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Lead Removal from Contaminated Water by Corn and Palm Nut Husks

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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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

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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; palmnuthusk; 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 decompositions. 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 et al. [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 and Garba [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 et al. [15] and Nwagbara et al. [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 back, 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 Owerriin the development of lead remediation technology.

2. MATERIALS AND 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 was completely dried 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. TREATMENT OF LEAD CONTAMINATED WATER WITH CHARRED CORN COB AND PALM NUT HUSKS

3.1 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 substrate labeled CCH-1, CCH-2 and CCH-3was charged with 50 ml of 102 ppm 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 hours at room temperature.

After 48 hours, 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 DISCUSSION

Figs. 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 (charredpalm 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 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) it’s powdery nature gives it 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 et al. [25] on the variation in lead removal by ground powdered molecular sieve and molecular sieve sphere. 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) Saqiba et al. [36] on arsenic removal by waste blue pine and walnut shell (b) Amarasinghe et al. [37] on lead and cadmium removal from contaminated water by tea waste (c) Mataka et al. [38] on lead removal by seed powder.

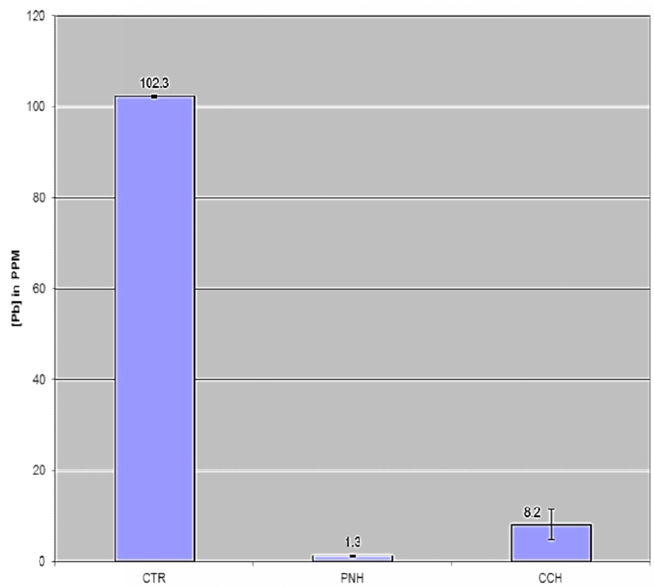

Fig. 1. Residual lead concentrations in PPM after treatment compared to control. CTR = Control; PNH = Palm Nut Husk; CCH = Corn Cob Husk

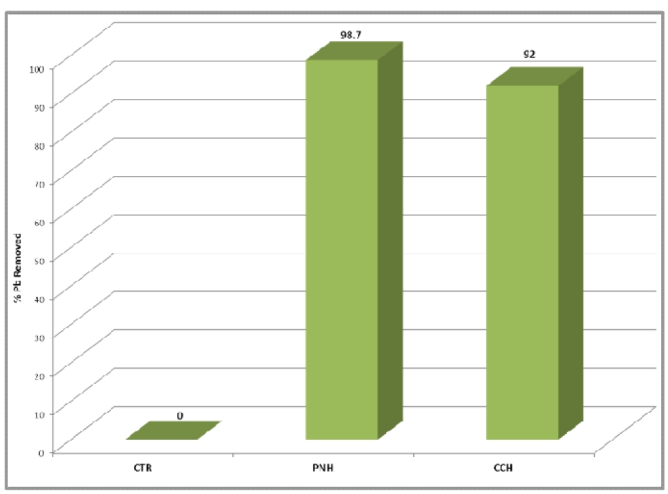

Fig. 2. Percent Lead removed by substrates was calculated using the formula: % R = [(Ci-Cf/Cf)] 100 where % R = percent removal; Ci = initial metal concentration, Cf = residual metal concentration after reaction time. CTR = Control; PNH = Palm Nut Husk; CCH = Corn Cob Husk

5. CONCLUSION

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%) efficiency. 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 beef ectively 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].

COMPETING INTERESTS

Authors declare that there are no competing interests.

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