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Research Article

Adsorption of Cr(VI) and Arsenic onto Bentonite

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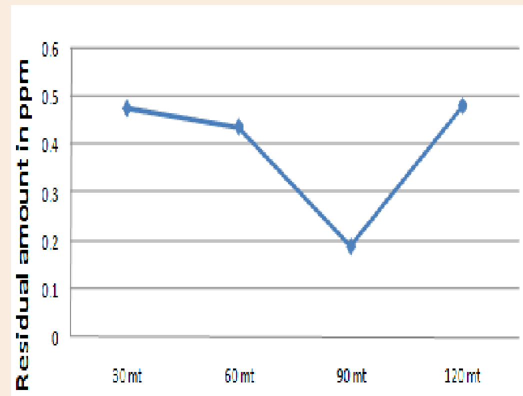
Abstract

Bentonite is hydrated alumina-silicate clay composed of the smectite class mineral Mont morillonite. The negative charge of the clays is balanced by exchangeable cations eg Na+, Ca2+. The percentage of silica varied from 35.60% to 47.52% and percentage of alumina varied from 26.90% to 32.94%. Though many adsorbents eg fly ash, coal, activated slag and agricultural wastes have been tried, Montmorillonite has been found to be a good adsorbent for heavy metals.

The kinetics of adsorbance of hexavalent Chromium and Arsenic have been studied with different intervals of time and different grades of Bentonites of Rajmahal Hills of Jharkhand. The bentonites collected from different places were treated with benzidine giving blue color which indicated the presence of Montmorillonite. It is crystal clear that maximum removal of Cr(vi) takes place at 120 mt. It has been found that first order kinetics is followed in the case of adsorption of Cr(vi) and As(III) by bentonites. Removal of heavy metals takes place up to a certain period after that some release is also taking place. The removal of heavy metals depends on the surface area and ion exchange capacity.

The usefulness of bentonite minerals is a result of high chemical and mechanical stabilities and a variety of surface and structural properties.



Keywords: Montmorillonite, Smectite, Hexavalent Chromium

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Introduction

The occurrence of arsenic and heavy metal in natural ground water has become a common phenomenon in the Gangetic plain[1-3]. This occurs due to mineral arseno pyrite which is associated with sedimentary rocks and weathered rocks. Hexavalent chromium is one of the major water pollutants causing serious ecological problem[4].

Industrial wastes contain chromium in the hexavalent form as chromate and dichromate. The use of Cr(vi) in chrome plating, aluminium anodizing, wood preservatives, ceramics, inorganic pigments are the cause of major concern for the environmentalists[5] . The permissible limit for arsenic and hexavalent Chromium is 0.05 ppm.

The methods of removal of arsenic and hexavalent chromium in water are coagulation, precipitation, ion exchange and adsorption. Adsorbents used are flyash, coal, activated alumina, and agricultural wastes[6-8] . Among the clays, bentonite is an eco- friendly method and low cost adsorbent for the removal of Arsenic and hexavalent Chromium. It is hydrated alumina-silicate clay composed of the smectite-class mineral Montmorillonite[9-11] . The negative charge of clays is balanced by exchangeable cations e.g Na^+ and Ca^{2}+ [12-13]. The adsorption capacity of Montmorillonite can be due to their high specific area, high chemical and mechanical stabilities. The study done in the laboratory is to exploit locally available low cost bentonite for the removal of arsenic and hexavalent chromium[14]. Bentonite mainly consists of alumina, silica and iron oxide. The ratio of (Al_2O_3/SiO_2) is 1/6, calcium as major constituents along with traces of Na, K, Fe, Mg Oxides in the form of impurities.

The method of chemical precipitation is also one of the techniques but capital cost is considerably high. Ion exchange is less costly in terms of both capital and operating expenditure. Activated alumina has proven to be a good adsorbent but release of free Al in water is dangerous to health[15]. Keeping these things in mind, bentonite minerals of Rajmahal Hills of Jharkhand has proved to be a better option of removal of Cr(vi) and Arsenic .

