EFFICIENCY OF UPFLOW WATER SYSTEM IN THE IRON REMOVAL FROM AQUEOUS SOLUTION

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Abstract— In some areas of Thailand, groundwater was color which was due to a compound of iron contamination. The domestic consumer complains of the brownish color which iron imparts to laundered goods.This article investigate the synthetic calcium hydroxy apatite, the system design of iron removal from water, and the removal of iron from water with calcium hydroxy apatite. The Fe^{2+} average concentration of 4.96 mg/L was prepared for the experiment. Iron removal system was consisted of glass column (diameter of 1.75 cm, height of 40 cm) and connected with plastic tube (diameter of 6.1 cm, height of 40.5 cm) in vertical plane. The 10 g of calcium hydroxyapatite was filled into the glass column. The direction of water was moved from the tip of glass column and up flow to plastic tube on the top. The average flow rate of the water was 0.40 mL/s. The treatment was continuous flow of 20 L/day. The experiment was stopped when the system was performed below 50 percent removal, and it was stopped at the water volume flow reached 48 L. It was found that the maximum efficiency of the treatment of Fe^{2+} removal up to 98.39 percent, the minimum efficiency was 46.98 percent, and the average efficiency was 85.18 percent. The Fe^{2+} was removed at 20.28 mg/g of calcium hydroxyapatite. Iron removal system had the ability to remove Fe^{2+} in the water efficiently. The results of this researchcan be applied to solve problems in the community that was affected by groundwater contaminated with iron.

Index Terms— Upflow Water System, Iron Removal, Hydroxyapatite, Chemistry.

I. INTRODUCTION

Problems found in the water comes from groundwater was the water color which was due to a compound of iron contamination. When the Fe^{2+} in water exposed to air, it was oxidized by oxygen to form insoluble substances and were the cause of water turbidity and color. The domestic consumer complains of the brownish color which iron imparts to laundered goods. Iron appreciably affects the taste of beverages. The taste of iron may be readily detected at concentration of 1-2 mg/L. It also raises questions about bacteria, because the growth of iron bacteria was fast, so drinking water standards of the U.S. Public Health Service, thus requiring less iron than 0.3 mg/L [1].By eating too much iron, it can develop a condition called hemochromatosis in the body. Iron can be toxic for your body when consumed in excess. It can contaminate your body organs, leading to organ failure. In hemochromatosis, iron can accumulate in your heart, pancreas and liver. Buildupof iron in the liver can cause liver cancer, cirrhosis, liver failure or an enlarged liver. Cirrhosis means scarring of the liver, which causes poor liver function. It can develop diabetes from iron overload in your pancreas. Accumulation of iron in your heart can cause heart failure and random heartbeats called arrhythmias. If left untreated, hemochromatosis may cause death [2].In Thailand, ground water was applied directly to the consumer without a prior analysis and treatment of the iron before used in many areas of the country, when drinking it too much, it can accumulate in some organs, and cause ofhemochromatosis in the body, so it should be concerned consumer health in many areas. Current research has led to the calcium hydroxy apatite used in various branches of sciences. Calcium hydroxy apatite crystal structure was hexagonal, it was suitable for use as a sorbent because there was a large surface area, and was a good ability to exchange ions, such as Chromium [3],Lead, Copper, Cadmium [4], Copper, and Zinc [5]. However, there were not study in the adoption of the iron removal from groundwater. Therefore, the removal of iron from the water supply comes from groundwater with calcium hydroxy apatite was something that should be studied as well. This article investigate the synthetic calcium hydroxy apatite, the system design of iron removal from water, and the removal of iron from water with calcium hydroxy apatite.

II. DETAILS EXPERIMENTAL

A. Synthetic Calcium hydroxy apatite

Synthetic calcium hydroxy apatite using wet chemical precipitation as follows, drop 1 L of 0.6 M H_3PO_4 into 1 L of 1 M $Ca(OH)_2$, along with the all the time stirring, and constant drop rate of 500 mL/h at room temperature.White substance was obtained, and it had led to the oven at 100 ^{O}C for 24 h, then it had led tothe furnace at 800 ^{O}C for 3 h. The white substance was ground to a fine powder, then sizing by sieve size 70 mesh (0.210 mm). The white power was obtained, and it was analysis by Fourier Transform Infrared Spectrometer, and X-rays Diffraction (XRD) Spectrometer.

