RESEARCH ARTICLE

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Wastewater Treatment of Stone Cutting Industries by Coagulation Process

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Background & Aims of the Study: The wastewater created as a result of stone cutting industries enters some pools for re-consumption so that its suspended solids settle by gravity. By taking to account the high volume of water and sludge, treatment of wastewater and removal of sludge cause many problems for stone cutting units. The objective of this study was to determine the quality of wastewater and to investigate the effects of coagulants on suspended solids removal efficiency from wastewater of some stone cutting industries (Qom, Iran).

Materials & Methods: In this experimental study, the effects of different doses of coagulants including Alum, poly aluminum chloride, Polymer, Ferric chloride ($Fecl_3$) and Lime on Turbidity, “total suspended solids” (TSS) and “total solids” (TS) removal were investigated by Jar Test. Removal efficiency of different coagulates was estimated.

Results: The results indicated that lime in dose 100 PPM is the best coagulant for turbidity removal and the highest efficiency for TS removal is related to using Alum in dose 100 PPM.

Conclusions: Considering the findings of this study, it can be concluded that using coagulants causes reduction in settling time and speeds up the return of water to the consumption cycle of stone cutting factories, and also increases turbidity removal efficiency.

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Background

One of the active industries in Iran is the stone cutting units. In construction industry use of stones is inevitable considering their physical and apparent specifications. The most types of stones used in construction operation include porcelain, marble, travertine and granite (1).

The objective of using water is to facilitate cutting, cooling the heat created due to friction and preventing the dust during cutting and wear away (2). The average annual water consumption in this industry is about 0.5 million m^3 and one of the ways for reducing water consumption is to reuse the wastewater (3).

The primary wastewater from stone cutting contains high amounts of stone powder (4). Considering the risks of the wastewater created from stone cutting industries, in order to prevent environmental contaminations,

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discharge of this wastewater to environment is not recommended (5).

During the rain a high volume of this stone powders becomes suspended and settles in downstream farm lands, this issue causes reduction in soil quality, besides it, that discharge of wastewater caused from stone cutting industries in regions where there are resources of drinking water could cause health problems (6).

A part of the heavy costs of stone cutting units is spent for separation, wastewater treatment and sludge disposal. Also, discharge of wastewater and the sludge caused by stone cutting industries to the landfills causes heavy expenses and irrevocable losses for the environment (4,6).

Normally, the factories keep the produced sludge in open pools for 2 to 3 weeks, during this time, the water existing in sludge decreases by evaporation. Thus, the suspended solids settle and compact in the pool's bottom and this sludge shall be discharged in landfills (7). The sludge caused from stone cutting containing elements such as potassium, magnesium, phosphates and other components is very helpful for promoting quality of poor farming soils (8).

Detection of the best method for reduction of contaminates available in wastewater is conducted by considering physical and chemical specifications of the composing elements of waste water (1). According to the results of researches conducted on the wastewater created by stone cutting industries, amount of "total suspended solids" (TSS) in these wastewaters is about 1200 mg/L (2).

Use of coagulation process for treatment of wastewater created by stone cutting industries causes increase in settling speed for suspended solids and return of water to production line without turbidity and it also causes reduction in consumption of polishing emery and segments (1). The objective from using coagulation and flocculation in treatment of the wastewater caused from stone cutting industries is to remove colloidal material existing in wastewater. Also, the nutritive materials existing in wastewater might be removed during this process (9).

Arslan EI *et al*. conducted a study in Turkey under the title of "physicochemical treatment of marble waste water and recycling of sludge". The first section of their study was related to use of coagulation and flocculation processes. They investigate several parameters, including turbidity, total solids (TS), suspended solids (SS) and chemical oxygen demand (COD) in cutting, faience and equalization processes (10). Along this, another study was conducted by Nasserdine K *et al*. in Hebron to improve the quality of output effluent from stone cutting industries by coagulation process. In this research, the existing methods of wastewater treatment were investigated and Jar Test was used for optimizing water recycling and studying possibility of treatment (11).

In application of physicochemical treatment in effluent by coagulation and flocculation processes, a large amount of sludge might be created which shall be removed during further processes (12). Al-Zboon K *et al*. in 2010 studied the possibility of using stone cutting sludge in production of concrete which has both environmental and economical effects. In this case, the watery sludge was used as water resource in production of concrete (13).

