IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 7, Issue 9 Ver. I. (Sep. 2014), PP 54-56
www.iosrjournals.org

Physico-Chemical Characterization of Riverbed Sand from Mullai Periyar, Tamilnadu

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Abstract: *The objective of this work is to study the physico-chemical properties of riverbed sand collected from mullai periyar river basin near Gudalur in Theni district, Tamilnadu, India. In order to understand the adsorption property of sand, pH, pH zero point charge (pHzpc), cation exchange capacity (CEC), Bulkdensity and surface area were measured. The cation exchange capacity (CEC) of riverbed sand was estimated using the copper bis-ethylenediamine complex method. The specific surface area and CEC of soil were 15.25* $m^2\ g^{-1}$ *and 43.5* $meq\ g^{-1}$ *respectively. The result revealed that riverbed sand can acts as good adsorbent for removal of heavy metal ions from aqueous solution and wastewater.*
Keywords: *Bulkdensity, cation exchange capacity, heavy metal, riverbed sand, surface area*

I. Introduction

Contamination of water by toxic heavy metals has been a major environmental problem since long. Most of heavy metal ions are toxic to living organisms. These metal ions are non-degradable and are persistent in the environment. Therefore, the elimination of heavy metal ions from wastewater is important to protect public health. A large number of methods (conventional ion exchange, adsorption, electrolytic or liquid extraction, electrodialysis, chemical precipitation, membrane filtration) have been developed for decontamination of industrial waters [1 - 11]. Adsorption is a well known equilibrium separation process and an effective method for water decontamination applications [12 - 16]. Adsorption has been found to be superior to other techniques for purification water in flexibility and simplicity of design, ease of operation and insensitivity to toxic pollutants [17].

Different types of adsorbents are used for removing metal ions from aqueous solutions [18], each presenting somelimitations that may include either cost of the materials or complex chemistry hindering recovery. Clay minerals are important constituents of soil and they play the role of a natural scavenger for metals as water flows over soils or penetrate underground [19]. The high specific surface area, chemical and mechanical stability, layered structure, high cation exchange capacity (CEC), Brönsted and Lewis acidity, have made the clay minerals excellent materials for adsorption [20, 21].

Present work has been addressed to study the Physico-Chemical characteristics of riverbed sand collected from mullai periyar river basin near Gudalur in Theni disrtrict, Tamilnadu, India to understand the adsorption mechanism of sand in detail.

II. Experimental:

2.1.Study area:

The Periyar river originate in Periyar Tiger Reserve (Kerala) and flow through the Theni Forest Division. The present intensive study was carried out at Gudalur Range (23 km^2) located (9º 37'N, 77º 16' E) in southern Western Ghats of Theni Forest Division (723 km^2), Theni district, Tamilnadu, India. The soil samples were collected from mullai periyar river basin near Gudalur, Theni District, Tamilnadu, India was shown in Figure 1.

2.2. Soil collection and preparation:

The soil samples were initially sun dried for 7 days followed by drying in hot air oven at 383±1 K for 2 days. The dried soil was crushed and sieved and then stored in sterile, closed glass bottles till further investigation [22].

2.3. Soil pH

The pH of the aqueous slurry was determined by soaking 1g of sand in 50 ml distilled water, stirred for 24 h and filtered and the final pH was measured using pH meter.

2.4. Zero point charge

The zero point charge (pH_{ZPC}) for the adsorbent was determined by introducing 1.0 g of riverbed sand into six 100 mL Erlenmeyer flasks containing 100 mL of 0.1 M potassium nitrate solution. Initial pH values of the six solutions were adjusted to 2, 4, 6, 8, 10 and 12 by either adding few drops of nitric acid or potassium hydroxide. The solution mixtures were allowed to equilibrate in an isothermal shaker (25±1°C) for 24 h. Then the suspension in each sample was filtered and the final pH was measured again. The procedure was repeated by varying the mass of riverbed sand introduced into the solution from 0.1-1.0 g. The value of pH_{ZPC} can be determined from the curve that cuts the pH 0 line of the plot Δ pH versus $pH_{0.}$

2.5. Bulk density:

Bulk density was determined using core method [23].