B. Prepare a Solution of Iron (Fe^{2+})

The 10 mL of conc.H_2SO_4 was filled into 25 mL of distilled water, the acid solution was obtained, then 3.511 g of $Fe(NH_4)_2(SO_4)_2.6H_2O$was dissolved into this solution. The iron solution was obtained, then 0.1 M $KMnO_4$ was filled to drop by drop until this solution

was red, and adjust the volume with distilled water to a 500 mL. It was obtained a stock solution of iron (Fe^{2+}) concentration of 1000 mg/L.

C. Upflow Iron Removal System

Iron removal system was shown in Fig. 1. It was consisted of glass column (diameter of 1.75 cm, height of 40 cm) and connected with plastic tube (diameter of 6.1 cm, height of 40.5 cm) in vertical plane. The 10 g of calcium hydroxyapatite was filled into the glass column. The direction of water was moved from the tip of glass column and upflow to plastic tube on the top.The flow rate of the water was 0.35-0.45 mL/s. The treatment was continuous flow of 20 L/day. The water out of the system were triplicate analyzed for pH and iron (Fe^{2+}). The experiment was stopped when the system was performed below 50 percent removal.

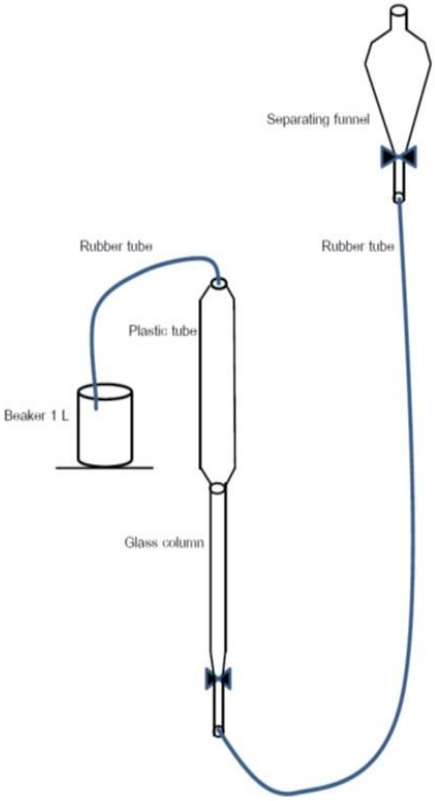


Fig.1. Upflow Iron Removal System

D. Analysis of Iron (Fe^{2+})

Iron analyst with Adaptation of the EPA Phenanthroline Method 315 B.

III. RESULTS AND DISCUSSION

A. Synthetic Calcium hydroxy apatite

FT-IR Spectrum of calcium hydroxy apatite are synthesized as shown in Fig. 2. It was found peak of OH stretching at about 3571 cm^{-1}, showed peak of PO asymmetric stretching at around 1035-1091 cm^{-1}, found peak of PO symmetric stretching at around 962 cm^{-1}, and found peak of PO bending at approximately 566-632 cm^{-1}.

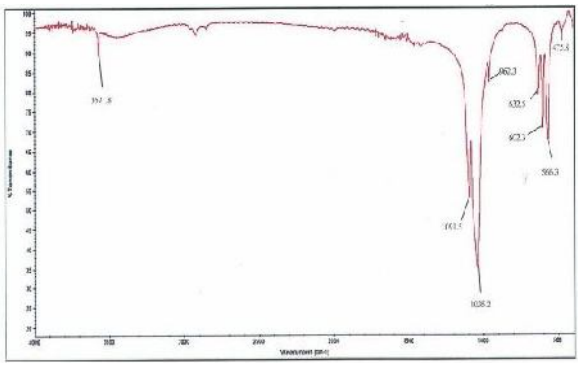


Fig. 2FT-IR Spectrum of Calcium hydroxy apatite

XRD Spectrum of calcium hydroxy apatite as shown in Fig. 3. Record the spectrum with 2θ, from 20 degrees to 70 degrees, when compared to JCPDScard 9-432 HAP it was found a matching pattern. Besides, it was found spectrum of tri-calcium phosphate present in it, due to the high calcination temperature to 800 ^{O}C, calcium hydroxy apatite partial decomposition of tri-calcium phosphate.

