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THE APPLICATION OF ZEOLITE IN THICKENERS FOR OPTIMAL WATER RECOVERY AND PREVENTING ENVIRONMENTAL POLLUTION

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ABSTRACT *- Thickener is the most important device that separates water from concentrate. Outlet water from thickener overflow must comply with the standards of transparency and the level of toxins. One way to reduce the hardness of water is ion replacement. In this paper we use the zeolite powder (coagulant) in combination with materials such as bentonite powder (coagulant aid), $FeCl_3$ and poly aluminum chloride. If the settling time of particles in the deposition experiments was about an hour, this compound was recorded as appropriate case for water purification. Results showed that polyaluminum chloride had the highest efficiency in removing turbidity and low color of the water. On the other hand, pH for coagulant was less effective in reducing alkalinity. Due to cation exchange and high absorbing aqueous solution cations, such as ammonium and heavy metals, natural zeolite can be considered as an important material with low cost for water purification in a thickener. An interesting point is that the natural zeolite was not good adsorbent for organic and anionic ions. Bentonite as an adsorbent and heavier due to the high density and berry color properties and adsorption played an important role in clarifying water.*

Key words: *zeolite, thickener, concentrate, cation exchange, coagulant*

INTRODUCTION

Nowadays, the world is facing a water crisis due to lack of clean drinking water. With the rapid development of industry, large quantities of wastewater from industrial processes are produced and discharged in soil and water. Sewages usually have toxic effects on ecosystems and contain many contaminants such as oil, cationic and anionic ions and other substances that are toxic. Removing these contaminants requires a variety of affordable techniques and technologies.

At present, it is believed that the adsorption is a simple and effective method which use for water and industrial wastewater purification is successfully efficient. Activated carbon and clay minerals are widely used as an adsorbent for the adsorption of ions and organic ingredients. [1]

Introduction to the thickener

In order to produce one ton of ore, about 2 to 3 tons of water must be consumed. Much of the water recovery operations take place in the thickener. Thickeners are continuous, or discontinuous, units with relatively shallow tanks in which, under the force of gravity, clear liquid moves up while concentrated product is gathered

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down. Thickener difference with other types of sedimentation basins such classifier is that in some cases, Suspended solids in the feed pulp stick together using flocculants. [2]

Because sedimentation rate for fine particles is extremely low due to their low weight, and since the size of the thickener is inversely proportional to the sedimentation rate, it is necessary to increase the rate of sedimentation of solid particles. In practice this is possible only by increasing the particle size. So, sticking particles together can increase their sedimentation rate. Two methods of coagulation and flocculation are used in order to do this. In cases where the particles surface are electrically charged, by adding the opposite charge, uncharged particle surface and the electrostatic repulsion force disappearance of particles close and stick together under Van Der Waals Force. This process is called coagulation. But, in flocculation, by adding long chain polymer molecules to a dilute suspension solution, the connection is created between the particles. Flocks have complex forms and trap amount of liquid in themselves [3, 4]. Particles may stick by colliding with each other, and the flocculation phenomenon is formed again. Consequently, settling occurs depending on the size of the flocks that are called flocculent settling [5].

The distribution of different areas in a thickener has shown in Figure 1 [2].

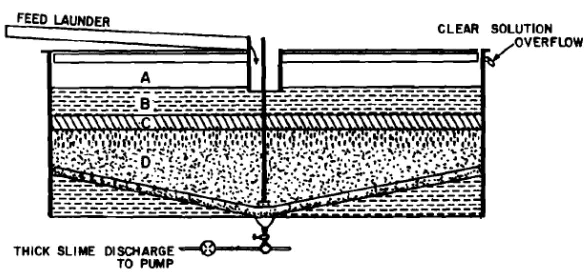

Figure 1. Different parts of an operating thickener. A: the transparent solution, B: the massive settling zone, C: the transfer zone, D: the pressure zone [2, 6]

Zeolite for the removal of heavy metals

Zeolites are natural resins with cation exchange and heavy metals removal properties. The use of zeolite includes the removal of arsenic cations, titanium, aluminum, cobalt, chromium, lead, zinc and others [7, 8].

The basic physical and chemical properties of zeolites are due to their chemical composition and crystalline structure. Alkaline and earth alkaline metals, as well as presence of numerous minerals and open spaces, have determined the various properties of zeolites. The application of zeolites in various industries is dependent on their physical and chemical properties. Some of these properties include: density, size, shape, porosity, hardness, adsorption and cation exchange (Figure 2) [9, 10].

