USING A NATURAL COAGULANT FOR TREATING WASTEWATER

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ABSTRACT

One of the major sources, which wastes the environment is the wastewater produced from the human activity. At present, in order to decrease waste hazards and to restrict the resulted effects on the environment, investigators studying the possibility of using new methods and materials to treat wastewater. Coagulation and flocculation process are physical-chemical methods that widely used in the treatment of wastewater. Today, the prime concern of the environmental engineers is how to lower the coagulants and flocculants cost and to improve the characteristics of the produced sludge for safe utilizing. In this work, it is tried to use bentonitic clay as a solid natural coagulant.

The study was carried out on two types of wastewater. The first was acidic wastewater from mining characterized as water clarity from 15-20 %, COD 27-35.5 mg/l pH 2.9-4.1, SS -193-197.3 mg/l and some heavy metals; the second was oily wastewater characterized as water clarity - 22.5 %, COD-77.0 g/l, SS of 300 mg/l, and oil products of 9.0 g/l. Some chemicals were also used in this study; they were cationic type flocculants of high molecular weight with the bentonitic clay as coagulant and constant pH of 7.5 at temperature of 25 °C. The process accomplished in a number of systems by Jar test and evaluated by measuring the water clarity, COD, oil content and percent of SS removal.

The obtained results indicated that, using bentonite as a coagulant not only effective and economical but also, encapsulated toxic matters inside the crystals of bentonite and that makes it environmental permit compliance.

INTRODUCTION

As known, the sewages are produced from oil refining, water mines, petrochemical plants, organics of synthesizing plants, coke-chemical etc. contains different amounts of harmful and toxic matters. These are the major sources, which wasting our environment. The most harmfully of these sewage matters mainly in oxidizing processes, owing to degradation of water oxygen, which a one of the water contents and this lead to increasing the biochemical oxygen requirements and that can be expressed by BOD (biochemical oxygen demand) index of water or COD (chemical oxygen demand) in mg/l [1,2]. In addition, it was recognize that, treating industrial sewages and wastewater by using coagulants and flocculants at different types and dosages reduces toxic matters from these wastes [3, 4]. But the big problems are the chemicals cost and the sediments that produced from the process and its bad effects on the water resources, especially when the sediments contain high levels of toxic matters as COD, phenols, oils, heavy metals, …etc [5]. Many materials used to absorb contaminants from wastewater. Clay-based treatment products are available at a low cost, typically bentonite clay modified with various polymers and chemicals. Bentonite clay can treat oil, sulfate, phosphate, and metals and is extremely effective at removing certain cationic components from wastewater. Bentonite has a remarkable affinity for metals, particularly heavy metals in solution [6, 7, 8, 9, 10]. Bentonite is also used frequently in treating waters containing heavy color, low turbidity. In addition to its weighting action, also benefit obtained from the known ability of clays to adsorb organic compounds. Furthermore, the addition of clay to a low - turbidity water provides increase opportunity for particle collisions, resulting in rapid formation of settleable floc [5]. The resulting mass (floc) is a complex mixture of encapsulated contaminants and clay solids held together by Van der Waals and electrostatic forces. The contaminants are microencapsulated and surrounded by a barrier of clay particles making it nonreactive to external leaching [9].

A prime concern of the environmental engineer today, is how to lower the coagulants and flocculants cost and at the same time to improve the characteristics of the produced sludge to be safely utilized. To overcome this problem it was attempted to use bentonite clay in this work as a coagulant with the flocculants to treat two types of wastewater.

MATERIALS AND METHODS

Materials

The wastewater samples used in this study are characterized as shown in Table 1:

TABLE 1. Wastewater samples characteristics

Sample type	№	Characteristics					
		Water clarity (%)	COD (mg/l)	SS (mg/l)	Oil products (mg/l)	Heavy metals &Sulfates	pH
Mine wastewaters	1	15 colored	35.5	193	-	yes	2.9
	2	20 colored	27	197.5	-	yes	4.1
Oily wastewater	3	22.5 colored	77000	300	9000	yes	8.9

The chemical reagents are used with bentonite clay in this study were as follows: ferric sulfate as coagulant; cationic type-high molecular weight (Zetag32) and anionic type-high molecular weight (Praestol2515) as flocculants; H_2SO_4 and NaOH as pH modifier.

Method

The study was carried out by the Jar test standard method using a 1-liter wastewater and then its pH measured and adjusted to be around 7.5. Conditioning time for coagulants was 3 min and 30 seconds for flocculants at 350 rpm, and then 9 min for flocculation at 50 rpm and settling time – 3 min. To evaluate the results, we measured water clarity by using the standard *Colorimeter* method, COD by using *Titration* method, oil content by using *Chromatographic* method, pH by *pH-meter* and SS removal by filtration and drying method. The results and discussion are shown below.

