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Studies on removal of Pb (II) by modified bentonite

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Abstract

Lead is one of the most toxic elements causing detrimental health effect. Adsorption kinetics was studied for removal of Pb(II) from aqueous medium using modified Bentonite. Aloe barbadensis miller (Aloevera) and Sapindus mukorossi were utilized to modify bentonite with a view to increase the surface area. High cation exchange capacity and surface area make bentonite suitable for adsorption of heavy metals. The bentonite mineral was characterized by FTIR, TGA, DTA, and XRD. The residual concentration of Pb(II) after treatment with modified bentonite of Rajmahal and Barmer was recorded at different time intervals. Inductively coupled plasma-Optical emission spectroscopy was used to analyses the residual concentration of lead. Rajmahal and Barmer (Rajsthan) bentonite modified with Sapindus mukorossi solution removed Pb(II) completely at a contact time of 90 minutes. Rajmahal bentonite modified with aloe barbadensis miller (aloevera) also emerged as a potential remover of lead from aqueous medium

Keywords: Sapindus mukorossi, FTIR, Modified bentonite, Kinetics, Cation exchange

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1. Introduction

Heavy metal concentration in ground water as well as surface water can be attributed to anthropogenic as well as geochemical reactions [1-2]. Amongst important heavy metals such as chromium, lead, cadmium and mercury, lead is a prominent toxic metal causing kidney and brain damage including multiple disorders [3-4]. Bentonite clay, a smectite group of minerals, has been used as a potential remover of Cr (VI), Cd (II) and other heavy metals due to its high cation exchange capacity and surface area [5]. This has emerged as a green low cost and eco-friendly method of removal of heavy metals. Bentonite consists of montmorillonite unit, which gives red colour with O-phenylenediamine and blue colour with benzidine [6]. Bentonite minerals have higher content of oxides of such as Na, K, Si, Al with traces of rare earth metal [7]. The cation exchange capacity is represented as:

$$BH + M^+ \rightarrow BM + H^+$$

where, M^+ is cation, H^+ is cation, M^+ exchanges H^+ cations and hence BH is an exchanger. The residual negative charges on the surface arise due to the octahedral substitution of Al^{3+} by Mg^{2+}. Residual negative charge is balanced by exchangeable cations [8-10]. Removal by agricultural solid waste, aquatic weeds, tree leaves and medicinal plants have been found suitable [11-13]. Modification of bentonite may be done with imidazole, (3-mercaptopropyl) triethoxysilane to afford mercapto functionalized Bentonite. Plant derived non-ionic surfactant such as cocoglucoside, lauryl glucoside, may also be replaced as, surfactants in lieu of Cetyl trimethyl ammonium bromide (CTAB). Sources of saponins are Soap bark tree, Ginseng and Alfalfa but Aloevera and Sapindus mukorossi solution have been used in the present paper as surfactants to modify the bentonite due to their availability and eco-friendly. The characterization of Bentonite is done by X- Ray diffraction, FTIR, and SEM. These techniques altogether confirm the presence of montmorillonite unit. The present paper aims to devise an eco- friendly and green substance to remove lead from aqueous medium.

