APTEFF, 40, 1-220 (2009)
DOI: 10.2298/APT0940177S
UDC: 628.3.034.2:664.1:628.345
BIBLID: 1450-7188 (2009) 40, 177-182
Original scientific paper

TREATMENT OF SUGAR BEET THICK JUICE SPENT WASH BY CHEMICAL AND NATURAL COAGULANTS

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The possibility of treatment of wastewater from bioethanol production by aluminium sulfate and natural coagulant extracted from common bean seed was studied. The highest coagulation activity at pH 6.5 is reached with analum dose of 1 g/l, but only a little lower coagulation activities were obtained by the dose of 0.05 and 0.10 g/l, which is more favourable for economic and environmental reasons. When natural coagulant from common bean was applied the highest coagulation activity, 14.3%, at pH 6.5 is reached with a dose of 0.5 ml/l. However, when common bean natural coagulant was used simultaneously with alum, the highest turbidity removal resulting in 24% coagulation activity was achieved and this was more efficient than when alum or natural coagulant were used.

KEY WORDS: Tick juice stillage; coagulation; alum; natural coagulants

INTRODUCTION

Sugar beet and intermediates from beet-processing are very good raw materials for bioethanol production, due to their content of fermentable sugars which can be directly used for fermentation without any pretreatment. Molasses is a traditional raw material for distilleries, but it is not sufficient for bioethanol production as a fuel. Raw extraction juice has the lowest price from beet-processing intermediates, but its disadvantage is low storability. Thick juice is more expensive than extraction juice but its storability is excellent, that is comparable with molasses (1).

Effluent originating after alcohol distillation, known as distillery wastewater, spent wash, stillage, and so on, is highly loaded and causes extensive soil and water pollution. The production and characteristics of spent wash are highly variable and dependent on feedstock and various aspects of the ethanol production process. For example, an average molasses based distillery generates 15 L of spent wash per 1 L of ethanol produced (2). Elimination of pollutants from distillery effluent is becoming increasingly important from the environmetal point of view. Due to the large volume of these effluent and presence of certain hardly biodegradable compounds, the treatment of this stream is rather chal-

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lenging by conventional methods. Therefore, to improve the existing treatments, a number of novel phisico-chemical and biological treatments have been conducted (3).

The main objective of the present study is preliminary investigation of the usage of aluminium sulfate and/or natural coagulants from common bean, in the treatment of thick juice spent wash. Aluminium sulfate (alum) an inorganic salt is the most widely used coagulant in water and wastewater treatment. The disadvantage of this process is the presence of aluminium in the obtained sludge, which causes further environmental problems. Moreover, the obtained sludge can not be used as a feed. Our previous studies indicated the ability of extract from common bean (*Phaseolus vulgaris*) seed to act as a natural coagulant (4). In this study, common bean natural coagulant will be investigated for its suitability to substitute alum in thick juice spent wash treatment.

EXPERIMENTAL

Wastewater

Wastewater was collected from the Laboratory for ethanol and yeast, Faculty of Technology, Novi Sad, after bioethanol production experiments (1). The characteristics of wastewaters are shown in Table 1.

Table 1. Typical characteristic of thick juice spent wash

Parameter	Range	Average value
pH	4.68 – 4.85	4.74
Settleable matter (ml/l)	1.8 – 3.5	2.5
Suspended solids - SS (mg/l)	8540 - 9815	9322
Total solids - TS (mg/l)	31900 - 32830	32345
Total fixed residue at 550 ^oC (mg/l)	2937 - 3200	3150
Total volatile residue (mg/l)	28963 - 29630	29220
Chemical oxygen demand - COD (mgO_2/l)	85230 - 90000	87600
Total Kjeldahl nitrogen - TKN (mg/l)	980 - 1005	995

It can be seen from Table 1 that the thick juice spent wash is highly acidic in nature, and highly loaded with organic matter. It contains high suspended solids, making about 30% of total solids. These suspended solids have poor settleability, which is indicated by very small amount of settleable matter. Analysis of the data demonstrated that the thick juice spent wash has a little better characteristics than molasses spent wash (5, 6) - the large advantage of thick juice spent wash is that it does not contain coloured pigments. Because these pigments are hardly biodegradable, thick juice spent wash is much easier for treatment than the molasses one.