RESULTS AND DISCUSSION

Results of the mining wastewater samples treatment

In this section, the effects of traditional coagulant with flocculant on the mining wastewater treatment were investigated and the results compared with that produced from the studying of bentonite as a coagulant in conjunction with the same flocculant. The obtained results from the application on both types of wastewater are shown in Figures 1, 2, 3 and 4 below.

Figure 1 illustrates the obtained results from the treatment of the first mine-wastewater sample. The figure specifies the effects of varying the dosages of ferric sulfate alone and the effects of cationic type, high molecular weight flocculant (Zetag32) with 5 mg/l ferric sulfate or with 0.1 g/l bentonite at pH around 7.5 and temperature 25 °C.

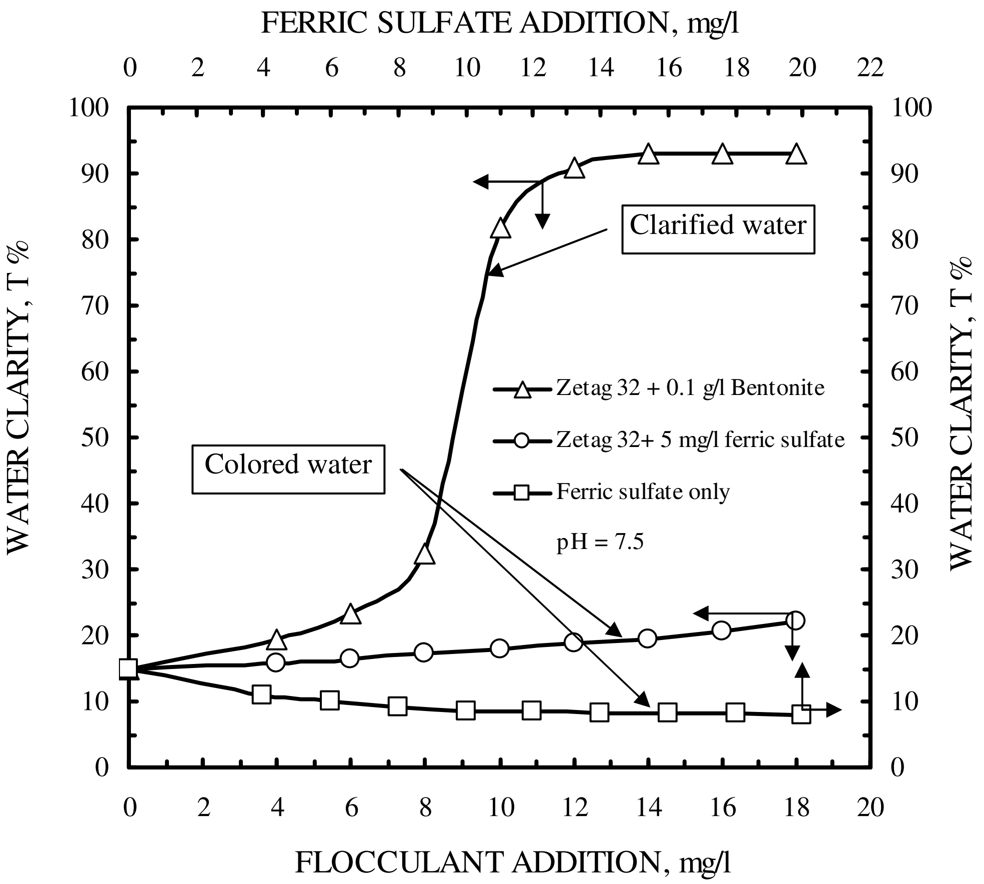

FIGURE 1. The effects of flocculant (Zetag32) with a traditional coagulant, and with bentonite as a coagulant on treatment of the first mine-wastewater sample.

These results show that, using ferric sulfate alone reveals a reverse effect on the clarity of water, where it decreases dramatically by increasing the dosages of ferric sulfate. These decreases may be due to the presence of positive ions of Fe in wastewater (227.38 mg/l) and others (Na, K, As, Cu, Hg, Zn, Mn, Pb, Cd, Co, Cr and Ni) that would inverse the action of the coagulant due to the increasing of the positive ions, which leads to intensifying the water turbidity. However, the obtained results from applying the cationic flocculant with ferric sulfate reveals insignificant increases in water clarity by increasing flocculant dosages, and the maximum clarity achieved at 18 mg/l flocculant was only about 22 % colored water. These insignificant increases may be due to the flocculant enmeshment (sweep-floc coagulation) produced from overdosing of the flocculant, which tends to give fairly thick layers around the suspended solids, and therefore produces the most marked effects. This agrees with the most published works [11, 12].