2. Materials and Methods

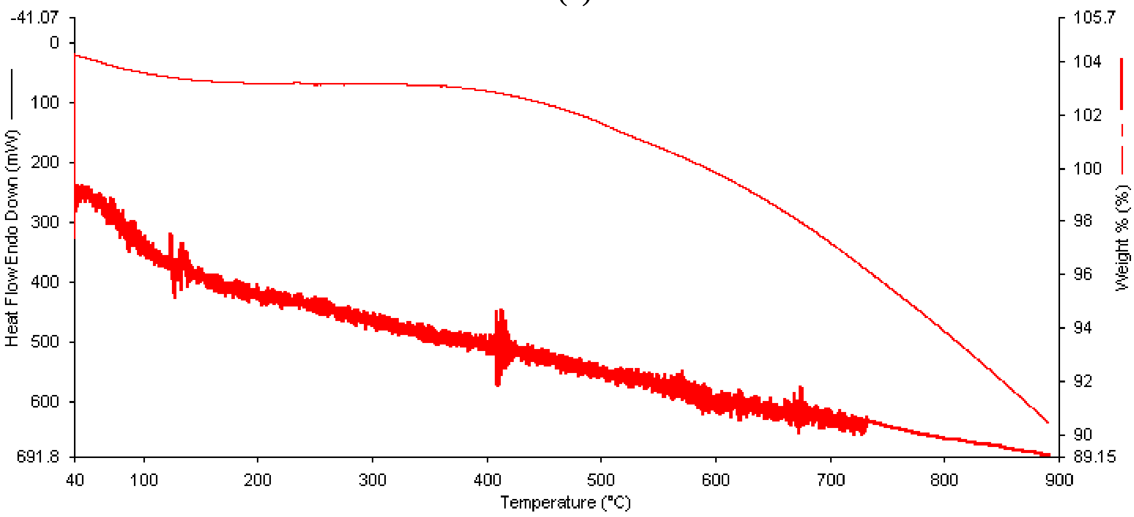
Bentonite minerals have been collected from Barmer, Rajasthan and Rajmahal hills. After treating with Sapindus mukorossi and aloevera extract, the Bentonite powder of 300-mesh sieve is heated up to 80°C for 5 hours followed by washing with distilled water. 100 ml 2-ppm Pb (II) solution is treated with modified Bentonite up to 30 minutes, 60 minutes, 90 minutes and the residual concentrations are known by Spectroquant lead kit with UV double beam spectrophotometer pharo 300. Further results are confirmed after analysis by inductively coupled plasma-optical emission spectroscopy (ICP-OES). Both the results are in good agreements with each other. SB2 and SB7 stand for Rajasthan and Rajmahal Bentonite respectively. SB2RSPb3 stands for modified Bentonite with reetha solution after treatment with 100 ml 2-ppm solution up to 30 minutes and SB2AVPb3 for modified Bentonite with aloevera solution. Calorimetric determination of SiO_2 and Al_2O_3 as the Alizarin red S-complex was done from UV –Vis. Spectrophotometer Systronic 2203. FTIR was done using KBr pellet. The thermal stability of bentonite mineral was established with thermo gravimetric analysis. XRD was done using D8 Diffractometer. Specimen length was fixed at 10nm and receiving slit size was 0.1000mm.

3. Results and discussion

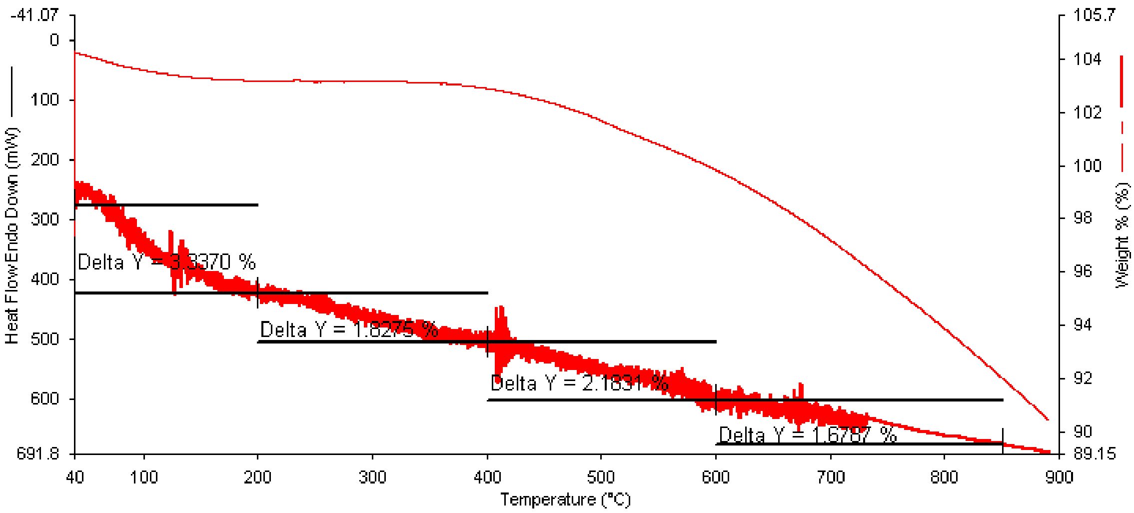
FTIR spectra of bentonite mineral showed stretching frequency of OH at 3620.72cm^{-1}, Si-O-Si linkage stretching vibrations around 1633.6cm^{-1}. The peaks in FTIR spectra confirm the presence of oxides of Si and Al [14]. (Figure 2)

The PXRD Pattern of Barmer and Rajmahal hill Samples at a glancing angle of 2Θ (degree) with different intensities show the presence of montmorillonite unit (Figure 3). The thermogravimetric analysis was done between temperature ranges of 100°C to 900°C showing endothermic peak. The first weight loss takes place around 100°C showing loss of hygroscopic water and the second weight loss indicate the dehydroxylation of the sample (Figure 1 (a), (b), (c)) .Total weight loss shows the presence of montmorillonite unit [15]. The residual concentrations of Pb(II) after treatment with 1g modified bentonite has been shown in Table-1. The residual concentrations of Pb (II) confirm that SB2AVPb6 and SB2AVPb9 removed lead completely from the aqueous medium. Rajmahal Bentonite modified sample with sapindus mukorossi (reetha) also removed completely lead from aqueous medium in 90 minutes.

