recent studies have demonstrated that neurological damage from early childhood exposure to lead contributes to delinquent and criminal behavior [12]. Studies done by P.A Meyer et al [13] suggest that chelation, a process of removing metal ions from solutions, especially to counter poisoning by heavy metal and save the lives of persons with high blood lead levels, is the only medical treatment available for lead exposure. However, chelating drugs are not always available in developing countries and have limited value in reducing the effects of chronic lead exposure.

Lead pollution and exposure to Nigerian populace is a serious problem. Recently, Galadima[14] reported the lead pollution in Nigeria that claimed the lives of over five hundred children and left thousands of people with severe health problems. Lead contamination of water sources in Owerri locale has been reported by Ogueke [15] and Nwagbara [16]. Both independently concluded that the water samples studied contained lead above safe levels. Thus, there is a great need for native and cheap methods for lead remediation because its removal from water and soil will have positive and beneficial implications on the ecosystem, economy, agriculture, and health globally. A vast and varied array of remedial processes such as pump and treat [17], in-situ and ex-situ-stabilization [18-19], electro-deposition and electro-kinetic extraction [20], phytoextraction and phytoremediation [21], chemical precipitation and chelation [13, 22-23], and ion exchange [24] exist for the remediation of heavy metals such as lead from soil and water.

Unfortunately, these processes have met mixed success. For example, pump and treat is expensive and may produce tailing or incomplete remediation; in-situ and ex-situ stabilization creates unknown fate of the contaminant; electro-deposition is expensive and is limited by size of the area to be remediated; chemical precipitation, chelation, and ion exchange have potential secondary impacts such as introduction of toxic chemical reagent or transformation products, that may need additional; phyto-extraction is limited by plant rooting depth, contaminant type, level of contamination, conducive weather for plant growth, long remediation period and poor removal efficiency.

Recent response to the ever growing need for cheap, safe, and effective technics for water clean-up has led to the emergence of a number of alternative processes; Agwaramgbo et al [23,25-27] reported the use of biomaterials such as coffee, tea, mustard green caffeine, spinach, fish bone and edible plant extracts as adsorbents in the remediation of lead contaminated water. A review of agricultural or bio-materials that have been used as sorbents for the removal of heavy metals such as lead from contaminated water include Lignin, seaweed, chitosan, peat moss [28], modified coconut fibers [29], maize tassels [30, 31], olive cake [32], woodchar [33,34], polymerized orange skin, banana husk, pine bark, and sawdust [35]. Currently, there is great research interest in the use of native, natural, and abundant waste materials such as walnut shell [36] and waste tea [37], seed powder [38] in heavy metal remediation.

However, none of these is native to the study area, therefore the work reported here, investigates the efficacy of charred husks from two safe, natural, cheap, and abundant agricultural wastes from Owerri in the development of lead remediation technology.

2. MATERIALS & METHODS FOR LEAD ADSORPTION

The lead nitrate by Liaoyang Guanghua Chemical Company Limited in China was bought from local chemical store, KENTIN LTD, Scientific, Medical, Equipment and Chemicals, Owerri, Nigeria, was used without further purification. Corn and palm nut husks were obtained from local Owerri market.

2.1. Preparation of Lead Nitrate Solution 102 ppm

Following the procedure used by Agwaramgbo [39] 0.102 g of lead nitrate bought from local chemical store was dissolved in enough distilled water (added incrementally with vigorous agitation for complete dissolution of the lead nitrate) to give a liter of solution.

2.2. Preparation of Charred Corn Cob and Palm Nut Husks

The corn grains and palm nuts were manually removed from the husks. Each husk material completely and charred in an open system. The charred husks were respectively crushed into fine powder and sieved with a 2-mm mesh sieve for homogeneity.

3.0 TREATMENT OF LEAD CONTAMINATED WATER WITH CHARRED CORN COB AND PALM NUT HUSKS:

3.1.1 Treatment of Lead Solution with Charred Corn Cob Husk Substrate:

Following a modified version of the treatment method used by Agwaramgbo [32], each of the respective triplicate reaction plastic bottles containing the 5g of charred corn cob husk labeled CCH-1, CCH-2 and CCH-3 substrate was charged with 50 ml of 102ppm of lead nitrate solution prepared above. The bottles and their contents were hand wrist shaken for four 15 minutes interval and the reaction vessels were allowed to stand un-agitated for 48 hr at room temperature. Similarly, to respective triplicate reaction plastic bottles containing the 5g of charred palm nut husk labeled PNH-1, PNH-2 and PNH-3 was added 50 ml of 102ppm of lead nitrate solution prepared above.