Experimental

The bentonite samples are dried and washed. The Montmorillonite unit gives blue coloration with benzidine solution. The powdered sample up to 300 mesh sieve is dried up to 100^{o}C in an oven. 50ml 2ppm solution of Cr(vi) is prepared by dissolving 5.73mg $K_2Cr_20_7$ in 1 liter water. 500mg of different samples of bentonite is mixed with 50ml 2 ppm Cr(vi) and allowed to stand up to 30mt, 60mt and 120 mt respectively. Varying masses of bentonite samples were taken up to a certain interval of time. The residual Cr(vi) was measured by UV double beam spectrophotometer pharo300. 2 ppm solution of Arsenic was prepared by weighing sodium arsenite and dissolving in water. Bentonite was mixed with 50ml 2ppm As(III) solution up to different interval of time. The Arsenic content was measured by AAS element AS AAS 4141M.

Results and Discussion

The residual amount of Cr(vi) showed a declining trend with different intervals of time while studying the removal of chromium (vi) from synthetic samples. It is clear from Table 1,2,3,4 and 5 that removal is taking place but in some cases release of Cr(vi) also takes place. The effect of adsorbent dosage also takes place on the removal of Cr(vi) from the synthetic sample. It is crystal clear that maximum removal of Cr(vi) takes place at 120 mt. Sample RHB_5 is not effective for removal of Cr(vi). It has been found that first order kinetic is followed in the case of adsorption of Cr(vi) by bentonites. The most widely used model of adsorption is Freundlich model which gives a linear equation.

In the case of Arsenic (III) solution similar bentonite was used as adsorbent. It was collected from different sites of Rajmahal Hills e.g Bakudih Railway Station, Mandali Mirjachowki, Amda pada, Madro Fossil Park and Deoghar (Sarath), all from Jharkhand state of India.

RHB_1 – Bakudih railway station bentonite sample.
RHB_3 – Bentonite Sample of Tarapaher, Mandro of Rajmahal Hills.
RHB_5 – Bentonite Sample of Sahibganj behind J.N.Vidalya Stadium.
RHB_6 – Bentonite Sample of Amdapada Dumka
RHB_9 – Bentonite sample of Deoghar (Sarath)

The Percentage of Silica varied from 35.60% to 47.52% in all the samples and percentage of alumina varied from 32.94% to 26.90%.

The adsorption of As(III) solution takes place by bentonite samples (RHB_3 and RHB_6). Table 6 and 7 clearly indicates the removal of As (III) during different intervals of time showing linearity e.g first order kinetics. But As(III) decreases up to 90mt and after 120mt the residual arsenic (III) increases showing that the release of arsenic (III) has taken place clear from Table6. The effect of adsorbent dosage with 1 gm and 1.5 g of RHB_6 bentonite has also been studied. The adsorption study has also been taken with RHB_3 Sample of bentonite shown in Table 7. Thus the present study indicates that bentonite mineral of Rajmahal Hills is a ecofriendly good adsorbent with suitable adsorptive capacity. Due to its low cost and abundance, these bentonites can be exploited for removal of Cr(vi) and As (III).

Table 1 Effect of contact time on adsorption by bentonite

Bentonite Sample	**50 ml 2 ppm Cr(vi) +0.5g RHB_1**	**Time**	**Residual amount in ppm**
RHB_1	"	30 mt	1.80
	"	60 mt	1.43
	"	90mt	1.40
RHB_1	50ml 2ppm Cr(vi)+ 1 gm RHB_1	60mt	1.40

Table 2 Effect of contact time on adsorption by bentonite

Bentonite Sample	**50 ml 2 ppm Cr(vi) +0.5g RHB_3**	**Time**	**Residual amount in ppm**
RHB_3		30 mt	1.90
	"	60 mt	1.86
	"	90mt	1.84
	"	120mt	0.07

Table 3 Effect of contact time on adsorption by bentonite

Bentonite Sample	**50 ml 2 ppm Cr(vi) +0.5g RHB_6**	**Time**	**Residual amount in ppm**
RHB_6		30 mt	1.86
	"	60 mt	1.26
	"	90mt	1.82
	"	120mt	1.68

Table 4 Effect of contact time on adsorption

Bentonite Sample	**50 ml 2 ppm Cr(vi) +0.5g RHB_5**	**Time**	**Residual amount in ppm**
		30 mt	1.90
RHB_5	"	60 mt	1.86
	"	90mt	1.84
	"	120mt	0.07