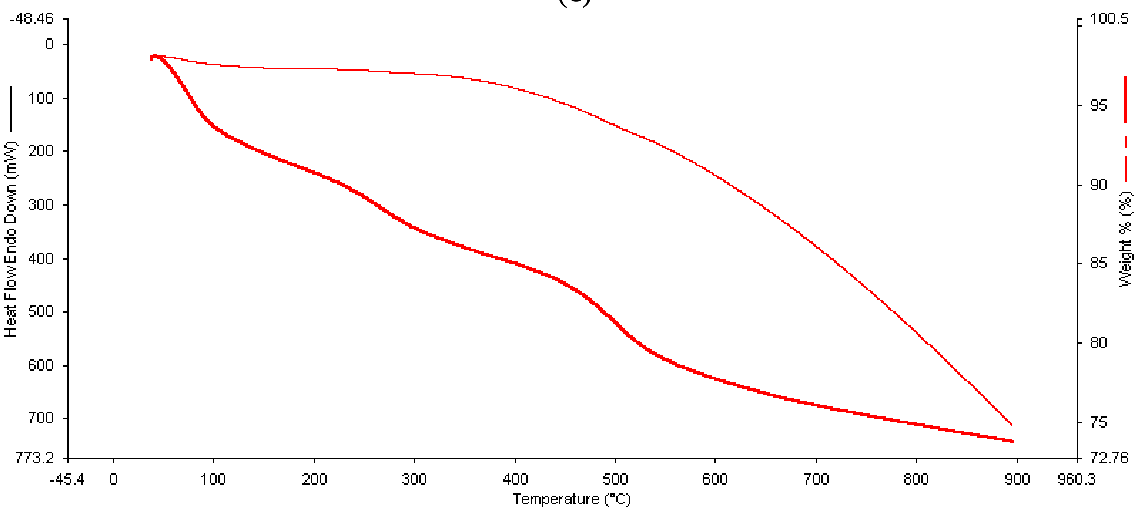
(a)



(b)



(c)



Figures 1(a), 1(b), TGA and DTA of modified bentonite & **Figure 1 (c)** TGA and DTA of bentonite