Coagulants

$Al_2(SO_4)_3x18H_2O$ (alum) was used as 5% sollution. Natural coagulants were obtained in this way: white common bean seeds were ground and sieved through the sieve with pore size of 0.4 mm. An amount of 10 g/l of a smaller fraction was suspended in 0.5 mol/l NaCl solution. This suspension was stirred for 10 minutes on a magnetic stirrer in

order to extract active coagulant components. After that, the suspension was filtered through arugged filter paper. The obtained filtrate - crude extract was stored in a fridge at 5ºC.

Coagulation test

Jar test was carried out to evaluate coagulation activity of alum and natural coagulant. A volume of 100 ml of wastewater was filled in four 500 ml bakers. Before coagulation the pH was adjusted by 1 mol/l NaOH or 1 mol/l HCl to a desired value. The coagulants were added to the beakers at different doses, and the content was stirred at 200 rpm for 1 minute. The stirring speed was then reduced to 80 rpm and was kept for 30 minutes. Then, the suspensions were left to allow sedimentation. After 1 hour of sedimentation, an aliquot of 10 ml of clarified sample was collected from the top of the beaker and pH and COD were determinated. The residual COD of sample was COD_S. The same coagulation test was performed with no coagulant as the blank. The residual COD in the blank was COD_B. Coagulation activity was calculated as follows:

$$\text{Coagulation activity (\%)} = 100 \cdot (COD_B - COD_S)/COD_B \quad [1]$$

Analytical methods

pH, settleable matter, suspended solids, total solids, total fixed residue at 550 ^oC, COD and TKN were analyzed in conformity to Standard Methods for the Examination of Water and Wastewater (7).

RESULTS AND DISCUSSION

Coagulation with alum

As the first step in our investigation was studied the influence of pH and alum dose on efficiency of the coagulation-flocculation process. Table 2 shows theeffect of different doses of alum on the coagulation activity at the original wastewater pH of 4.64.

The application of alum at the original wastewater pH was not appropriate because of the very low coagulation activity achieved. This might be expected considering that recommended pH range for alum application is from 5.5 to 7. Because of that, the pH value of wastewater was adjusted to 6.50 before coagulation. The results of these experiments are presented in Table 3.

Table 3 shows an important improving of removing of colloidal particles from investigated wastewater by alum. The highest coagulation activity at pH 6.5 is achieved with analum dose of 1 g/l, but only a little lower coagulation activities were obtained by doses of 0.05 and 0.10 g/l. Coagulation with low alum dose is very favourable because of lower treatment costs and lower aluminium concentration in the obtained sludge.

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Table 2. Effect of alum dosage on coagulation activity at pH 4.64

Alum dosage (g/l)	Coagulation activity (%)	pH of water after treatment
0.050	3.99	4.65
0.100	3.99	4.64
0.150	NE*	4.64
0.250	NE	4.62
0.500	NE	4.58

* No effect

Table 3. Effect of alum dosage on coagulation activity at pH 6.50

Alum dosage (g/l)	Coagulation activity (%)	pH in water after treatment
0.013	7.94	6.50
0.025	NE*	6.50
0.050	10.70	6.45
0.100	10.70	6.40
0.150	8.02	6.37
0.250	NE	6.31
0.500	3.78	6.14
1.000	12.30	5.93
2.000	NE	5.52
3.000	4.23	5.25

* No effect

In the further experiment, natural coagulant was added solely to wastewater at pH 6.50. The optimum pH for coagulation with natural coagulants from common bean was above 9 (Šćiban et al., 2005), but the adjusment to this pH requires large amount of an alkaline solution, and this pH is not appropriate for alum coagulation. Table 4 shows the effect of different doses of natural coagulants on the coagulation activity at pH 6.50.

