DEVELOPMENT OF A SIMPLE TECHNOLOGY TO REMOVE ARSENIC IN GROUND WATER BASED ON USING "LATERITE"-ADSORBENT, A COMMON NATURAL IRON ORE IN VIETNAM

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ABSTRACT

Laterite is a natural iron ore being quote highly abundant distributed in Vietnam. Many authors affirmed the adsorption ability of iron oxide and iron hydroxide but there was no serious investigation of limonite-one of natural iron oxide species. So that limonite was subject of our research.

To carry out the research, the laterite was firstly ground and sieved to particles of size 0.1-1.0 mm. Then they were pretreated in oven at 500, 600, 700 and 800^{0}C in order to remove humidity and vapor components. X-rays analyzed results showed that the iron oxohydroxide and α-Fe_2O_3 compositions were not changed even heating at 800^{0}C. But composition of $Fe_2O_3.H_2O$ was almost disappeared at upper than 600^{0}C. All kind of pretreated limonite samples were tested their arsenic adsorption ability and untreated samples, dried at 150°C, were chosen for following investigations, because of its highest adsorption ability. The determination of langmur adsorption isothermal showed that the adsorption capacity of Laterite was approximately 900 mg/kg for As(V) and 500 mg/kg for As(III) in equilibrated arsenic concentration of solution of less than 1000 ppb.

Full adsorbed sorbent can be regenerated by sodium hydroxide solution.

Key words: adsorption ability, arsenic adsorption, laterite.

Introduction

Nowadays, with the development of society, people's demands of foodstuff safety and sanitariness are of increasingly interest. The use of clean water in living became urgent issues. In recent years, heavy metals contaminated water in Vietnam (especially arsenic contamination) is the major concern. Many research projects, publications showed that arsenic contamination level is much higher than WHO permitted standard 10 μg/l.

There are many methods which can be applied for arsenic removal in water. However, after referring some documents of iron oxide and iron hydroxide adsorption ability, we chose limonite, a commonly distributed ore in Vietnam, as researched and applied subject. This ore contains mainly Fe_2O_3 and iron hydroxide.

Table 1. Laterite component (Thach That - Ha Tay)

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Σ S	K_2O
%	40,69	14,38	32,14	0,14	0,18	1,94	0,33

Results and discussion

To carry out the investigation, ore was firstly separated to small pieces, dried by exposure in the atmosphere and ground to particles of size 0.2÷1 mm (sample D1). Sample D2 is prepared as following:

Ore is ground and mixed thoroughly with water, dried and took particles of size 0.2÷1 mm. In the preliminary research, we concentrated on investigation of arsenic adsorption ability in fixed conditions. The results showed that Laterite, untreated by heat and mixed with water, has the highest adsorption ability. However, As(III) and As(V) capacities are different. The results are shown in following table:

Table 2. Arsenic(III) and Arsenic (V) after adsorption

Sample	As (III) Conc. after adsorption (ppb)	% As(III) adsorbed	As (V) Conc. after adsorption (ppb)	% As(V) adsorbed
D_1-CN	104,821	79,04	1,3117	99,70
D_1-500	209,487	58,10	24,1032	95,18
D_1-700	212,775	57,45	52,4057	89,52
D_1-900	288,107	42,38	199,1275	60,18
D_2-CN	105,752	78,85	28,1028	94,38
D_2-500	204,332	59,13	28,4249	94,32
D_2-700	250,550	49,89	46,1616	90,76
D_2-900	320,764	35,85	238,910	52,22

To clarify above issue, we investigated specific adsorption curve of As(III) and As(V). The results are shown in following table.

Table 3. Interested parameter in Arsenic(V) adsorption

A_s^{5+}			
Influent Conc. (ppb)	Equilibrium Conc. (ppb)	Content (g/kg)	Coefficient b
1000	2,6377	0,0100	$4,32685.10^{-3}$
2000	5,1530	0,0199	$4,45784. 10^{-3}$
5000	12,7347	0,0499	$4,68543. 10^{-3}$
10.000	20,1297	0,0997	$6,30449. 10^{-3}$
20.000	33,2481	0,1997	$8,74925. 10^{-3}$
50.000	314,6523	0,4969	$4,05652. 10^{-3}$
100.000	11376,495	0,8862	Aver = $5,43006. 10^{-3}$

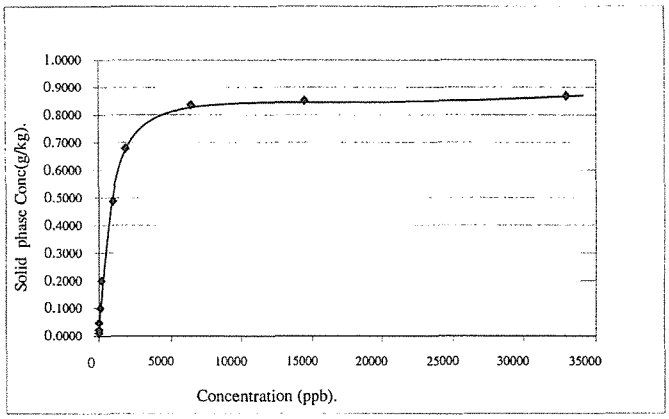

Fig 1. As(V) isothermal adsorption curve

Table 4. Interested parameter in Arsenic(III) adsorption

A_s^{3+}			
Influent Conc. (ppb)	Equilibrium Conc. (ppb)	Content (g/kg)	Coefficient b
1000	58,28	0,0094	$3,2663.10^{-4}$
2000	96,54	0,0190	$4,0713.\ 10^{-4}$
5000	302,16	0,0470	$3,4095.\ 10^{-4}$
10.000	776,32	0,0923	$2,8935.\ 10^{-4}$
20.000	1763,28	0,1823	$3,2250.\ 10^{-4}$
50.000	9906,89	0,4009	$3,9573.\ 10^{-}$
100.000	49678,891	0,5032	Aver = $3,4705.\ 10^{-4}$