By taking into account the location of Qom province in Iran, the semi arid region and the problem of water shortage, recycling the wastewater is critical. Based on the results of research, there are 186 stone cutting units in Qom province that are all located around Qom city (maximum of 15 Km radius) and in four districts of KoohSefid, old Tehran-Qom road, Kashan road, and old Esfahan road.

By considering the large number of stone cutting units in Qom province and as a result, mass production of wastewater, appropriate options such as coagulation and flocculation shall be provided for speeding up the suspended solids settling and waste water treatment.

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Aims of the study: The objective of this study was to investigate the quality of wastewater and use of coagulation process for suspended solids and turbidity reduction of wastewater caused in stone cutting industries of Qom city (in Iran) for reusing this wastewater. For this, the coagulants included of Alum, poly aluminum chloride, Polymer, Ferric chloride ($Fecl_3$) and Lime in different doses were used on TSS, turbidity and TS removal by Jar Test.

Materials & Methods

This study was conducted experimentally at laboratory of Public Health School Laboratory of Qom University of Medical Sciences (Qom, Iran).

The required sample for performing tests was prepared from Pakaliran stone cutting factory (Iran). About 30 L sample of the factory effluent was taken for performing the tests and the parameters such as pH, electrical conductivity (EC), TSS, TS, total dissolved solids (TDS), turbidity and temperature were measured in them. Measuring the turbidity, EC, pH and temperature were conducted by turbidity meter device (model AQVALITIC), EC meter (model CANT20), pH meter (model R.T.CO), and thermometer.

Experiments were performed using various coagulants with different doses. The amount of suspended and dissolved solids was measured by filtration and furnace settling methods (14).

In order to determine turbidity and suspended solids removal efficiency, the amount of turbidity of one liter wastewater was measured in 10 minutes time intervals for 2 hours via settling process optimized type and the coagulant dose of Alum, poly aluminum chloride, Polymer, $Fecl_3$ and Lime in selected doses 500, 200, 100, 75, 50 and 25 PPM were used in different steps of rapid and slow mix and settling. After determining the optimum dose of coagulant, the pH, EC, TSS, TS, TDS, turbidity and temperature were measured (14).

Data analysis: Removal efficiency of different coagulates was estimated.

Results

The characteristics of the stone cutting wastewaters are given in Table 1.

Table 1) Wastewater characteristics

Parameters	Value
pH	7.2
Temperature (°C)	20
Turbidity (NTU)	390
Electrical conductivity (µs/Cm)	12500
Total solids (mg/L)	9600
Total suspended solids (mg/L)	2100
TDS (mg/L)	7500

Figure 1 shows turbidity removal during the settling, without coagulation process.

Figure 2 presents the percentage of turbidity removal. Experiments were carried out using various coagulants with different doses.

Figures 3 and 4 show the percentage of TSS and Ts removal.

It has been established that coagulant dosage is an important parameter influencing the performance of the coagulation process (7) this statement is confirmed by figure 5. This figure has shown optimum doses for TS and TSS removal from wastewater.

The amount of initially pH and Ec in stone cutting wastewater were 7.2 and 12500. In Jar Test, by adding coagulants, pH and Ec had little changes which are given in table 2.

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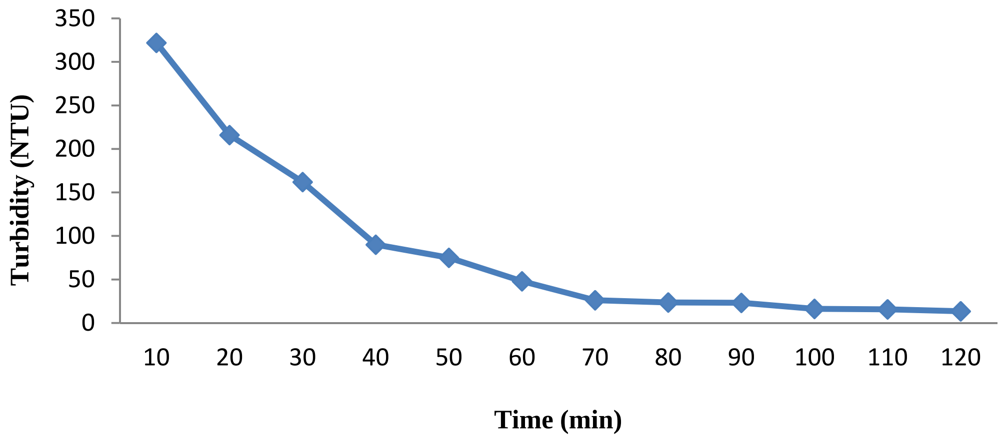

