Abstract

Endocrine disrupting chemicals (EDCs) disturb the endocrine system's functionality causing negative effects on health in an organism and its progeny. They can interfere with natural hormone cycles in humans or animals, potentially affecting metabolism, development, reproduction and growth. Phthalates are among the many examples of EDCs, which have been used as plasticizers for longtime around the world. Due to their extensive usage, they are found in many surface waters, sludge and waste waters. The occurrence of phthalates in water, and their exposure to non-target organisms cause adverse effects such as congenital anomalies, endocrine disruption and chronic toxicity. This study determined residual levels of three phthalates namely; dimethyl phthalate (DMP), benzyl butyl phthalate, (BBP) and bis(2-ethylhexyl) phthalate (BEHP) in wastewater sampled from wastewater treatment plants (WWTPs) of Nyalenda, Homabay and Kisii during wet and dry seasons. The wastewater samples were extracted and cleaned by solid phase extraction cartridges (SPE) ready for high performance liquid chromatography (HPLC) for quantitative analysis. Most of the sites sampled had detectable levels of DMP, BBP and BEHP in wastewater. High concentrations were detected during wet season compared to dry season in all sampled sites. Nyalenda WWTP recorded the highest concentrations of phthalates than Homabay and Kisii WWTPs. The concentrations of all selected phthalates were recorded highest at the inlet sampling points from all WWTPs, in both seasons sampled. Almost all the selected phthalates were below the limit of quantification (LOQ) at the outlet sampling points of Homabay and Kisii WWTPs in both seasons. The residue levels obtained showed significant differences at 5% confidence limits with zcal for all phthalates in all WWTPs less than the critical value (Zcritical = 1.96). Therefore, the null hypothesis was rejected. Consequently, a cost-effective technique of removing DMP, BBP and BEHP from their solutions using water hyacinth biochar (WHB) as an adsorbent was investigated. A mass of 0.1 g of WHB both before and after adsorption was used for characterization process. Elemental analysis of WHB was determined using XRF (EDXRF), the XRD patterns were obtained using bruker operating with Cu Kά(λ = 1.541nm) and samples scanned in coupled TwoTheta/Theta. The FTIR spectra were obtained between 4000cm-1 and 400cm-1 using Shimadzu type. The adsorption process was done using an orbital shaker agitated at 125 rpm and residual levels determined using the HPLC. The optimum conditions obtained from the adsorption of DMP, BBP and BEHP onto WHB were as follows; equilibrium time was 25 minutes, maximum adsorbate concentration adsorbed at 0.1 g of WHB was 4 mg/L, temperature of 298 K was appropriate and 0.8 g of WHB was effective for the adsorption of above 67% of 10 mg/L of each selected phthalate. The kinetic data fitted the pseudo second order model with regression values for DMP, BBP and BEHP found to be 0.9987, 0.9984 and 0.9986, respectively. The Freundlich model demonstrated to be a good model for fitting the adsorption data, which was attributed to heterogenous distribution of charged functional groups at adsorption sites of WHB's surface. The calculated thermodynamic parameters, namely; change in Gibb's free energy (ΔG), change in enthalpy (ΔH) and change in entropy (ΔS) showed that the adsorption process was favorable, exothermic, spontaneous and of a physical type. This was due to the fact that all of them were negative values. Dimethyl phthalate was the most effectively removed by WHB as adsorbent. The removal efficiency decreased with increasing molecular weight of the phthalates. The findings demonstrated that WHB is a good low cost and environmentally adsorbent for removal of phthalates from water.