Evaluation of the Effects of Parts of Red Mangrove and Weight on Adsorption of Cr (vi) in Aqueous Medium

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Abstract- Adsorption using plant materials has been found an effective technique for removal of dissolved ions. To evaluate the effect of parts of red mangrove and weight on adsorption of Cr (vi) in aqueous medium, adsorption data of freshly prepared red mangrove leaves, bark and root powders were obtained from batch experiments and analyzed as function of powder weight. The results indicated that the adsorption was dependent on weight of mangrove powder. Adsorption capacity decreased from (2996.00 to 175.05 mg/g), for leaves; (2172.50 to 132.40 mg/g), for bark and (2819.50 to 1750 mg/g), for root as weight of powder used was increased from 0.2 to 4g. It was also found that greater Cr (vi) adsorption occurred on root and leaves than bark. Adsorption profile diagram described for bark is much lower than those of root and leaves of the same weight. The results suggest that adsorption of Cr (vi) is effective at low mangrove powder weight. The results also suggest that red mangrove biomass, especially the leaves and root, can be used as low cost adsorbent for the removal of Cr (vi) ion in aqueous solution.

Index Terms- adsorption data, mangrove biomass, Cr (vi), aqueous medium, *Rhizophora mangle*

I. Introduction

Adsorption involves the attraction and retention of a liquid or a solid (adsorbate) unto a surface (adsorbent) resulting into high concentration of the molecules of the substance on the surface. Several factors have been reported to influence adsorption (Babel & Kurniawen, 2004; Oliveira *et al*., 2008; Naiya *et al*., 2009). These include nature of adsorbent and adsorbate, surface area of adsorbent and hydrogen ion concentration (pH) of solution. Cr (vi) is a toxic and highly soluble chromate anion (Das & Vinodhini, 2010; Vargas *et al*., 2012). It is necessary to reduce or remove Cr (vi) from wastewater and the environment. Natural materials from plants can remove dissolved ions from solution medium (Venkateswarlu *et al.,* 2007; Klimmek *et al*., 2001; Abdullahi *et al*., 2012; Babitha *et al.,* 2016). Red Mangrove *(Rhizophora mangle)*, an evergreen plant, grows abundantly in the coastal areas of southern Nigeria. The plant, particularly the stem, is a source of fire-wood to the local people.

In a recent research project, Nduka (2019) evaluated the adsorptive capacity of red mangrove biomass (leaves, bark and root) on chromium (VI) in aqueous solution, using batch adsorption technique. Nduka (2019) noted that the adsorption process depended on several variables considered such as adsorbent dosage, pH, chromium (VI) concentration, contact time, and particle size. Further details of this project are still being discussed. In the present paper, experimental adsorption data of red mangrove biomass were analyzed with respect to weight for red mangrove leaves, bark and root powder sorbents. The objective is to report the effects of parts of red mangrove and weight on adsorption of Cr (vi).

II. Experimental

Materials and Reagent: Atomic Absorption Spectrophotometer (AAS) (Agilent MP-AES 42100), mechanical grinder, Stuart orbital shaker and Whatman No. 1 filter paper. De-ionized water obtained from the main chemistry laboratory was used to prepare the solutions. 1000mg/L of Cr (vi) solution was prepared by dissolving 2.828g of 'Analar grade' potassium dichromate ($K_2Cr_2O_7$) in 1 liter of deionized water. Working solution of 40mg/L was prepared from the stock solution (1000mg/L) by dilution.

Collection and Processing of Red Mangrove Leaves, Bark and Root: Red Mangrove leaves, bark and root (Figure 1) were harvested from swampy mangrove forest near Bakana community in Degema Local Government Area of Rivers State, Nigeria, on the 10th day of January, 2019. They were washed thoroughly with tap water to remove dirt, soil particles and other soluble particles and sun dried for 3days (for the leaves) and 5days (for the root and bark). The dried samples were ground with the mechanical grinder and then sieved through a 5×10^2µm mesh sieve to obtain mangrove leaves, bark and root powders (Figure 2). These were then stored fresh, without modification, in tightly covered plastic containers for adsorption.