Figure 1) Effect of settling, without coagulation process for turbidity removal

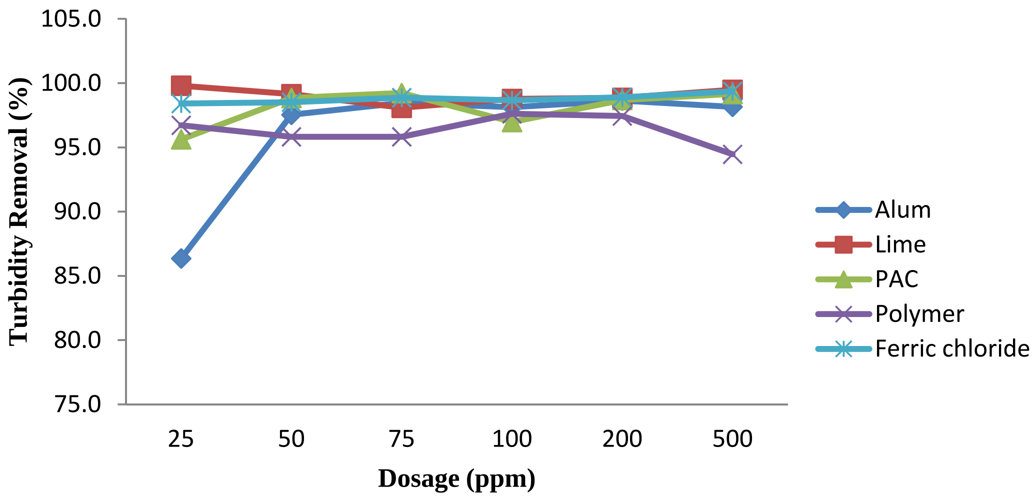

Figure 2) Turbidity removal efficiency versus coagulant doses for cutting process wastewater

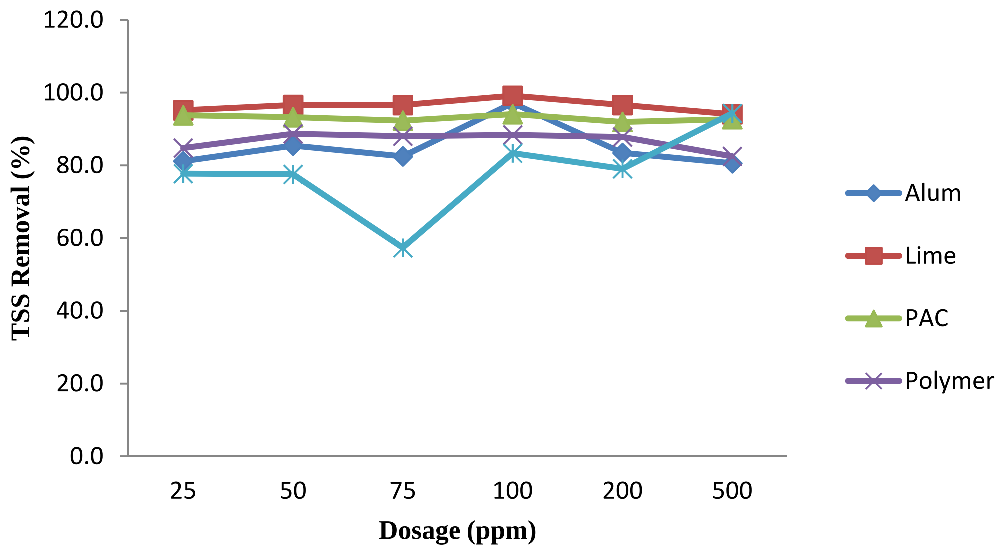

Figure 3) "Total Suspended Solids" removal efficiency versus coagulant dosage for cutting process wastewater