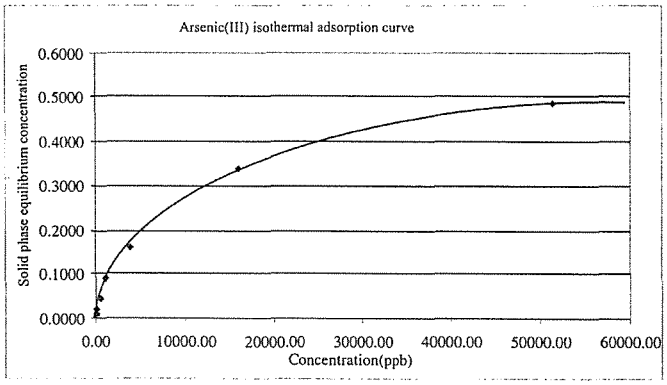

Fig 2. As(III) isothermal adsorption curve

By comparison of two graph, we can realize the difference in slope and adsorption capacity. It proved that arsenic(V) adsorption ability of laterite are much better than that of arsenic(III). Adsorption capacities are 900μg/g and 500μg/g for As(V) and As(III) respectively.

By above researches, we realized that arsenic adsorption velocity is relatively high and from obtained results we carried out the research on mobile-adsorption ability in laterite column. Mobile-adsorption ability is investigated in 0.76 cm^2-section glass column and 5 g laterite is packed in column with initial arsenic concentration in mobile-phase is 500 ppb. Tested mobile-phase velocity is 1ml/min.cm^2. Adsorption curves of As(V) and As(III) are showed in following figures.

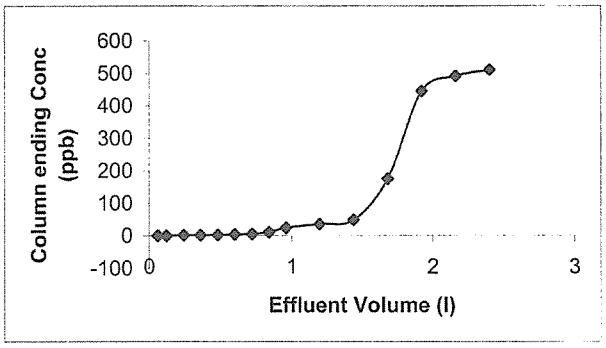

Fig 3. Relation between effluent arsenic(V) concentration and solution volume through column with flow velocity 1 ml/min.

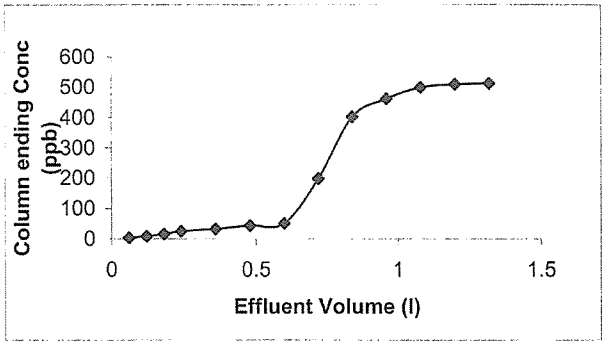

Fig 4. Relation between effluent arsenic(III) concentration and solution volume through column with flow velocity of 1 ml/min.

In theory, with ideal adsorption, when concentration of solid-phase equilibrate with that of liquid-phase in solution which is 500 ppb, the effluent concentration must be 500 ppb. The volume go through column is 6.4 liters according to following expression:

$$C_r = \frac{bC}{1+bC}.C_{r_o}$$

However, in actual experiment, when effluent concentration is approximate to that of influent, the volume of go through solution is only approximate 2.4 liters. The difference is due to solution did not go through column when the channel flow. On the other hand, it is very difficult to reach equilibrium in mobile adsorption condition.

To research adsorbent reproduction ability, we carried out washing with NaOH solution with different concentration between 0.05 and 0.2 M. The results are shown in following table.

Table 5. Reproduction efficiency by NaOH

NaOH Conc.	No.	Influent Conc. (ppb)	Effluent Conc. (ppb)	Detained amount (mg)
0,05 M	0	500	247, 735	0,6307
	1	500	356,423	0,3589
	2	500	401,725	0,2457
	3	500	420,654	0,1984
	4	500	426,150	0,0946
0,1 M	0	500	205,246	0,7369
	1	500	240,334	0,6492
	2	500	361,135	0,3472
	3	500	385,112	0,2872
	4	500	415,648	0,2109
0,15 M	0	500	169,142	0,8272
	1	500	195,261	0,7619
	2	500	234,336	0,6642
	3	500	271,124	0,5722
	4	500	289,516	0,5262
0,2 M	0	500	130,420	0,9240
	1	500	174,893	0,8128
	2	500	205,027	0,7374
	3	500	240,168	0,6496
	4	500	231,135	0,6722

It is clear that in every experiment, detained arsenic of first adsorption is highest, the adsorption ability decreased in following turn. For NaOH 0.05M and 0.10M, adsorption efficiency significantly decreased. Thus, NaOH 0.15M can be applied for column reproduction.

Conclusions

Through researches and investigations in order to contribute to solutions of complete arsenic removal in domestic water, we can conclude that laterite is a commonly distributed ore in Vietnam and arsenic adsorption

ability of this ore is relatively high. After adsorption process we conducted the investigation of effluent solution and other elements beside influent elements are not detectable. It demonstrated that adsorbent did not bring about secondary contamination. This is a new research orientation which must be perfected and applied in reality.

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