Figure 2. Natural Zeolite [9]

Composition of waste

Waste includes approximately 99.9 percent water and about one-tenth percent of solids that part of it is the organic matter and other solid minerals to be dissolved or suspended in water. Sewer odor is often due to organic matter in it. These materials are more available for microbial decomposition, and microbial decomposition sometimes leads to the unpleasant odor [11].

Classification of waste

Waste depending on the amount of BOD (the amount of oxygen required for the oxidation of residual organic matter by bacteria) are graded. Waste which BOD is respectively 210, 350 and 600 mg per liter is called, respectively, weak, medium and strong waste. In order to prevent water pollution in many parts of the world, no residual, even after the treatment, which BOD is higher than 20 mg per liter, must not be allowed to enter surface or groundwater flows. [12, 13]

EXPERIMENTAL/MATERIALS AND METHODS

Application of Zeolite in water clarification

According to the description given in the introduction, the primary role of zeolites in water purification is due to the special properties of this material. The experiments were designed to demonstrate this.

Devices for testing

- Turbidity meter
- Chemical Oxygen Demand (COD)
- Jar test (and otherwise Spiral Magnet: in the first, the device turns on with rotation speed of 50 for 10 minutes, after that for 5 min with more rotation speed, and finally had to be in the previous status for a few minutes and then the machine turn off)
- Grade meter for heavy minerals
- Hardness
- Salinity meter
- pH gauge

Materials for testing

- Zeolite powder (as a coagulant)
- Sawdust (sawdust soaked in acid until absorb capability increased about 2-fold, this compound added to the water. If it had the toxic effects, alkali be added to neutralize the toxic effects)
- Bentonite powder (as a coagulant aid)
- Aluminum chloride (alum)
- $FeCl_3$
- Aluminum sulfate
- Polyaluminum chloride
- Aluminum sulfate (to facilitate the settling of fine particles**)**

Experiment design using zeolite and its role in water purification

But ultimately, tests to determine the best use of zeolites and other materials are as follow:

1. The used zeolite, alone with 2% after that 4% and then finally reach to 8 percent.
2. Zeolite (2%) + Bentonite (0.5%) + sawdust (0.5%)
3. Zeolite (4%) + Bentonite (1%) + sawdust (0.5%) + charcoal (0.5%)
4. Zeolites (6%) + Bentonite (2%) + sawdust (0.5%) + charcoal (0.5%) + flocculant (2 g/L)
5. Zeolite (3%) + Bentonite (1%) + $FeCl_3$ (0.5 g/ L) + poly aluminum chloride or aluminum chloride (alum) (0.5 g/ L)
6. Zeolites (6%) up to a temperature of 350 to 400 ° C is heated for several hours (anhydrous zeolite) and is powder + Bentonite (1%) + lime (1%)
7. Water is heated and poured in test cylinder (or pond) + natural zeolites (8%) + lime (1%).

Each test with its own No. will be listed in the tables of results and discussion part.

First, by using pH meter, we have determined the pH of desired water. Percentages of heavy metals, such as chromium, copper, cadmium and lead in used water, at the beginning and after each test, were determined. At each step, the effect of material addition on the water transparency was checked by turbidity meter.

With the addition of a material be recorded the number of hours for material sedimentation in water. If it took about an hour, you do not need anything else to do. If you use a large pool with a volume of 10 cubic meters and flow rate of 1 cubic meter per day, you should observe what output will have pool input (It should be noted that pool should stay about 10 hours with no addition of water and then the material or materials added to it and evaluated their impact. In other words, determine how much time is reduced sedimentation). If the pool is not available you can use cylinders of 1000 ml., so that the entire volume of materials and water into each cylinder will eventually reach 1000 ml. Occupied volume by the amount of added materials at each stage is determined and the difference of this value compared with the volume of 1000 ml was added water to the cylinder, then stirred with a stirrer and allow settling.

In each test, we determine the water hardness in ppm of calcium carbonate (mg of calcium carbonate in 1 liter of water) and the effects of the Zeolite on salinity reduction also can be characterized. Finally, the effect of natural Zeolite for reducing heavy metal pollution is also checked.