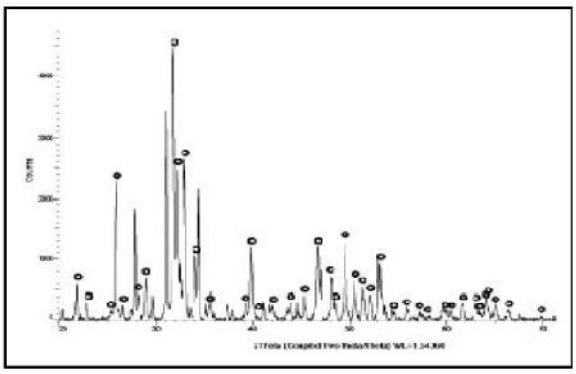


Fig.3. XRD Spectrum of Calcium hydroxy apatite

B. Solution of Iron (Fe^{2+})

Pipette 5 mL of stock solution, and then adjusted to a 1 L with distilled water. The solution was triplicate analyzed of iron (Fe^{2+}) concentration. It was found that 4.94 4.98, and 4.96 mg/L,respectively, and was equal to the averageof 4.96 ± 0.02 mg/L.The average pH of the iron solution was 2.70.

C. Upflow Iron Removal System

Fill in the solution of iron into the separating funnel.The flow rate of the water was adjusted to0.35-0.45 mL/s.It was obtained an average flow rate of 0.40 mL/s.The velocity of the water in the glass column was 0.21-0.29 cm/s.It was obtained an average velocity of 0.25 cm/s.The pH of the system before the experiment was 7.50.

D. Iron Removal

The pH of the water flowing into the system was average of 2.70. The iron content of the water flowing into the system was average of 4.96 mg/L. The system work continuously 20 L/day. Water sample was collected and analyzed every 1 L. Iron removal was given in Table 1.

Table1. Iron Removal

Day	Flow out of Fe^{2+} concentration (mg/L) ± SD	Removal efficiency (%)	Volume of water flow in(L)	pH of water flow out
1	0.61±.01	87.70	1	5.8
	0.70±.02	85.89	2	5.5
	0.59±.01	88.10	3	5.1
	0.71±.01	85.69	4	4.9
	0.49±.02	90.12	5	4.8
	0.53±.01	89.31	6	4.8
	0.41±.01	91.73	7	4.7
	0.35±.02	92.94	8	4.7
	0.31±.04	93.75	9	4.6
	0.37±.01	92.54	10	4.6
	0.41±.01	91.73	11	4.6
	0.51±.01	89.72	12	4.5
	0.35±.03	92.94	13	4.5
	0.18±.00	96.37	14	4.5
	0.18±.02	96.37	15	4.4
	0.16±.02	96.77	16	4.4
	0.19±.01	96.17	17	4.3
	0.19±.01	96.17	18	4.1
	0.20±.02	95.97	19	4.1
	0.20±.02	95.97	20	4.0
		average 92.30		
2	0.08±.01	98.39	21	4.1
	0.41±.01	91.73	22	4.0
	0.45±.01	90.93	23	4.0
	0.67±.02	86.49	24	4.0
	0.38±.02	92.34	25	3.9
	0.43±.01	91.33	26	3.9
	0.47±.05	90.52	27	3.8
	0.82±.01	83.47	28	3.8
	1.56±.01	68.55	29	3.7
	1.56±.02	68.55	30	3.6
	1.39±.01	71.98	31	3.6
	1.37±.01	72.38	32	3.5
	1.28±.02	74.19	33	3.4
	1.08±.02	78.23	34	3.4
	0.88±.02	82.26	35	3.3
	0.91±.01	81.65	36	3.2
	0.78±.02	84.27	37	3.2
	0.62±.02	87.50	38	3.1
	0.57±.03	88.51	39	3.0
	0.71±.01	85.69	40	3.0
		average83.45		
3	0.43±.03	91.33	41	2.9
	0.89±.02	82.06	42	2.9
	1.12±.02	77.42	43	2.9
	1.43±.06	71.17	44	2.8
	1.42±.02	71.37	45	2.8
	1.40±.02	71.77	46	2.8
	1.91±.05	61.49	47	2.7
	2.63±.02	46.98	48	2.7
		average 71.10		