The results in Figure 1, shows that using the bentonite materials instead of the ferric sulfate with the same flocculant (Zetag32) gave high water clarity and no color could be seen. The optimum results obtained at flocculant dosage of 14 mg/l with 0.1 g/l bentonite dosage (see also Fig. 2).

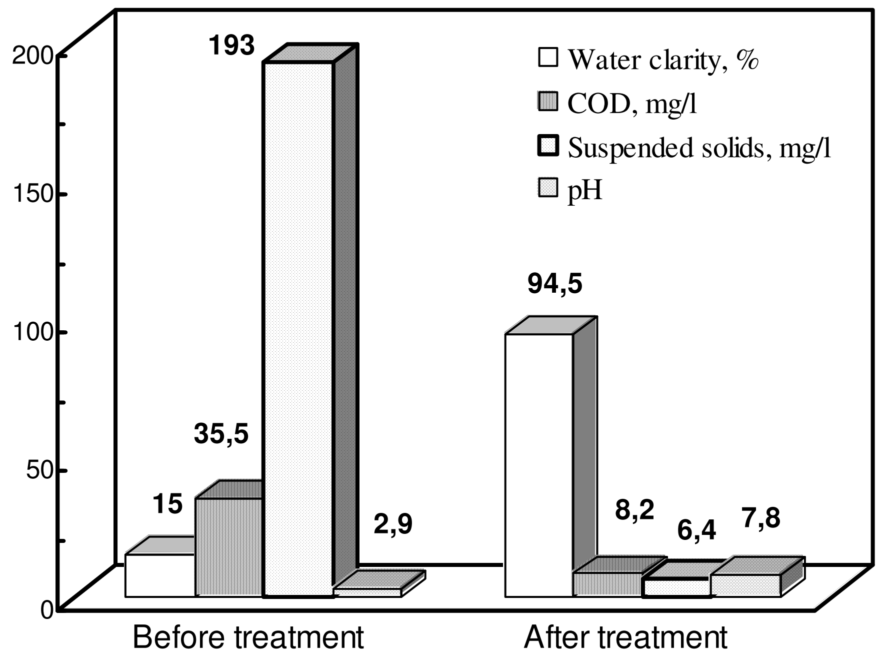

FIGURE 2. The optimum results obtained from treatment of the first mine-wastewater sample.

This optimum results shows that, water clarity increased from 15 to 94.5 % with no colored water (6.3 times), chemical oxygen demand (COD) decreased from 35.5 to 8.2 mg/l (77 %), suspended solids decreased from 193 to 6.4 mg/l (96.68 %), pH increased from 2.9 to 7.8. Finally as expected, the heavy metals and sulfates decreased to a minimum degree due to the increasing of color removal [6, 7, 8, 9, 12].

Figure 3 shows the obtained results from the treatment of the second mine-wastewater sample. The results indicates the effects of varying the dosages of ferric sulfate only and the effects of the cationic one (Zetag32) with 5 mg/l ferric sulfate. In this figure also, these results were compared with that obtained from adding 0.1 gm/l bentonitic clay with the same flocculant at the same conditions.

The obtained results from Figure 3 show that, ferric sulfate alone reveals a moderately increase on the clarity of water, where it increases to 54 % at 5 mg/l and then decreases dramatically by increasing the dosages of coagulant. The increases in water clarity may be due to the wastewater characteristics itself. These increases may be due to the sweep-floc coagulation produced from dosing of the coagulant and that agree with the previous work [11, 12]. However, applying the cationic flocculant with ferric sulfate on this type of wastewater reveals significant increases in water clarity by increasing flocculant dosages, and where maximum clarity achieved at 2 mg/l flocculant was about 80 % with slightly colored water. These insignificant increases may be due to the flocculant enmeshment and/or destabilization by interparticle bridging produced from dosing of the flocculant, which tends to give a thick layers around the suspended solids or to form a large amount of precipitate that will enmesh the colloidal particles as it settles. The obtained results agreed also with most published works [11, 12].