RESULTS AND DISCUSSION

Based on the obtained results it can be concluded that poly aluminum chloride coagulant at the optimum doses has better performance in removing turbidity and low color of the water. On the other hand, pH for coagulant has the lowest effect on reducing alkalinity. So in areas where surface water has a low natural alkalinity, using of this coagulant without manually increasing the amount of water alkalinity, have high efficiency in turbidity removal. According to little effect for alkalinity on the performance of the coagulant would be most likely mechanism for the removal of colloidal particles by adsorption and neutralization.

Table1. Comparison of water purification in designed experiments using zeolite

Test No.	Type of water	Time of treatment (hour)	COD (mg/lit)
4	Thickener overflow	1	78
		5	54
		10	35
		48	19
5	Urban water	1	27
		5	20
		10	10
		48	10
3	Thickener overflow	1	135
		5	58
		10	35
		48	27
2	Thickener overflow	1	82
		5	58
		10	37
		48	23
6	Thickener overflow	1	260
		5	80
		10	75
		48	75
7	Thickener overflow	1	250
		5	95
		10	72
		48	76

The results show that natural zeolite is an important material with low costs for water and wastewater purification. Due to cation exchange properties in the natural zeolites, this material is high efficient in absorbing cations, such as ammonia and heavy metals in aqueous solution (See Figure 3). If the pollution index for each metal in Table 2 were less than 1, than the sediment of special metal would be polluted. As can be seen, the addition of natural zeolite will reduce significantly heavy metal pollution.

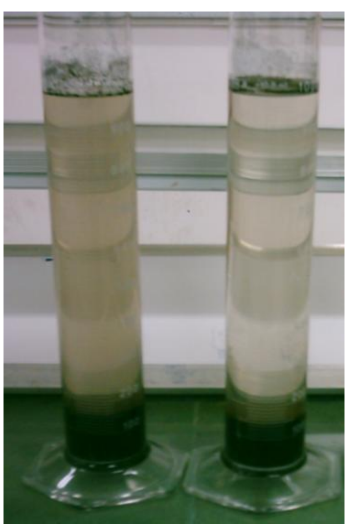

Figure 3. Zeolite effect on transparency for thickener overflow liquid in a coal washing plant after 24 hours. Zeolite is added to the cylinder on the right

The interesting point is that the natural zeolite was not a good adsorbent for anionic and organic ions. Even through the heating of natural zeolites that so-called natural zeolite without water, ability for adsorbing organic and anion ions by natural zeolite can slightly increase that this amount is low and inefficient (Test No.6 in table1).

$FeCl_3$ role was very important in urban water purification and transparency (Test No.5 in table1). This material did not have significant impact on the thickener overflow.

Table2. The pollution index of heavy metals in tailing dam sediments of a copper mine before and after adding 4 g/ l of natural zeolite in thickener water

Type of heavy metal	Pollution index of heavy metals in the first (mg/kg)	Pollution index of heavy metals after adding zeolite (mg/kg)
Co	0.87	0.68
Cu	15.30	9.91
Mo	3.54	2.77
Zn	1.79	1.4
Cr	0.798	0.65
Mn	1.17	0.92
Ni	0.33	0.31
Pb	1.49	1.16
Ti	0.76	0.65
Fe	9.21	6.98

Bentonite as an adsorbent and heavy stuff (up to 2 g) due to the high density, adsorption and bleach properties plays an important role in water transparency.

Activated carbon for the removal of residual chlorine in water, reducing and removing dissolved organic material and Radon gas removal in water were added. Aluminum sulfate was efficient in facilitating the settling of fine particles.

There were many problems for adsorbing cationic ions by natural Zeolites (Table3).

Table3. Effect of Zeolite content on COD decrease

Zeolite content (%)	Average COD concentration (mg/L)
2	257
4	209
8	263

CONCLUSION

- The polyaluminum chloride coagulant had the highest efficiency in removing turbidity and low color of the water.
- pH for coagulant was less effective in reducing alkalinity.
- The natural zeolite was not a good adsorbent for organic and anionic ions.
- $Fecl_3$ role was very important in urban water purification and transparency.
- Bentonite as an adsorbent and heavier, due to the high density and berry color properties and adsorption played an important role in clarifying water.
- Aluminum sulfate was efficient in facilitating the settling of fine particles.
- The addition of natural zeolite will reduce heavy metal pollution significantly.

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