From the data in Table 1, it was found that on the first day the system was effective in removing iron has averaged 92.30 percent. On the second day the system was effective in removing iron has averaged 83.45 percent, and on the third day the system was effective in removing iron has averaged 71.10 percent. When water flows through the system 48 L. The system efficiency was lower than 50 percent. The removal efficiency of 46.98 percent iron on the third day. The pH of the water flowing out of the system is reduced from 5.8 to 2.70.Overview of the iron removal efficiencyas shown in Fig. 4. Changing the pH of the water flowing out of the system as shown in Figure 5.

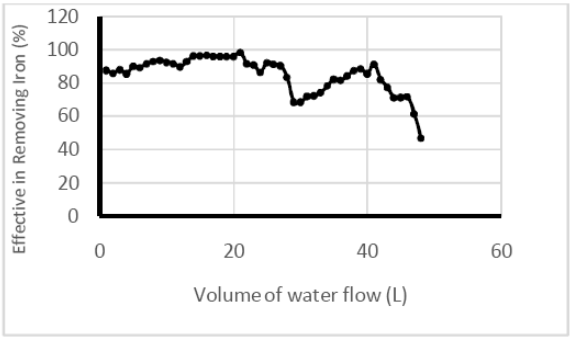


Fig.4 Effective in Removing Iron

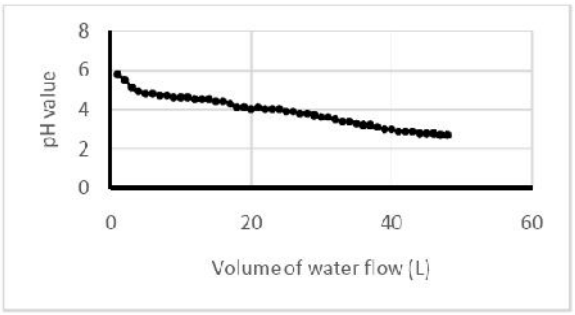


Fig.5 changing the pH of the Water Flowing out of the System

When water flows into the system, including 48 L.The amount of iron was flow into a system of 238.08 mg.By measuring the amount of iron that flows out of the system, it was found that all flow amount equal to 35.29 mg. So the amount of iron adsorbed by the system was equal to 202.79 mg.When calculated per gram of calcium hydroxy apatite absorbs iron was 20.28 mg.

CONCLUSIONS

The flow rate of the water was adjusted to 0.35-0.45 mL/s, and it was obtained an average flow rate of 0.40 mL/s.The velocity of the water in the glass column was 0.21-0.29 cm/s, and it was obtained an average velocity of 0.25 cm/s. This velocity was a reasonable speed made calcium hydroxy apatite was in a fluid condition (fluidized bed) within a glass column, and it was not flow out of the system.Calcium hydroxy apatite crystal structure was hexagonal [6], it was suitable for use as a sorbent because there was a large surface area, and was a good ability to exchange ions. It was appropriate to be used as a remove contaminant such as iron in the water. The Fe^{2+} average concentration of 4.96 mg/L was prepared for the experiment. The 10 g of calcium hydroxyapatite was filled into the glass column. The treatment was continuous flow of 20 L/day. When water flows through the system 48 L, the system efficiency was lower than 50 percent, the removal efficiency of 46.98 percent iron on the third day, then the experiment was stopped. So the amount of iron adsorbed by the system

was equal to 202.79 mg.When calculated per gram of calcium hydroxy apatite absorbs iron was 20.28 mg.Iron removal system had the ability to remove Fe^{2+} in the water efficiently. The results of this researchcan be applied to solve problems in the community that was affected by groundwater contaminated with iron. The pH of the water flow into the system was low. The slightly acidic or neutral pH of the iron solution should be studied in the future. Adsorption isotherm of calcium hydroxy apatite and iron should be also studied.Expansion of the system to a larger scale to be adopted in the design for the removal of water contaminated with iron should be further study. Besides, it should be study for pollutant adsorption in wastewater, and performance comparing with activated carbon [7].

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