The bottles and their contents were hand wrist shaken for four 15 minute interval and the reaction vessels were allowed to stand un-agitated for 48 hrs. at room temperature.

After 48 hrs, the mixture from each reaction bottle was filtered using Whatman filter paper (No. 1). The resulting supernatant from each reaction bottle was transferred into another labeled clean sample bottle and sent out to the Ministry of Environment, Uyo, Akwa-Ibom State, Nigeria, for lead analysis using UNICAM 969 Solar Atomic Absorption Spectrophotometer (AAS).

4. RESULTS AND DISCUSSIONS:

Figures 1 and 2 show the average residual lead remaining in each reaction vessel after the lead solution was separately treated with each of the two adsorbents (charred palm nut and corn cob husks) for 48 hrs at room temperature and the percent of lead removed compared to the control, respectively" Ctr (102.3 ppm, 0%); palm nut husk (1.3 ppm, 98.7%); and corn cob husk (8.2 ppm, 92%). Thus, the data on both Figures strongly suggest that both charred corn cob and palm nut husks demonstrated great efficacy in lead removal from the contaminated aqueous solution. The results are consistent with those reported by Agwaramgbo *et al.* [25] in which unmodified and un-activated charred spinach removed lead from contaminated aqueous solution with 92% removal efficiency. However, palm nut husk removed slightly more lead than corn cob husk. The 1.3 and 8.8 ppm of residual lead levels after the contaminated water was treated with the adsorbents exceeded the lead permissible exposure limit (PEL) of 0.05 ppm for drinking water set by the Federal Environmental Protection Agency of Nigeria (FEPA) and World Health Organization (WHO). Nonetheless, charred palm nut husk was able to remediate the lead contaminated water down to about 1 ppm, the permissible exposure limit set by FEPA and WHO for effluent water, respectively.

It was physically observed that the charred palm nut husk had a powdery texture while the charred corn cob husk which had a more coarse and grainy texture. None-the-less, both charred husks were sieved with a 2mm mesh sieve for homogeneity. The reason why the charred palm nut husk has a greater lead removal efficiency could be attributed to (i) its powdery nature gives more porosity and larger surface area (ii) Its particles are more compact (iii) its functional groups may participate more in the adsorption of the metal to the material surface. Reasons i and ii are consistent with the finding by Agwaramgbo [25] on the variation in lead removal by ground powdered molecular sieve and molecular sievesphere. The powdered molecular sieve removed more lead than the spherical counterpart. Furthermore, the efficacy of these natural agricultural waste materials in lead removal from contaminated water is in agreement with what has been reported by (a) Shaqiba *et al* [36] on arsenic removal by waste blue pine and walnut shell (b) Mataka [37] on lead removal by seed powder (c) Amarasinghe [38] on lead and cadmium removal from contaminated water by tea waste.