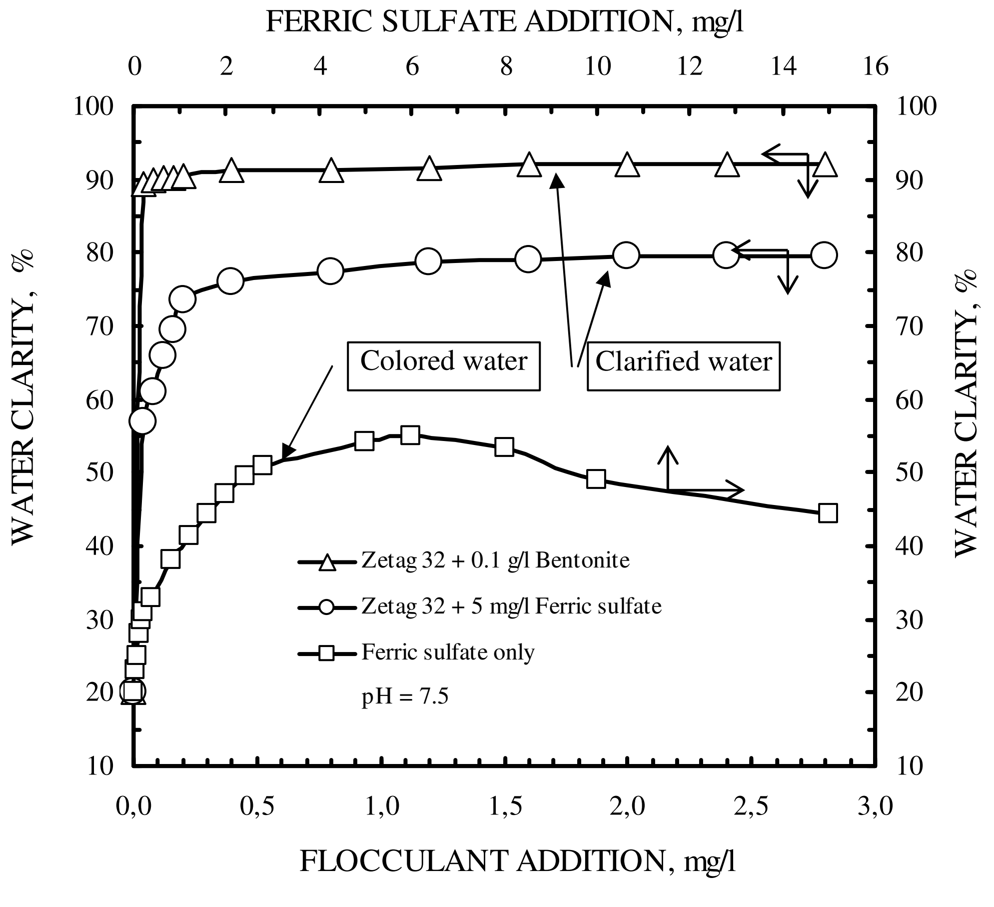

FIGURE 3. The effects of flocculant (Zetag32) with a traditional coagulant, and with bentonite as a coagulant on treatment of the second mine-wastewater sample.

Figure 3, also indicates that using bentonite instead of ferric sulfate with the flocculant (Zetag32) will produce high water clarity. The optimum results obtained at flocculant dosage of 1 mg/l and bentonite dosage of 0.1 g/l are shown in figure 4 below.

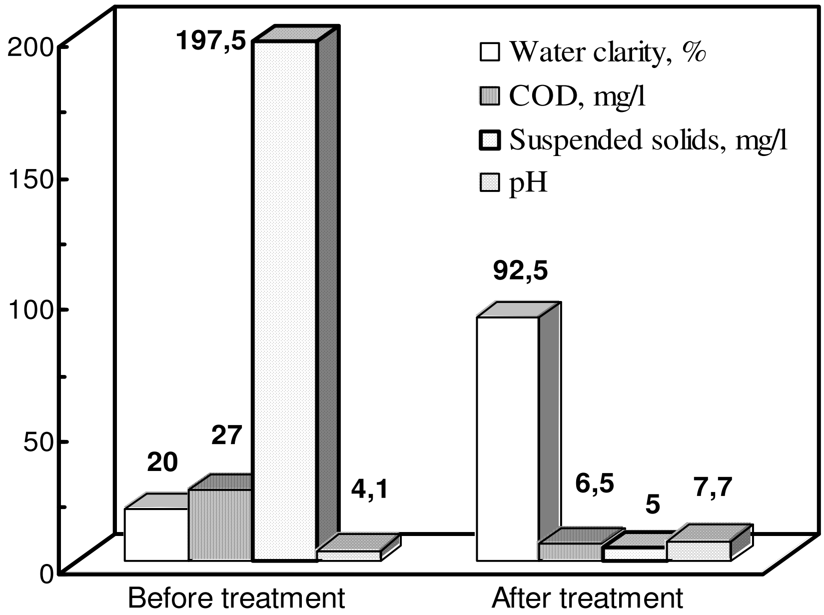

FIGURE 4. The optimum results obtained from treatment of the second mine-wastewater sample.

Optimum results show that, water clarity increased from 20 to 94 % without any traces for the color (4.7 times), while the chemical oxygen demand (COD) decreased from 27 to 6.5 mg/l (76 %), suspended solids decreased from 197.5 to 5 mg/l (97.47 %), and pH increased from 4.1 to 7.7. Moreover, as expected the heavy metals and sulfates decreased to a minimum degree due to decoloring the water [6, 7, 8, 9, 12].