The highest coagulation activity of natural coagulants at pH 6.5 is achieved with a dose of 0.5 ml/l, and only a little lower coagulation activity was obtained at a dose of 0.25 ml/l; to obtaine these doses of natural coagulant it was necessary to extract 5 mg and 2.5 mg common bean seed, respectively.

Table 4. Effect of natural coagulant dosage on coagulation activity at pH 6.50

Natural coagulant dosage (ml/l)	Coagulation activity (%)
0.250	10.9
0.500	14.3
1.000	NE*
2.000	5.8
5.000	NE
10.00	NE

* No effect

In the next experiments, the effect of natural coagulant doses was investigated with simultaneous addition of fixed dose of alum 0.05 g/l (Fig. 1).

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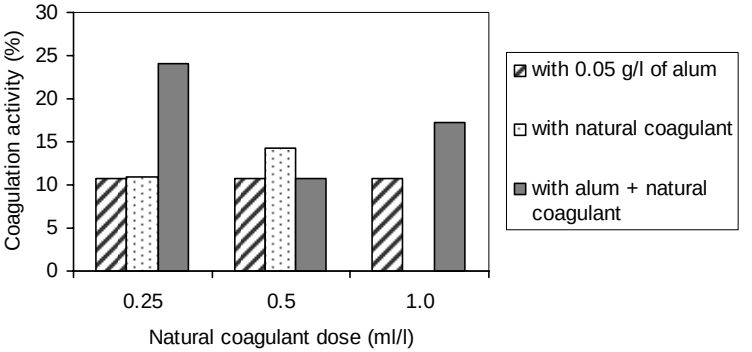

Fig. 1. Effect of natural coagulant dosage on coagulation activity at pH 6.50, with addition of 0.05 g/l of alum

Very good removal efficiency of organic matter from water was achieved when alum and natural coagulant were applied in combination 0.05 g/l and 0.25 ml/l, respectively. Moreover, when common bean natural coagulant was used simultaneously with alum, the higher turbidity removal was achieved in comparison to sole application of alum or natural coagulant. Although the coagulation activity achieved might seem relatively low at the first sight, the maximal achievable coagulation activity in this wastewater can be about 32% (see ratio suspended solids : total volatile residues from Table 1).

CONCLUSION

When natural coagulant from common bean was applied for wastewater treatment, more efficient removal of suspended solids was achieved. According to the results, common bean could be used as a substitute for conventional chemical coagulants such as alum. The highest coagulation activity was obtained when natural coagulant and alum were added to wastewater simultaneously. Regarding its biodegradability, food grade and renewable nature, common bean has a bright future as a source of coagulant for both water and wastewater treatment.

ACKNOWLEDGEMENTS

The financial support of the Ministry of Science and Technological Development of the Republic of Serbia (Project No. 20009) is greatly acknowledged.

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ТРЕТМАН ЦИБРЕ ОД ГУСТОГ СОКА ХЕМИЈСКИМ И ПРИРОДНИМ КОАГУЛАНТИМА

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У раду је испитивана могућност третмана отпадне воде од производње биоетанола алуминијум сулфатом и природним коагулантима екстрахованим из зрна пасуља. Најбоља коагулациона активност је постигнута на pH 6,5 са дозом алуминијум сулфата од 1 g/l, а само нешто мање коагулационе активности су остварене са дозама од 0,05 и 0,1 g/l, што је веома погодно како са економског, тако и са становишта заштите животне средине. Када је примењен само природни коагулант на pH 6,5, постигнута је коагулациона активност од 14,3% са дозом од 0,5 ml/l. Када се природни коагулант применио истовремено са алуминијум сулфатом, постигнута је највећа коагулациона активност од 24%, која је боља од коагулационих активности постигнутих појединачном применом алуминијум сулфата и природног коагуланта.

Received 25 August 2009
Accepted 6 October 2009