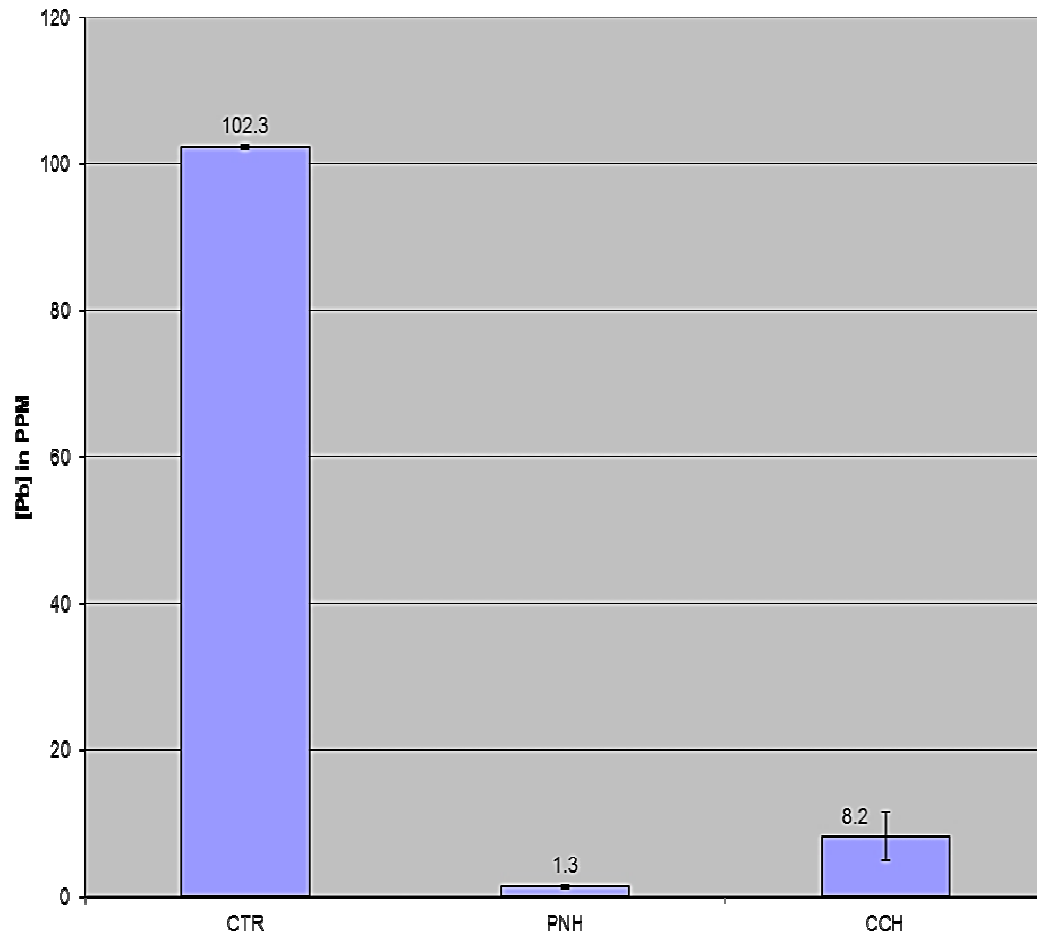


Figure 1: Residual lead concentrations in PPM after treatment compared to control. CTR = Control; PNH = Palm Nut Husk; CCH = Corn Cob Husk

5. CONCLUSIONS:

The result from the project reported here clearly demonstrated that both charred husks from palm nut and corn cob effectively removed heavy metals such as lead from contaminated water with greater than ninety percent (90%) of the lead being removed by each adsorbent. It is believed that charring enhances the adsorption capacity of the sorbents by opening and enlarging the pore size. More importantly, the process developed in this project (charred native, cheap, abundant, and safe natural waste palm nut and corn cob husks) can be effectively used to mitigate industrial lead contaminated effluent before they contaminate rivers as reported by Nwagbara [16] and Dan' azumi [40]. The results are in agreement with those reported by other researchers on the use of un-activated natural biomaterial as sorbents for the removal of heavy metals from contaminated water [23, 25-27, 33-36, 39].