Results of the oily wastewater sample treatment

To investigate the influence of bentonite as coagulant on the treatment of oily wastewater, first applied was using the flocculant Zetag32 in the presence and absence of the traditional coagulant (*ferric sulfate*). Second applied was using the bentonite as coagulant with Zetag32. Figures 5, 6, 7 and 8 below show the obtained results.

Figure 5 illustrates the effects of flocculant Zetag32 on the treatment of oily wastewater in the presence and absents of ferric sulfate. From these results, it can be seen that, applying the cationic flocculant (Zetag32) with or without 5 mg/l ferric sulfate has the same trend. However, increasing flocculant dosages increases the water clarity up to 85.5 % at 3 mg/l Zetag32 and 5 mg/l ferric sulfate, and up to 85 % at 4 mg/l Zetag32 only, however, the produced water remains colored. The results indicate that, the major part of oil content still contaminates the produced water. It has been observed that, only a part of the non-emulsified oil and the suspended solids are flocculated and settled.

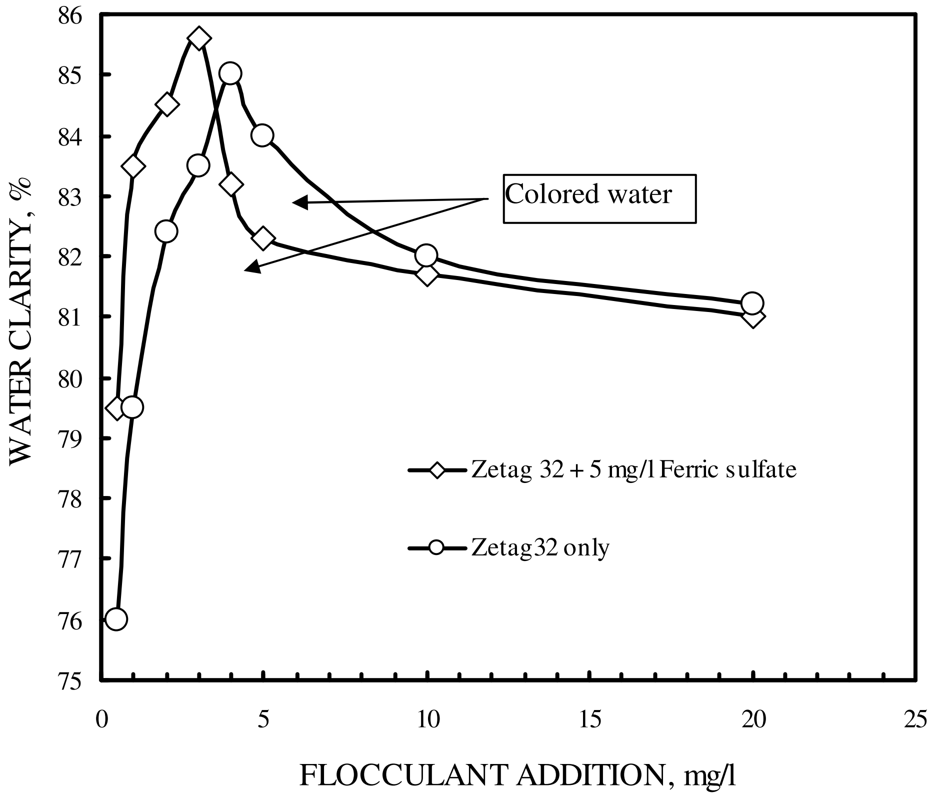

FIGURE 5. The effects of cationic high molecular weight flocculant on the clarity of the oily wastewater in the presence and absence of 5 mg/l ferric sulfate, at room temperature and pH 7.5.

Figure 6 indicates the results that obtained from applying bentonite as coagulant in the presence of cationic high molecular weight flocculant Zetag32 (4 mg/l) to treat the oily wastewater.