Table 5 Effect of contact time on adsorption by bentonite

Bentonite Sample	**50 ml 2 ppm Cr(vi) +0.5g RHB_9**	**Time**	**Residual amount in ppm**
		30 mt	1.88
RHB_9	"	60 mt	1.87
	"	90mt	1.85
	"	120mt	0.08

Table 6 Effect of contact time on adsorption of As(III) by bentonite

Bentonite Sample	**50 ml 2 ppm Sodium arsenite +0.5g RHB_6**	**Time**	**Residual amount in ppm**
		30 mt	0.475
	"	60 mt	0.437
	"	90mt	0.189
RHB_6	"	120mt	0.480
	50ml 2 ppm sodium arsenite + 1g RHB6	60mt	0.225
	50ml 2 ppm sodium arsenite + 1.5g RHB6	60mt	0.266

Table 7 Effect of contact time on adsorption of As(III) by bentonite

RHB_1	**50 ml 2 ppm sodium arsenite +0.5g RHB_3**	**Time**	**Residual amount in ppm**
		30 mt	0.249
RHB_3	"	60 mt	0.254
	"	90mt	0.256
	"	120mt	0.318

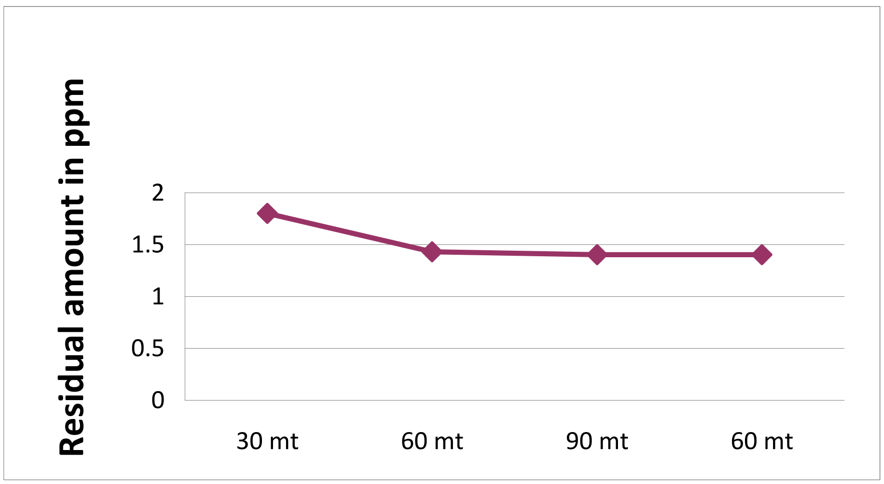

Figure 1 Effect of contact time on adsorption of bentonite 50ml 2ppm Cr(VI)+0.5g RHB_1

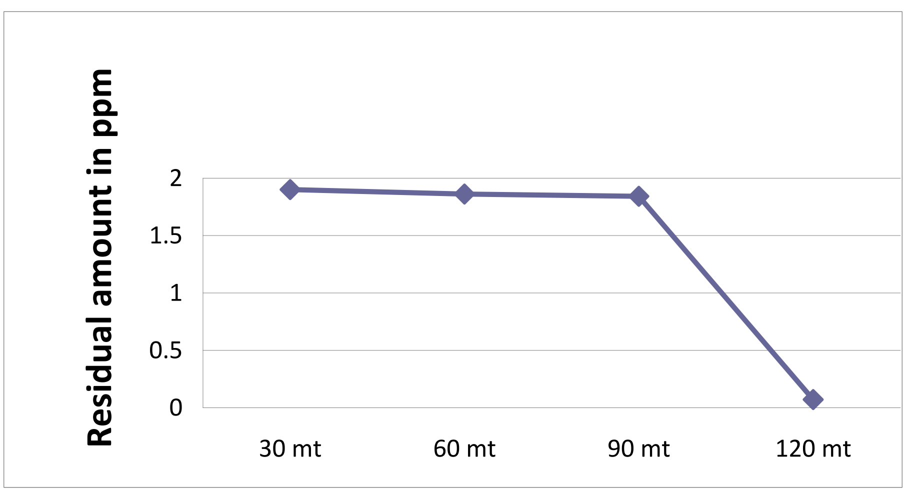

Figure 2 Effect of contact time on adsorption of Cr(VI) by bentonite 50ml 2ppm Cr(VI) + 0.5g RHB_3