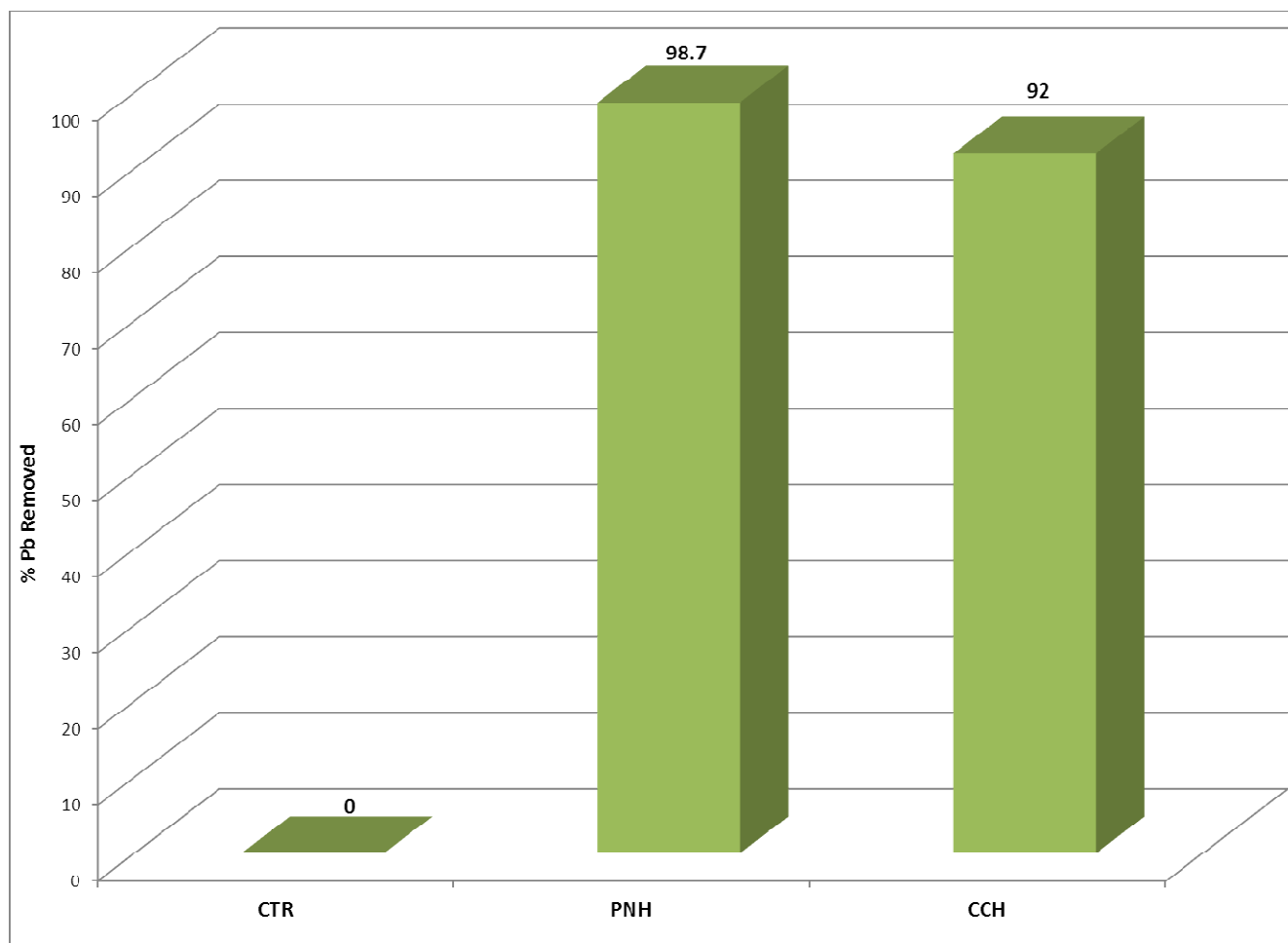


Figure 2: Percent Lead removed by substrates: CTR = Control; PNH = Pal Nut Husk; CCH = Corn Cob Husk
 Calculated using the formula: $\%R = [(C_i - C_f) / C_i] \times 100$ where %R = percent removal;
 C_i = initial metal concentration, C_f = Residual metal concentration after reaction time

6. REFERENCES

- [1] Laidlaw, M. S., Mielke, H. W., Filippelli, G. M., Johnson, D. L., Gonzales, C. R. Seasonality and Children's Blood Lead Levels: Developing a Predictive Model using Climatic Variables and Blood Lead Data from Indianapolis, Indiana, Syracuse, New York and New Orleans, Louisiana (USA). Environmental Health Perspectives, 2005; 113:793-800
- [2] Chaney, R. and Mielke, H. Standard for Soil Lead limitations in the United States, Trace Substance. Environmental Health, 1986; 20:357-377.
- [3] Sardis, T., Chettri, M. K., Papaioannou, A., Zachariadis, G., and Stratis, J. A Study of Metal Distribution from fuels using trees as Biological Monitors. Ecotox. and Environ. Safety, 2001; 48:27-35