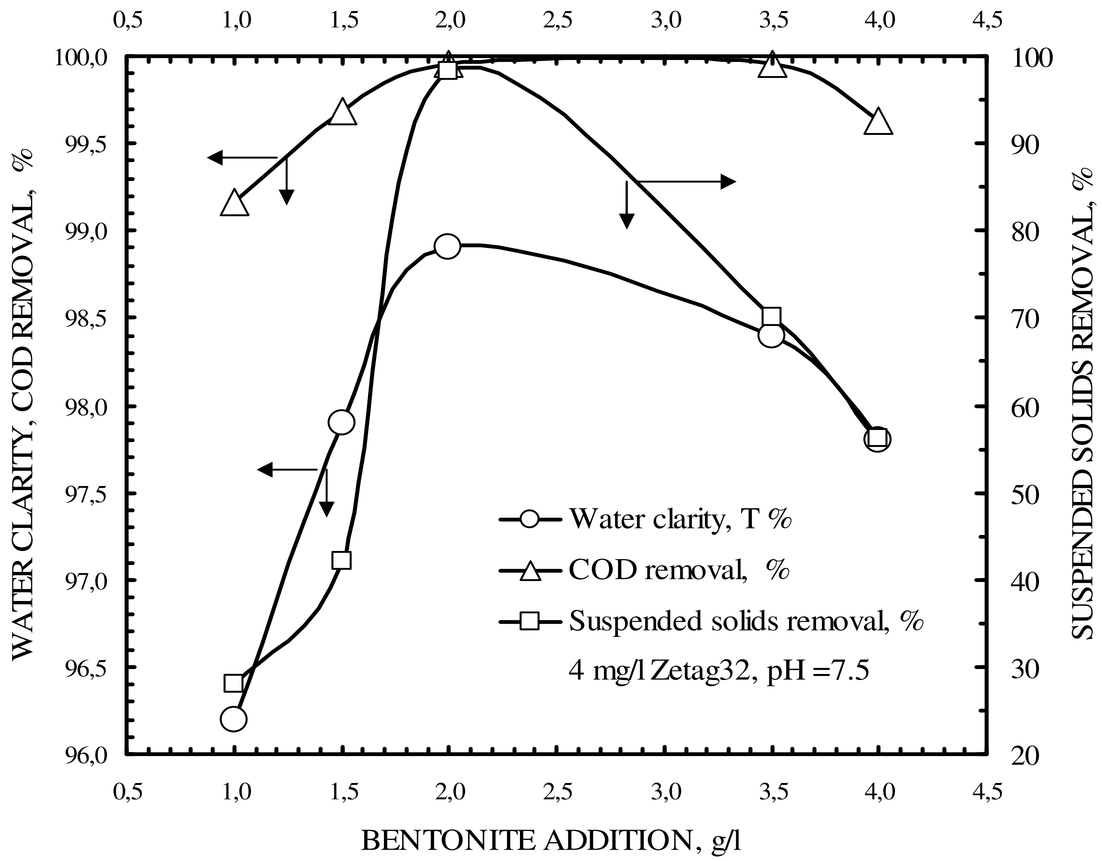

FIGURE 6. The effects of bentonite as a coagulant on the treatment of the oily wastewater in the presence of 4 mg/l Zetag32 at room temperature and pH 7.5.

As seen from Figure 6, as the bentonite dosage increases, water clarity, COD removal percentage and suspended solids removal percentage increase. The maximum values are seen at bentonite dosage of 2 g/l of oily wastewater in the presence of 4 mg/l *Zetag32*. In addition, the oil content measured for this optimum bentonite dosage and the results obtained are shown in Figure 7 below.

Figure 7 shows that using two grams of bentonite as a coagulant in the presence of 4 mg of flocculant Zetag32 to treat one liter of oily wastewater would enhance the obtained results. The water clarity increased from 22.5 to 99 %, COD decreased from 77000 to 30 mg/l (a removal percentage of 99.96 %), suspended solids decreased from 300 to 2 mg/l (a removal percentage of 99.34 %) and oil content decreased from 9000 to 0.5 mg/l (a removal percentage of 99.99 %) giving a pH of 8.2.

Figure 8 shows a comparison between the obtained results from using the traditional coagulant ferric sulfate and the natural coagulant bentointe in the presence and absence of flocculant Zetag32.

As seen from Figure 8, using bentonite as coagulant produces a clarified water with a percentage of clarity of 99 %, i.e., about 14 % greater than that obtained by using traditional coagulant (ferric sulfate).

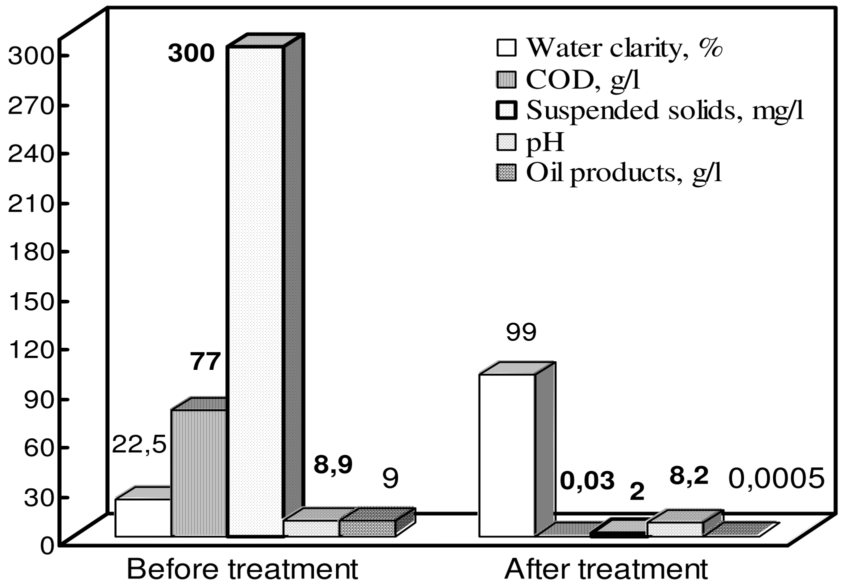

FIGURE 7. The optimum results obtained from the treatment of the third sample.