Batch Adsorption Experiments: Experiment was conducted using 0.2g of powder in 75ml flask. 20ml of 40mg/L of Cr (vi) solution was added to the flask and agitated in an orbital shaker at a constant speed of 150rpm for 90minutes. After adsorption, sample was withdrawn and filtered using the Whatman Filter Paper No. 1. The filtrate was taken for analysis of residual Cr (vi) concentration using the atomic absorption spectrophotometer (AAS). The procedure was repeated using different weights (0.2g, 1g, 2g, 3g and 4g) of the leaves, bark and root powders. For every measurement, the adsorption capacity (qf) and percentage (%) adsorption or removal were calculated using Equations 1 and 2. All the experiments were performed at ambient room temperature conditions which ranged between 29.5and 30.5^{o}C.

$$q_f = \left(\frac{C_o - C_f}{M}\right) \times V \quad (1)$$

$$\%\ Removal = \left[\frac{C_o - C_f}{C_o}\right] \times 100 \quad (2)$$

Where q_f = amount of Cr (vi) adsorbed during the adsorption period, ($mg.g^{-1}$); M = mass of red mangrove powder added, (g); V = volume of solution, (L); (C_o) and (C_f) are respectively the initial and residual concentrations of Cr (vi) before and after adsorption, ($mg.L^{-1}$).

Figure 1: Red Mangrove Samples: Leaves (A), Bark (B) and Root (C).

Figure 2: Red Mangrove Leaves (D), Bark (E) and Root (F) Powders.

III. RESULTS AND DISCUSSION

Effect of Red Mangrove Biomass on Adsorption: Adsorbent dosage influences adsorption (Sathish *et al.*, 2015). Thus, adsorption results were plotted as adsorption capacity (Figure 3A) and percentage adsorption (Figure 3B) as function of weight of powder for red mangrove leaves, bark and root. The results indicated that the adsorption was dependent on weight of mangrove powder used. Adsorption capacity (Figure 3A) of the sorbents decreased from (2996.00 to 175.05 mg/g), for leaves; (2172.50 to 132.40mg/g), for bark and (2819.50 to 1750 mg/g), for root, as weight of powder used was increased from 0.2 to 4.0g. Unsaturation and overlapping of active sites as well as overcrowding of particles at higher dosage have been adduced by several researchers (Sathish *et al.*, 2015; Cookey *et al.*, 2019; Nduka *et al.*, 2019). Percentage of Cr (vi) adsorbed (Figure 3B) increased slightly with increase in weight of powder, meaning that high weight of powder only made few additional surface available for adsorption of Cr (vi) or the surface area was in excess and the Cr (vi) adsorbed per gram of powder decreased. These also explain that though there was increment in percentage of Cr (vi) adsorbed, increment not proportionate to adsorptive capacity of the adsorbents at higher powder weight. Thus, adsorption capacity decreased as weight of powder used increased. However, Figure 3B indicates greater Cr (vi) adsorption on root and leaves than bark. Percentage adsorption profiles for leaf (72.37 to 89.86%) and root (73.88 to 90.09%) are much higher than that of bark (52.74 to 67.97%), suggesting that mangrove leaf and root powders are better adsorbents for Cr (vi) than mangrove bark powder.

In an adsorption process, the amount of materials adsorbed by a given mass of adsorbent depends, among others, on the nature and porosity of the adsorbent. Fresh mangrove samples from same source, ground and sieved through the same porosity are expected to have similar adsorption data, thus similar adsorptive performance. Visual observation of the powdered samples (Figure 2) reveals nothing more but slight variation in colour. However, as with all plants, mangrove is composed mainly of cellulose materials and has capacity for binding dissolve ions due to presence of polyphenolic, hydroxyl and carboxylic groups in its structure (Rozaini *et al.*, 2010). Possession of these and other related chemical compounds in red mangrove may account for the results obtained. It can be concluded in this study that mangrove roots and leaves have relatively higher ability to adsorb Cr (vi) in a single component aqueous medium compared to mangrove bark of the same weight. Red mangrove leaves and root are therefore recommended for use as adsorbent in removal of Cr (vi) in aqueous medium.