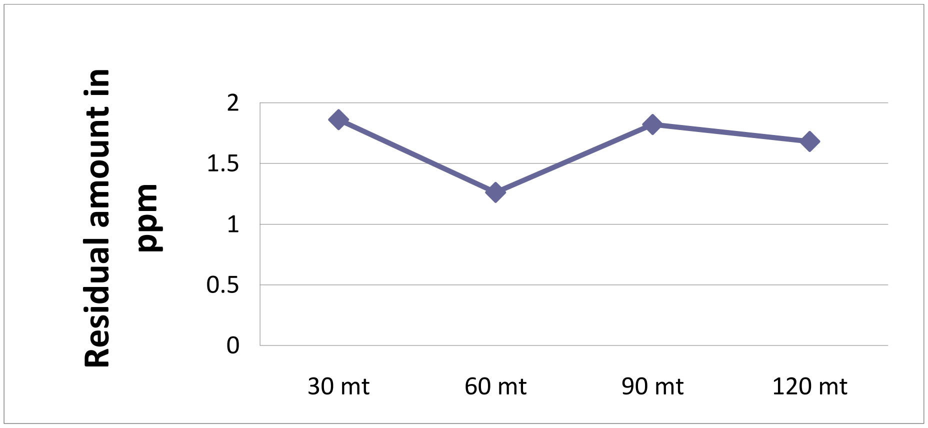

Figure 3 Effect of contact time on adsorption of Cr(VI) by bentonite 50ml 2ppm Cr(VI) + 0.5g RHB_6

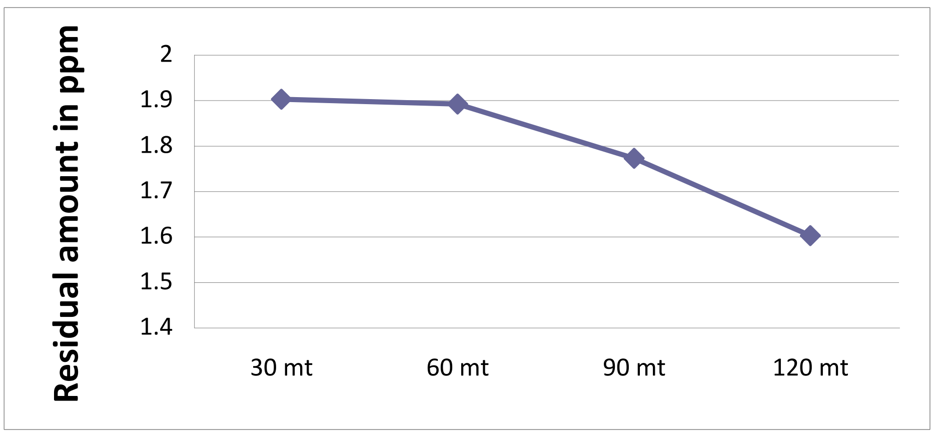

Figure 4 Effect of contact time on adsorption of Cr(VI) by bentonite 50ml 2ppm Cr(VI)+ 0.5g RHB_5

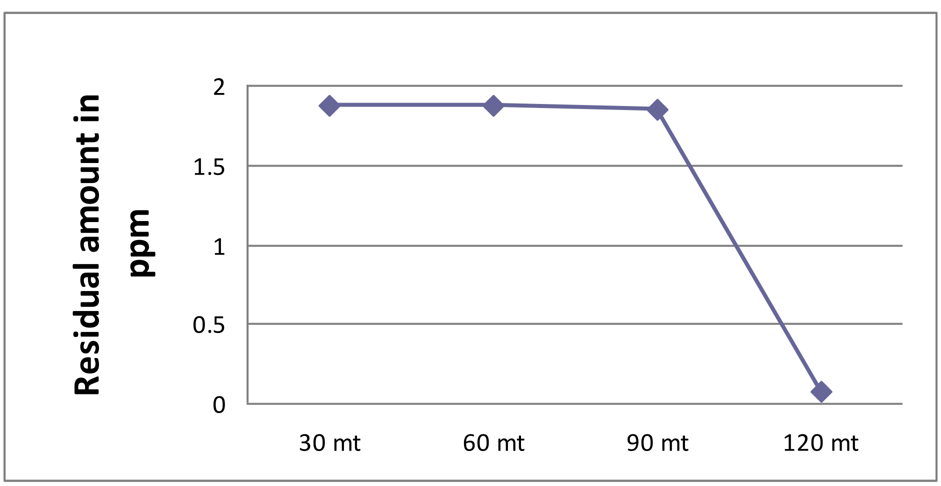

Figure 5 Effect of contact time on adsorption of Cr(VI) by bentonite 50ml 2ppm Cr(VI) + 0.5g RHB_9