- [4] Cotter-Howells, J. and Thornton, I. Sources and Pathways of Environmental Lead to Children in a Derbyshire Mining Village. *Environ. Geochem. and Health*; 1991;13(2):127-135
- [5] Mielke, H. W., Adams, J. L., Reagan, P. L., Mielke Jr, P. W. Soil-dust Lead and Childhood Lead Exposure as a Function of City Size and Community Traffic Flow: The Case for Lead Contaminated Soil Abatement in Minnesota. *Environmental Geochemistry and Health*.(Hardbound book supplement to volume 9 entitled Lead in Soil: Issues and Guidelines), 1989; 253-271
- [6] Mielke, H.W. Lead Dust Contaminated USA Communities: Companion of Louisiana and Minnesota. *Applied Geochemistry*, 1993; 8(Suppl. 2):257-261
- [7] Lovell Agwaramgbo, Jerrard Smith-Hopkins, Adriana Hawkins, and Deneyelle Wilson. Re-examination of Lead and Arsenic Contamination in New Orleans Parish School Soils. *American Chemical Society, Chemical and Engineering News, American CHED-TECH*. 2008; March 17:33
- [8] Tong, S. Lead Exposure and Cognitive Development: Persistence and A Dynamic Pattern. *Journal of Pediatrics and Child Health*, 1998; 34:114-118. doi: 10.1046/J.1440- 1754.1998.00187.x
- [9] Canfield, R.L., Henderson, C.R. Jr, Cory-Slechta, D.A., Cox, C., Jusko, T.A., Lanphear, B.P. Intellectual impairment in children with blood lead concentrations below 10 µg per deciliter. *New England J Medicine*, 2003;
- [10] Fewtrell, L. J., Pruss-Ustun, A, Landrigan, P, Ayuso-Mateos, J. L. Estimating the global burden of disease of mild mental retardation and cardiovascular diseases from environmental lead exposure. *Environ Res*, 2004; 94(2):120-133.
- [11] Needleman, H., McFarland, C., Ness, R., Fienberg, S., Tobin, M. Bone lead levels in adjudicated delinquents: A case control study. *Neurotoxicology and Teratology*, 2003; 24:711–717. DIO:dx.dio.org/10.1016/50892-0362(02)00269.
- [12] Strerteky, P.B. Lynch, M.J. The Relationship between Lead Exposure and Homicide. *Archives of Pediatric and Adolescent Medicine*, 2001; 155(5):579-582
- [13] Meyer, P.A. Brown, M.J, Falk, H. Global Approach to Red Using Lead Exposure and Poisoning. *Mutat. Res*, 2008; 659(1-2):166-175, doi 10.1016/j.mrrev
- [14] Galadima, A and Garba, Z.N. Heavy metal pollution in Nigeria: causes and consequences, *Elixir Pollution*, 2012; 45, 7917-7922.
- [15] Chika C. Ogueke, Clifford I. Owuamanam, James I. Ezekiel. Assessment of drinking water quality within a University community in Owerri, Nigeria, *American Journal of Food Science and Nutrition*, 2014; 1(1), 1-6.

- [16] Nwagbara J.O., Ibeneme S.I., Dim E.E., Iroegbu U.K., Selema A.O., Ejiogu B.C., Onyekuru S.O. Hydrogeochemical Analysis of Water Samples from Nworie River, Owerri Southeastern Nigeria, The International Journal of Engineering and Sciences, 2013, 2(9), 58-67.
- [17] Carl D. Palmer and William Fish. Chemical Enhancement to Pump- and- Treat Remediation; Ground Water Issues, Environmental Protection Agency (EPA), EPA 540/S-92/001, January 1992.
- [18] Jiang-Feng Peng, Yong-hui Song, Peng Yuan, Xiao-Yu Cui, Guang-Lei Qiu. The Remediation of Heavy Metal Contaminated Sediments. Journal of Hazardous Material, 2009; 161:633-640
- [19] C.N. Mulligan, R.N. Yong, B.F. Gibbs. Remediation Technologies for Metal Contaminated Soils and Ground water: An Evaluation. Engineering Geology, 2001; 60(1-4):193-207
- [20] R. D. Armstrong, M. Todd, J.W. Atkinson, and K. Scott. Selective electrodeposition of metals from simulated waste solutions. Journal of Applied Electrochemistry, 1996; 26(4):379-384. DOI: 0.1007/BF00251322
- [21] Lasat, M.M. Phytoextraction of toxic Metals: A Review of Biological Mechanisms. J. Environ. Qual, 2002; 31:109-120
- [22] Thomas R. Harper and Neville W. Kinham. Removal of Arsenic from wastewater using chemical precipitation methods. Water Environment Research, 1992; 64(3):200-20.
- [23] Lovell Agwaramgbo, Nancy Magee, ShaKayla Nunez, Kayla Mitt. Biosorption and Chemical Precipitation of Lead Using Biomaterials, Molecular Sieves, and Chlorides, Carbonates, and Sulfates of Na & Ca. Journal of Environmental Protection, 2013; 4:1251-1257.
- [24] Sarah Seleema, Ahmad Nauman Shah Saqiba, Adnan Mujahidb, Muhammad Hanifa, Ghulam Mustafac, Teriq Mahmooda, Amir Wasseem, Abdur Rahman Khan. Extraction of Pb(II) from water samples by ionic liquid-modified silica sorbents. Desalination and Water Treatment, 2014, In Press.
- [25] Agwaramgbo, L., Thomas C, Grays, C., Small, J., and Wright-Young, T. An Evaluation of Edible Plant Extracts for The Phytoremediation of Lead Contaminated Water. Journal of Environmental Protection, 2012; 3(8):722-730.
- [26] Agwaramgbo, L., Agwaramgbo, E; Mercadel, C., Edwards, S., Buckles, E. Lead Remediation of Contaminated Water by Charcoal, La Red Clay, Spinach and Mustard Green. Journal of Environmental Protection, 2011; 2(9):1240-1244.