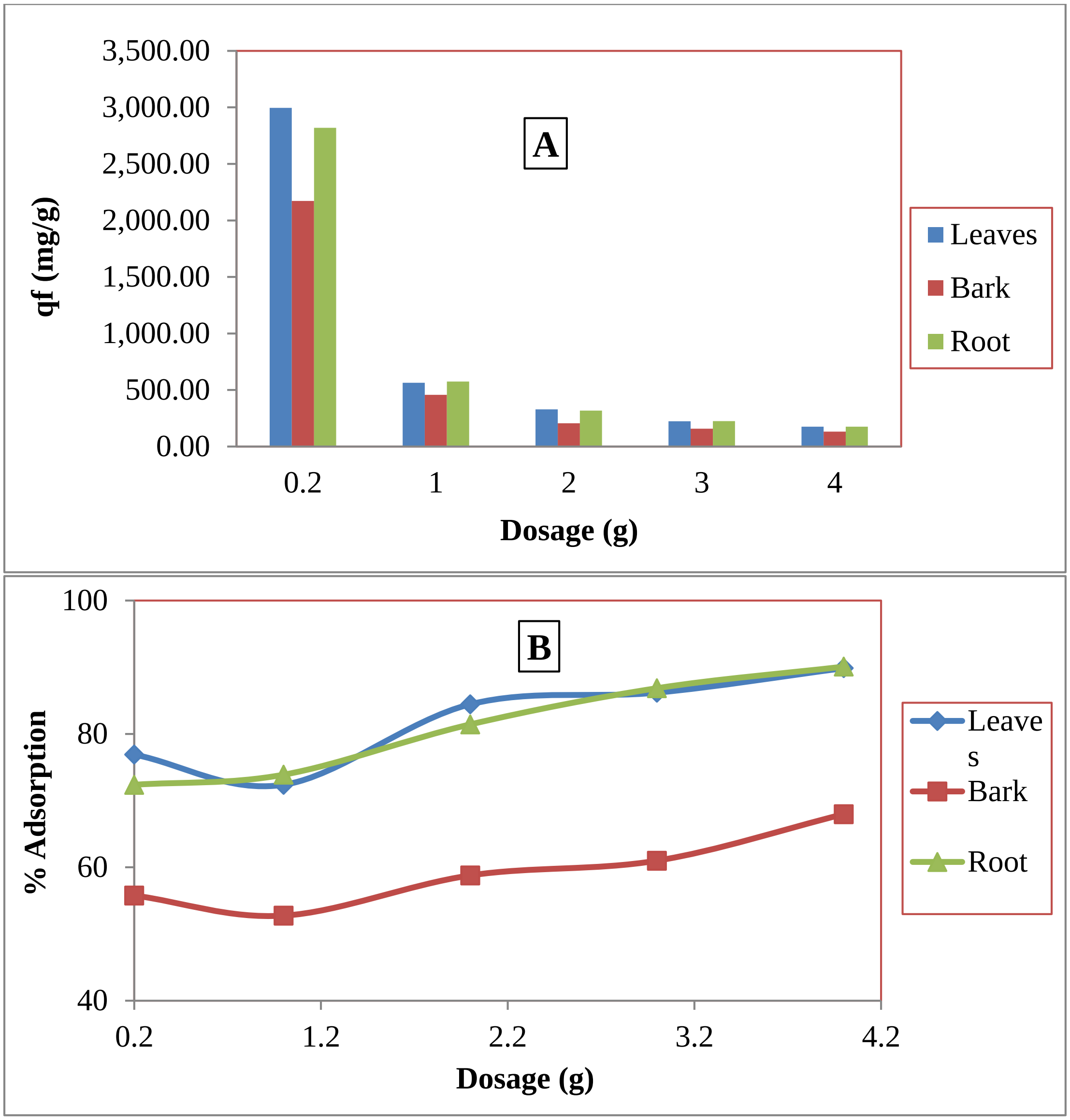

Figure 3: Effect of Parts Red Mangrove and Weight on Adsorption of 40mg/L Cr (vi) solution.

IV. SUMMARY AND CONCLUSION

This study has demonstrated the effects of parts of red mangrove plant (leaves, bark and root) and weight on adsorption of Cr (vi) in aqueous medium. It was found that mangrove leaves and root exhibited higher Cr (vi) adsorption than mangrove bark. The results also suggest that adsorption of Cr (vi) was effective at low mangrove powder weight. The investigations clearly indicate that mangrove root and leaves are better adsorbents for Cr (vi) than mangrove bark. Therefore, root and leaves of red mangrove plant can be used as adsorbents for treatment of water.

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