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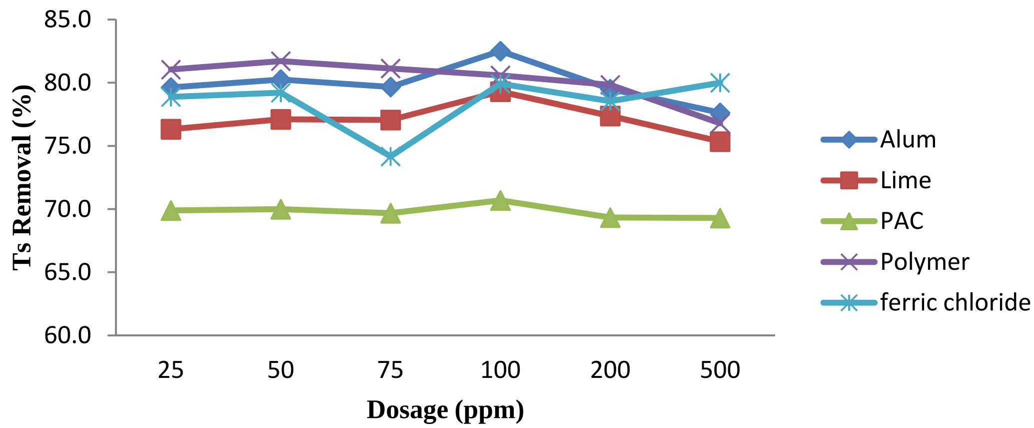

Figure 4) Total solids removal efficiency versus coagulant dosage for cutting process wastewater

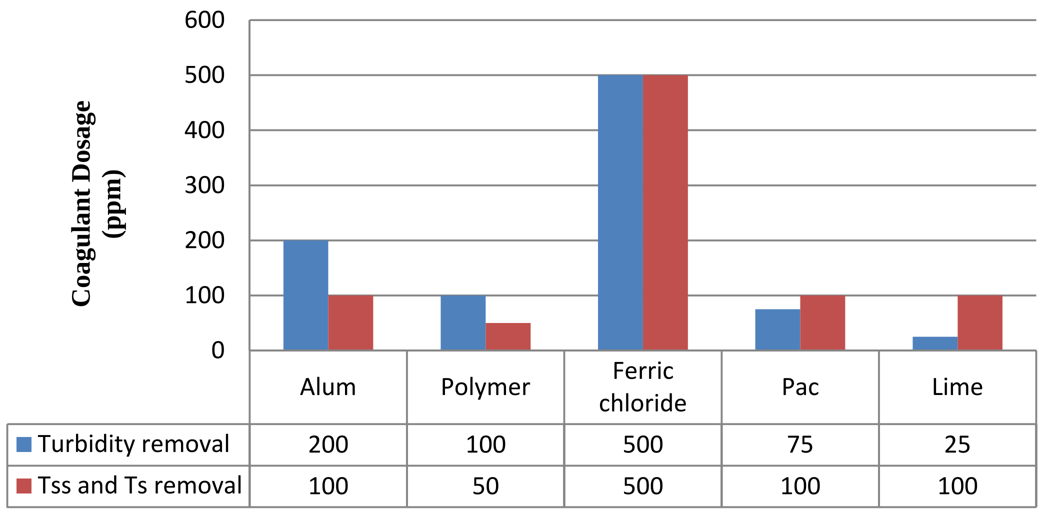

Figure 5) Optimum doses of coagulant for turbidity, "total suspended solids" and "total solids" removal

Table 2) Electrical conductivity and pH values for different coagulant, after Jar Tests

Coagulant Dosage (PPM)	Lime		Poly aluminum chloride		Ferric Chloride		Polymer		Alum	
	Ec	pH	Ec	pH	Ec	pH	Ec	pH	Ec	pH
25	12.86	7.88	13.5	7.29	2.6	7.42	2.5	7.63	2.6	7.55
50	13.12	8.01	12.8	7.67	2.54	7.28	2.53	7.64	2.65	7.54
75	13.14	8.04	12.6	7.7	2.64	7.16	2.6	7.69	2.64	7.44
100	13	8.07	12.57	7.71	2.63	7.07	2.7	7.69	2.7	7.34
200	12.94	8.27	12.65	7.58	2.7	6.95	2.8	7.65	2.7	7.24
500	12.95	7.35	12.95	6.41	3	7.62	3.1	7.09	2.9	7.1

Discussion

In comparing data showed in table 1 with standards of US Environmental Protection Agency (USEPA) it can be concluded that quality of output effluent does not conform to the standards of USEPA in cases of turbidity and TSS (15).