- [27] Lovell Agwaramgbo, Nichole Lathan, Shelby Edwards, ShaKayla Nunez. Assessing Lead Removal from Contaminated Water Using Solid Bio-materials: Charcoal, Coffee, Tea, Fishbone, and Caffeine. *Journal of Environmental Protection*, 2013; 4(7):741-745.
- [28] Bailey, S.E., Olin, T.J., Bricka, R.M., Adrian, D.D. A Review of potentially low-cost sorbents for heavy metals. *Water Research*; 1999, 33(11):2469-2479. Doi: 10.1016/S0043-1354(98)00475-8
- [29] Igwe, J.C; Abia A.A., Ibeh, C.A. Adsorption Kinetics and Intraparticulate Diffusivities of Hg, As and Pb Ions On Un-Modified and Thiolated Coconut Fibre. *Int. J. Environ. Sci. Tech.*, 2008; 5(1):83-92.
- [30] Abia, A.A.; Igwe, J.C. Sorption Kinetic and Intraparticulate Diffusivities of Cd, Pb and Zn Ions on Maize Cob. *Afr. J. Biotech*, 2005; 4(6):509-512.
- [31] Zvinowanda CM, Okonkwo JO, Shabalala PN, and Agyei NM. A novel adsorbent for heavy metal remediation in aqueous environment. *Int. J. Environ. Sci. Tech.* 2009; 6(3): 425-434.
- [32] Doyurum, S.; Celik, A. Pb (II) and Cd (II) removal from aqueous solutions by olive cake. *J. Hazard. Mater*, 2006; 138 (1):22-28. DOI: 10.1016/j.jhazmat.2006.03.071.
- [33] Venkatesan, G, and Senthilnathan, U, "Adsorption Batch Studies on the Removal of Cadmium Using Wood of *Derris Indica* based Activated Carbon", *Res. J. Chem. Environ.*, Vol. 17, No. 5, 2013, pp. 19-24.
- [34] Mayumi Minamisawa, Hiroaki Minamisawa, Shoichiro Yoshida, and Nobuharu Taka, Adsorption Behavior of Heavy Metals on Biomaterials, *J. Agric. Food Chem.*, Vol. 52, No. 18, 2004, pp. 5606-5611. doi: 10.1021/jf0496402
- [35] Srivastava, H.C.P.; Marthus, R.P. Mehrotra. Removal of Chromium from Industrial Effluents by Absorptions on Sawdust. *Environ. Technol. Lettrs*, 1986; 5:55-63.
- [36] Ahmad Nauman Shah Saqiba, Amir Wassem, Ather Farooq Khan, Qaisar Mahmood, Amir Habib, Abdur Rahman Khan. Arsenic Bioremediation by Low Cost Materials Derived from Blue Pine (*Pinus wallichiana*) and Walnut (*Juglans regia*). *Ecological Engineering*, 2013, 51, 88-94. Doi: 10.1016/j.ecoleng.2012.12.063
- [37] Amarasinghe, B.M.W.P.K and Williams, R.A, 2007. Tea waste as a low adsorbent for the removal of Cu and Pb from wastewater. *Chemical Engineering Journal*, 132: 299-309.

- 346
347 [38] L.M. Mataka, E.M.T. Henry, W.R.L. Masamba, and S.M. Sajidu, "Lead
348 remediation of contaminated water using MoringaStenopetala and Moringa
349 oleifera seed powder," Int. J. Environ. Sci. Tech., Vol. 3, No. 2, 2006, pp. 131-
350 139.
- 351
352 [39] Lovell Agwaramgbo*, Nichole Lathan, Shelby Edwards, and Charne Thomas,
353 "Comparative Study of Lead Removal by Extracts of Spinach, Coffee, and Tea,"
354 Journal of Environmental Protection, Vol. 4, pp 250-257, 2013 doi:
355 10.4236/jep.2013.43029.
- 356
357 [40] Salisu Dan' azuni and Mustapha Hasan Bichi.Industrial pollution and Implication
358 on Source of Water Supply in Kano, Nigeria. International Journal of of
359 Engineering & Technology, 2010, 10(1):76-81.
- 360
361
362