2.6. Cation exchange capacity of the sand

The Cation Exchange Capacity (CEC) of riverbed sand was estimated using The copper bis-ethylenediamine complex method [24]. A quantity of 50 mL of 1 M $CuCl_2$ solution was mixed with 102 mL of 1 M ethylenediamine solution to allow the formation of the $[Cu(en)_2]^{2+}$ complex. A slight excess of the amine ensures complete formation of the complex. The solution is diluted with water to 1 L to give a 0.05 M solution of the complex. A quantity of 0.5 g of dry adsorbent was mixed with 5 ml of the complex solution in a 100 mL flask and diluted with distilled water to 25 mL and the mixture was agitated for 30 min in a thermostatic water bath shaker and centrifuged. The concentration of the complex remaining in the supernatant was determined by mixing 5 mL of it with 5 mL of 0.1 M HCl to destroy the $[Cu(en)_2]^{2+}$ complex, followed by adding 0.5 g KI mL^{-1} and then titrating iodometrically with 0.02 M $Na_2S_2O_3$ in the presence of starch as an indicator. The CEC was calculated from the formula:

$$\text{CEC (meq 100 g}^{-1}\text{)} = \text{MSV } (x - y)/1000 \text{ m} \qquad (1)$$

Where:

M = The molar mass of the complex
S = Concentration of the thio solution
V = Volume (mL) of the complex taken for iodometric titration
m = Mass of adsorbent taken (g)

x = Volume (mL) of thio required for blank titration (without the adsorbent)

y = Volume (mL) of thio required for the titration (with the adsorbent)

2.7. Specific surface area

The specific surface area of riverbed sand was estimated using Sears' method [25] by agitating 1.5 g of the riverbed sand sample in 100 mL of diluted hydrochloric acid of a pH = 3. Then 30 g of sodium chloride was added with stirring and the volume was made up to 150 mL with deionized water. The solution was titrated with 0.10 N NaOH and the volume, V, needed to raise the pH from 4-9 was then recorded. The surface area according to this method was calculated by the following equation:

$$S\ (m^2\ g^{-1}) = 32\ V\text{-}25 \qquad (2)$$

Where, V is the volume of sodium hydroxide required to raise the pH of the sample from 4-9. This volume was measured in replicate and the average value was taken for the surface area calculation.

III. Results and discussion:

Table 1 gives the results of Cation Exchange Capacity (CEC), pH, bulkdensity, pH_{ZPC} and Specific Surface Area (SSA) of the riverbed sand. The Cation Exchange Capacity (CEC) and specific surface area of riverbed sand were 43.5 meq $g^{-1}$and 15.25 m^2 g^{-1} respectively. The value of pH of riverbed sand was determined to be 7. When the pH value is above 6.0 the sand was negatively charged. Thus, at the neutral environment hydroxyl groups exist on the surface of the sand material, which is beneficial for heavy metal adsorption. It is well known that there are two major requirements on the adsorbent to obtain the efficient adsorption performance. One is that the adsorbent should possess a large surface area where the adsorption could occur, and the other is that the adsorbent surface should have a good affiliation tendency to the substance that needs to be adsorbed.

Table 1: Physico-Chemical characteristics of riverbed sand

Parameter	Value
pH	7
pH_{ZPC}	8.7
Specific surface area	15.25 m^2g^{-1}
Bulkdensity	1.64 g/ml
Cation exchange capacity	43.5 meq g^{-1}

44 Conclusion

The present study shows that the riverbed sand, an abundant low cost adsorbent, can be used for removal of heavy metals from aqueous solutions and wastewater. The cation exchange capacity of the adsorbent calculated has been approves application of riverbed sand to be a suitable material for heavy metal removal from waters rich in metallic species.

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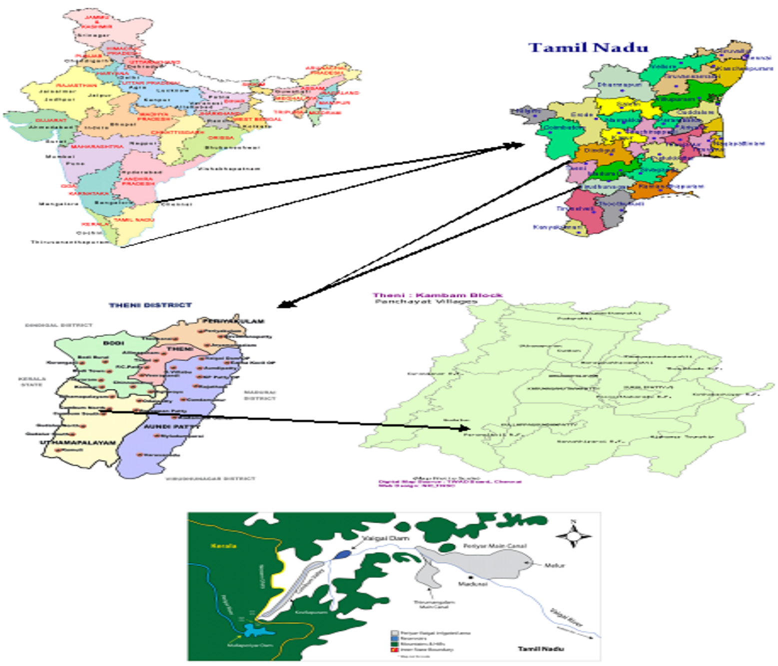

Figure 1: Study area location