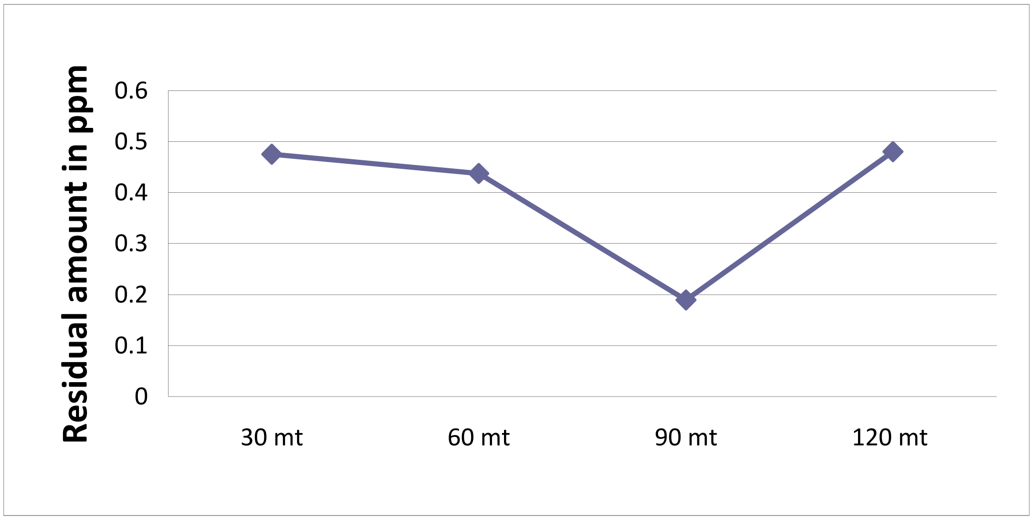

Figure 6 Effect of contact time on adsorption of As(III) by bentonite 50ml 2ppm As(III) + 0.5g RHB_6

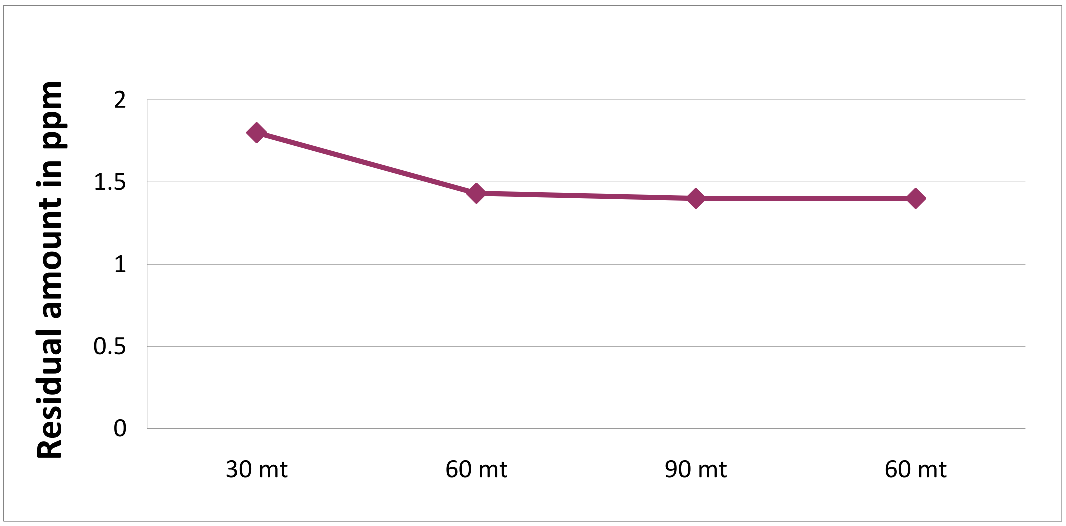

Figure 7 Effect of contact time on adsorption of As(III) by bentonite 50ml 2ppm As(III) + 0.5g RHB_3

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