According to the Figure 1, if we used gravity settling for turbidity removal caused by suspended solids without coagulation, the

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turbidity removal efficiency after 2 hours would be 95.8% which is a long time.

Figure 2 indicates the effect of doses of different coagulants on turbidity removal. The results are indicative that turbidity removal via coagulants has been remarkable. The best efficiency for turbidity removal was related to Lime with 99.8%, in dose 25 PPM.

The optimum amounts for Alum in dose 200 PPM with 98.6% turbidity removal, for polymer in dose 100 PPM with 97.6%, for $Fecl_3$ in dose 500 PPM with 99.4%, and poly aluminum chloride in dose 75 PPM with 99.2% was estimated.

Figures 3 and 4 are indicative of the effect of doses of different coagulants on TSS and SS removal from waste water. The amounts of TS and TSS were 2100 and 9600 before the test and after performing the test, the highest removal efficiency was gained for Alum and Lime in dose of 100 PPM. The TS and TSS removal efficiency for Alum was 82.5% and 97.1%, for polymer 81.7% and 88.7%, for $Fecl_3$ 80% and 94.3%, poly aluminum chloride 70.7% and 94.1% and for lime 79.3% and 99.1%.

In the study that investigated on the wastewater created from Marble Production Factory which was conducted by Aysel Arsalan *et al*. via Jar Test, optimum doses of coagulants for turbidity removal in wastewater were determined. The maximum removal efficiency was observed for aluminum sulfate in doses 200 and 500 PPM, for $Fecl_3$ 300 and 500 PPM, for "Agrofloc 100" 200, 400 and 600 PPM. At the end, it was specified that the dose 100 PPM of Agrofloc 100 coagulant for TS removal has the best efficiency (10).

In another study, Nasserdine K *et al*. under title of "environment management in stone cutting industries", it was specified that using Folcland polymer by optimum dose 1.5 mg/L can optimize efficiency for turbidity removal and by recycling stone cutting wastes, the quality of output wastewater can be improved and this will cause reduction of costs for consumed raw materials (11).

Considering table 2, the amount of initial pH in stone cutting wastewater has been 7.2. In Jar Test, by adding Alum and $Fecl_3$, pH had a little decrease and regarding Polymer and Poly Aluminum, it had a little increase.

Concerning Lime, the changes were more and the amount of pH in dose 500 PPM has reached over 9 which are in the range of almost alkaline. Among the most important advantages of Alum is its response in a wide range of pH (10).

The optimum dose for TS removal by using Alum is 100 PPM where the removal efficiency reaches to 82.5%. The results of this research indicates that in gravity settling of wastewater without using coagulants, after 40 minutes the removal efficiency of suspended solids would be 72%, while by using coagulants, in approximately 40 minutes, maximum suspended solids removal based on turbidity, by Lime would reach 99.8%. We can conclude that by using coagulants the settling time is reduced and return of water to the consumption cycle is speeded up, beside it, efficiency is increased. The obtained curves are indicative that the results are close to each other; however the best quality of wastewater observed by Lime in optimum dose 25 PPM with turbidity removal 99.8%.

The other results are indicating that by adding 100 PPM Lime to wastewater, TSS removal can be increased to 99.1% which shows maximum removal.

Conclusions: Considering the results of this study, it can be concluded that despite high efficiency for turbidity, TS and TSS removal by coagulants, the quality of wastewater created by stone cutting factory is not in standard level in cases of TS and TSS and in order to complete wastewater treatment operation and reaching wastewater discharge standards, it is required to study coagulation of Lime beside other coagulants.

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Since the treated wastewater turns back to the consumption cycle and there is no special standard for water used in stone cutting, it can be said that as mush the treated wastewater has less turbidity and suspended solids, the efficiency of devices is higher and more high quality products are produced.

Footnotes

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Conflict of Interest:

The authors declare no conflict of interest.

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