Available online at www.asric.org

ASRIC Journal on Agricultural Sciences 1 (2020) 35-42

Removal of Toxic Metals from Water using Cabbage, Carrots and Lettuce as Biofilters

Ismaila Emahi [a,1], Patrick O. Sakyi [a], Haider M. Hamzah [b],

[a] *Department of Chemical Sciences, School of Sciences, University of Energy and Natural Resources, Sunyani, Bono Region, Ghana*
[b] *Department of Biology, College of Science, University of Sulaimani, Sulaymaniyah, Kurdistan Region, Iraq*

Received 21 October 2019; revised 30 August 2020; accepted 30 October 2020

Abstract

The existing technologies for removing toxic metals from the environment are very expensive and impractical for use in developing countries. In the present study we investigated the use of Lettuce (*Lactuca sativa*), Cabbage (*Brassica oleracea var. capitata*) and Carrots (*Daucus carota subsp. Sativus*) as biosorbents for removing Copper (Cu), Lead (Pb), and Zinc metal ions from polluted water via biofiltration. The filtrates were analysed via Atomic Absorption Spectroscopy (AAS) in order to quantitate any remaining, unremoved metals. All three biosorbents showed considerable abilities to remove the above metals, with about 95% removal efficiency in the case of zinc (Zn^{2+}). In order to understand the chemistry of the adsorption processes, the biosorbent materials, after biofiltration, were analysed via FT-IR spectroscopy, which revealed that all three biosorbents contained compounds with phenol, ether, alkanol, carbonyl and alkanoic acid groups that were involved in the formation of surface complexes during the adsorption of the metal ions. To investigate the effect of this biofiltration process on the overall quality of water, the physicochemical parameters (pH, conductivity, colour, turbidity, TDS and TSS) were also measured on river water samples that have been pre-treated with the biosorbents. There was general improvement in the water quality although the biofilters appeared to have introduced some mineral ions, which increased the conductivity and TDS of the water.

Keywords: Biofitration; Lead; Zinc; Copper; Remediation; Mining; Pollution

1. Introduction

Environmental pollution from chemicals remains one of the serious threats globally (Schwarzenbach et al. 2010), but the indiscriminate release of toxic heavy metals into soil and water bodies is much more alarming (Valko, Morris, and Cronin 2005) and requires utmost attention. Unlike some organic contaminants, heavy metals, which are inorganic, cannot be broken down to non-toxic forms and therefore have long-lasting effects not only on human health but the ecosystem at large. Even at very low concentrations heavy metals including lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), zinc (Zn), silver (Ag), nickel (Ni) and arsenic (As) are well known to be cytotoxic and carcinogenic in nature (Gjorgieva Ackova 2018; Jia et al. 2017; Fashola et al. 2016; Tchounwou et al. 2012). Although heavy

[1] Corresponding author. *Email addresses*: ismaila.emahi@uenr.edu.gh (I. Emahi)

Khan, S., Q. Cao, Y. M. Zheng, Y. Z. Huang, and Y. G. Zhu. 2008. 'Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China', *Environmental Pollution*, 152: 686-92.

Li, Qiang, Lizhou Tang, Jiang Hu, Ming Jiang, Xiaodong Shi, Tianxi Zhang, Yuan Li, and Xuejun Pan. 2018. 'Removal of toxic metals from aqueous solution by biochars derived from long-root Eichhornia crassipes', *Royal Society Open Science*, 5: 180966.

Majumder, Subhajit, and Suresh Gupta. 2010. *Biofiltration for Heavy Metals Removal: A State-of-the-art Review*.

Malik, Davendra, Chakresh Jain, and Anuj Yadav. 2016. 'Removal of heavy metals from emerging cellulosic low-cost adsorbents: a review', *Applied Water Science*.