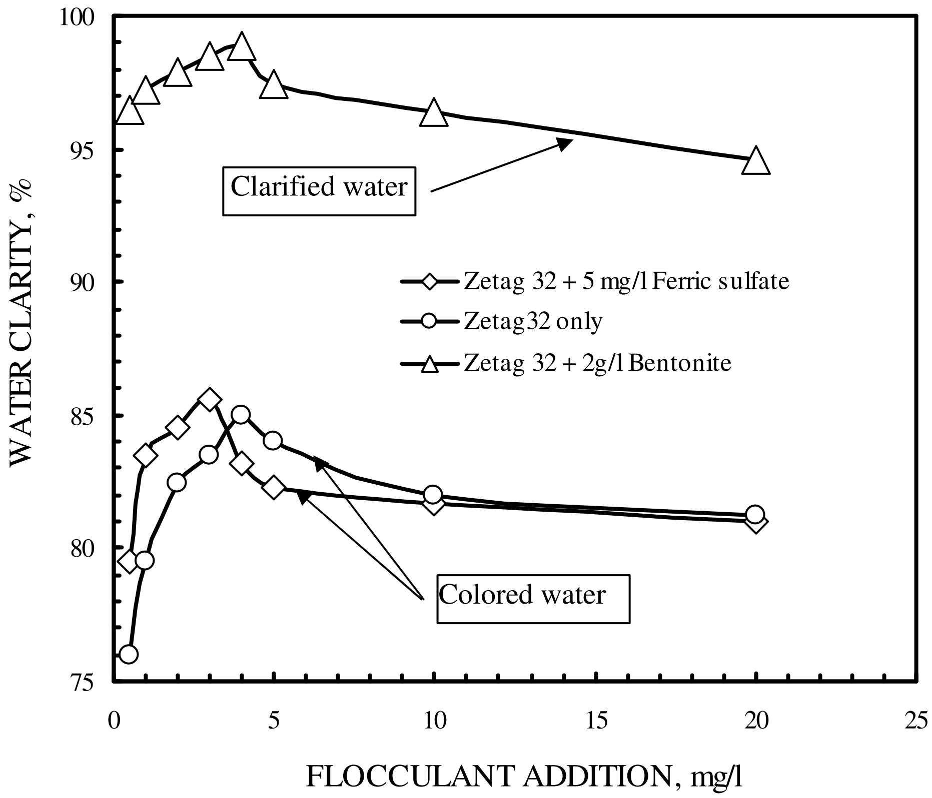

FIGURE 8. Comparison between the obtained results from using ferric sulfate and bentointe in the presence and absence of *Zetag32,* at the room temperature and pH 7.5.

The possible mechanism behind the very good results may be explained as follows: Bentonite is a clay mineral that usually occurs as smectite crystals of colloidal size about 10 Å thick. These crystals are negatively charged because of ionic substitutions at various sites within their structures and, as a result, exchangeable cations are "adsorbed" on their surface. In the case of oily and mine wastewater (turbid and colored contains organic compounds, heavy metals, oils, etc…), bentonite particles work as a nuclei adsorb the organic compounds, heavy metal and oils from the wastewater. Furthermore, the addition of bentonite provides increased opportunity for particle collisions, resulting in rapid formation of settleable flocs. The addition of cationic flocculant to the treatment system would improve the settling process by gathering together flocs particles produced from the coagulation by bentonite in a net bridging from one surface to another and binding the individual particles into large agglomerates. The obtained results are in agreement with the previous reported work [5, 6, 7, 8, 9, 13, 14]. The resulting mass is a complex mixture of encapsulated contaminants and clay solids held together by Van der Waals and electrostatic forces. The contaminants are microencapsulated and surrounded by a barrier of bentonite particles making it nonreactive to external leaching. These results are in accordance with the other reported data [9].

The qualitative blocks diagram of the treatment process for the all wastewater samples are shown in Figure 9.

CONCLUSION

It could be concluded from the obtained results that, using the bentonite clay as a coagulant give the following results:

- The flocculation process becomes more efficient and the cost is reduced.
- The bentonite approach to successful treatment of free and emulsified oils employs proven products technology.
- Improve turbid, color and heavy metals removal from wastewater.
- Environmental permit compliance, however, bentonite as it is untoxic material and gives unharmfully settling materials.
- Improve the filtration system.
- Improve water clarity and produces water can be recycled or safely discharge to the water streams.