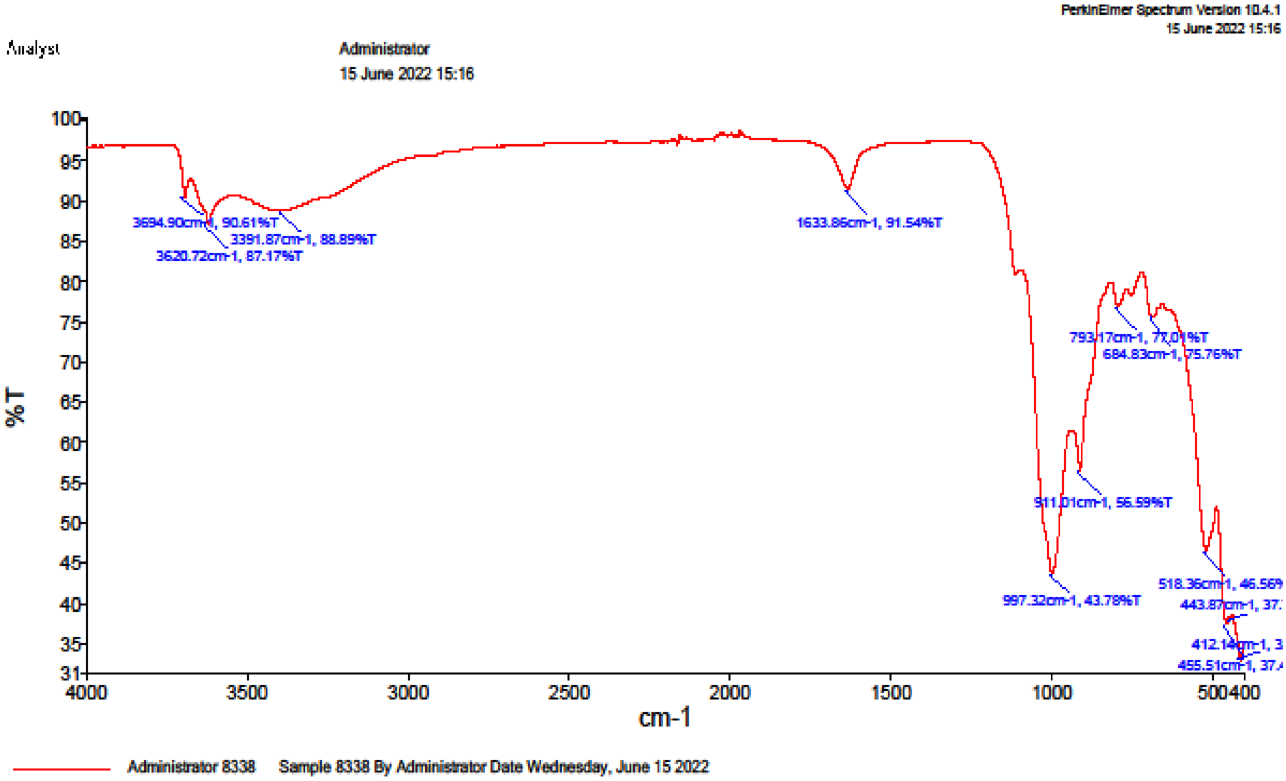


Figure 2. FTIR of bentonite sample

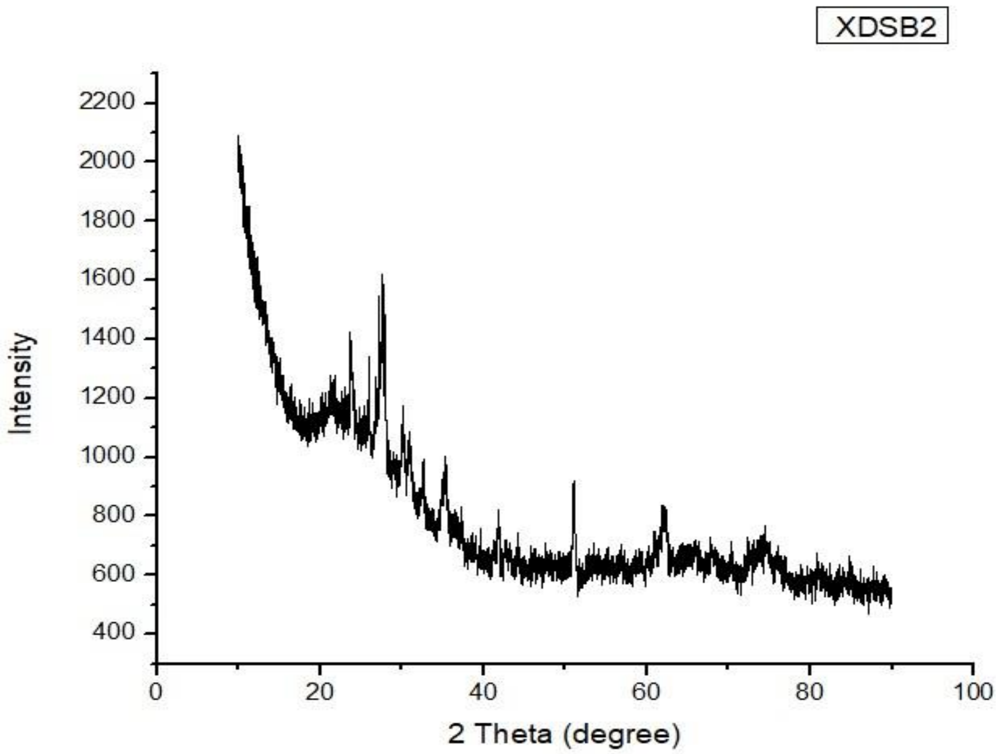


Figure 3. XRD of Bentonite sample SB2

Table 1. Residual concentration of Pb(II) after treatment with 1g Bentonite

Sl. No.	Sample No.	Time	Pb(II) Concentration (ppm)
1	SB2RSPb3	30 min	0.00533
2	SB2RSPb6	60 min	0.000
3	SB2RSPb9	90 min	0.00264
4	SB2AVPb3	30 min	0.00464
5	SB2AVPb6	60 min	0.00
6	SB2AVPb9	90 min	0.00
7	SB7AVPb3	30 min	0.00202
8	SB7AVPb6	60 min	0.00134
9	SB7AVPb9	90 min	0.00227
10	SB7RSPb3	30 min	0.00621
11	SB7RSPb6	60 min	0.00504
12	SB7RSPb9	90 min	0.00

4. Conclusions

Barmer and Rajmahal hill Bentonite both after modification with sapindus mukorossi (reetha) and aloevera emerged as an eco-friendly, green sustainable method for removal of hazardous metal such as Pb (II) from aqueous medium.

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