Moreira, Sarah, Diego Melo, Ari Clecius, Francisco Sousa, André Oliveira, André Oliveira, and Ronaldo Nascimento. 2015. 'Removal of Ni 2+ , Cu 2+ , Zn 2+ , Cd 2+ and Pb 2+ ions from aqueous solutions using cashew peduncle bagasse as an eco-friendly biosorbent', *Desalination and Water Treatment*: 1-14.

Müller, Mario, and Manfred Anke. 1994. 'Distribution of cadmium in the food chain (soil-plant-human) of a cadmium exposed area and the health risks of the general population', *Science of the Total Environment*, 156: 151-58.

Mumba, Peter, B. Q. Chibambo, and Wilfred Kadewa. 2008. 'A Comparison of The Levels of Heavy Metals in Cabbages Irrigated With Reservoir and Tap Water', *International Journal of Environmental Research (ISSN: 1735-6865) Vol 2 Num 1*, 2.

Othman, Chra. 2001. 'Heavy metals in green vegetables and soils from vegetable gardens in Dar Es Salaam, Tanzania', *Tanzania Journal of Science*, 27.

Rai, Prabhat Kumar, Sang Soo Lee, Ming Zhang, Yiu Fai Tsang, and Ki-Hyun Kim. 2019. 'Heavy metals in food crops: Health risks, fate, mechanisms, and management', *Environment International*, 125: 365-85.

Rostamian, R., Manouchehr Heidarpour, Sayed-Farhad Mousavi, and Afyuni Majid. 2015. 'Characterization and Sodium Sorption Capacity of Biochar and Activated Carbon Prepared from Rice Husk', *Journal of Agricultural Science and Technology*, 17: 1057-69.

Schwarzenbach, René, Thomas Egli, Thomas B. Hofstetter, Urs Von Gunten, and Bernhard Wehrli. 2010. 'Global Water Pollution and Human Health', *Ann Rev Environ Resour*, 35.

Shi, Zeming, Xinyu Wang, Yue Shi, Shijun Ni, Yunzhen Li, Dewei Wang, and Ruilin Wang. 2018. 'Impact of intensive mining on the distribution of heavy metals in water and sediment of Anning River, southwest China', *Geochemistry: Exploration, Environment, Analysis*, 19: geochem2017-054.

Srivastava, N. K., and C. B. Majumder. 2008. 'Novel biofiltration methods for the treatment of heavy metals from industrial wastewater', *J Hazard Mater*, 151: 1-8.

Tchounwou, P. B., C. G. Yedjou, A. K. Patlolla, and D. J. Sutton. 2012. 'Heavy metal toxicity and the environment', *Exp Suppl*, 101: 133-64.

Usman, Adel. 2008. 'The relative adsorption selectivities of Pb, Cu, Zn, Cd and Ni by soils developed on shale in New Valley, Egypt', *Geoderma*, 144: 334-43.

Valko, M., H. Morris, and M. T. D. Cronin. 2005. 'Metals, Toxicity and Oxidative Stress', *Current Medicinal Chemistry*, 12: 1161-208.

Warman, P. R., and K. A. Havard. 1997. 'Yield, vitamin and mineral contents of organically and conventionally grown carrots and cabbage', *Agriculture, Ecosystems & Environment*, 61: 155-62.

WHO. 2017. "Guidelines for drinking-water quality: fourth edition incorporating the first addendum." In. Geneva: World Health Organization.

Wuana, Raymond, and F. E. Okieimen. 2011. 'Heavy metals in contaminated soils: a review of sources, chemistry, risks and best available strategies for remediation', *Int Scholarly Res Network*: 1-20.

Zhou, Dong-Mei, Xiu-Zhen Hao, Yu-Jun Wang, Yuan-Hua Dong, and Long Cang. 2005. 'Copper and Zn uptake by radish and pakchoi as affected by application of livestock and poultry manures', *Chemosphere*, 59: 167-75.

Zwain, Haider, Mohammadtaghi Vakili, and Irvan Dahlan. 2014. 'Waste Material Adsorbents for Zinc Removal from Wastewater: A Comprehensive Review', *International Journal of Chemical Engineering*, 2014: 13.