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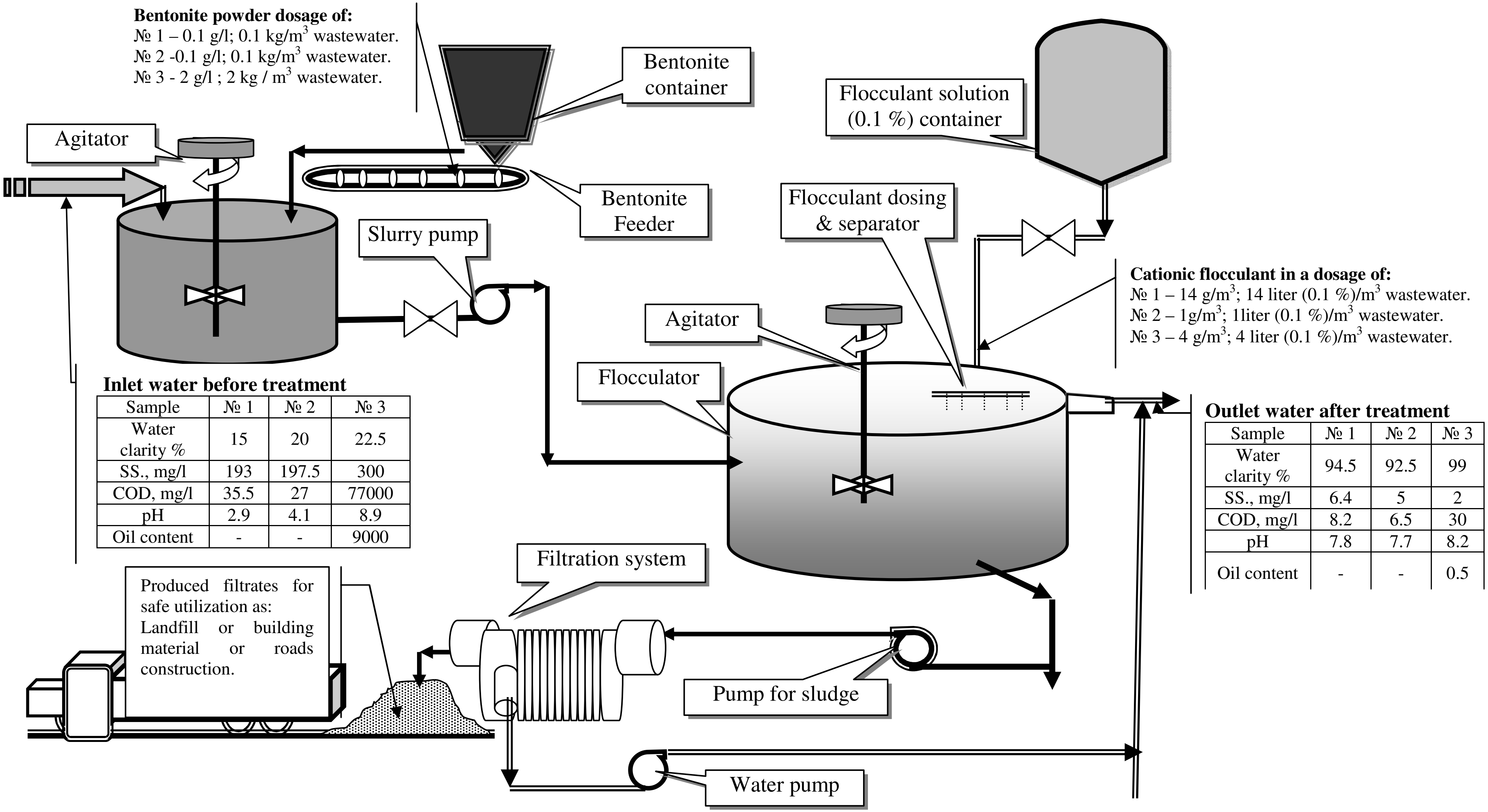

Inlet water before treatment

Sample	№ 1	№ 2	№ 3
Water clarity %	15	20	22.5
SS., mg/l	193	197.5	300
COD, mg/l	35.5	27	77000
pH	2.9	4.1	8.9
Oil content	-	-	9000

Outlet water after treatment

Sample	№ 1	№ 2	№ 3
Water clarity %	94.5	92.5	99
SS., mg/l	6.4	5	2
COD, mg/l	8.2	6.5	30
pH	7.8	7.7	8.2
Oil content	-	-	0.5

FIGURE 9. The qualitative blocks diagram of the treatment process for the all wastewater samples.