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Effective Use of Ferric Sulphate and Ferric Chloride in Treatment of Dairy Industry Wastewater

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Dairy plants need usually large quantities of clean water. More than 90 % of clean water is converted into wastewater demonstrating very high potential risk of environmental pollution. The present study is undertaken to investigate, under the same analytical conditions, the efficiency of ferric sulfate and ferric chloride used as coagulant in chemical treatment of raw wastewater collected from dairy plant. Results of visual and physicochemical evaluation of chemically treated wastewater indicated significant improvement of their selected characteristics, however different response to the coagulant treatment was observed within the tested samples. Removal efficiencies for individual parameters varied in the wide range between 20.9 and 97.2 %.

Key Words: Dairy industry wastewater, Coagulation, Ferric sulfate, Ferric chloride.

INTRODUCTION

Dairy plants are the places which produce "difficult" wastewater with large total load of organic pollutants like proteins or fats and chemicals used for cleaning and sanitizing processing equipment[1].

Wide range of complex solutions for treatment of wastewater exists in industrial plants. In reference to food industry wastewater, treatment processes have to assure first of all required quality of discharged effluents. Costs analysis also possible utilization of substances contained in wastewater are taken into consideration. Plant localization and the water quality impact assessment defining characteristics of wastewater which are led from the processing plant to the municipal sewage system or to surface waters are another important factor while selecting an individual wastewater treatment method.

Experience of many plants which process raw materials of animal origin indicate that the best results of efficient technological wastewater treatment are achieved with combination of physical methods (*i.e.*, screens, sieves, sedimentation tanks or flotation units) with chemical treatment. Fat flotation is often combined with addition of chemicals acting as coagulants and precipitants of pollutants. Selected polymers are usually used as binding agents in such technologies[2]. Some of the additional

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benefits for the application of ferric or aluminum salts in wastewater treatment are: precipitation of sulfur compounds, easier sludge dewatering, increased efficiency in elimination of pollutants and reduction in energy consumption in the biological process applied as final stage of treatment. It is also important to understand some disadvantages of this methodology and *e.g.*, the addition of treatment chemicals may increase the total volume of sludge, large amounts of chemicals may need to be transported to the treatment location and polymers used can be expensive[3]. Dairy industry wastewater demonstrates a complicated system containing different components, including pollutants coming from the processed raw materials, chemicals and residues of technological additives used in individual operations. Since chemical precipitation has become a widely used technology for both industrial as well as municipal wastewater treatment. The principal aim of the investigations presented in this publication is to verify the efficiency of the ferric sulfate and ferric chloride applied as coagulant for treatment of dairy industry wastewater.

EXPERIMENTAL

Raw wastewater samples were collected at random from industrial dairy plant. This dairy plant manufactures a variety of dairy products in a semi hydrated or dehydrated form (*i.e.*, butter, ghee, sweetened milk and milk powders) where technological wastewater is a mixture of two streams coming from powder plant and various processing units. Two fat traps A and B are the part of the effluent treatment plant of the dairy. After removal of fats both the streams are equalized in equalization tank and then it is supplied to the anaerobic digester. The samples of wastewater are collected from this point *i.e.*, digester inlet.

The parameters of raw wastewater samples were determined in accordance to Gujarat pollution control board limits and these were COD (chemical oxygen demand), BOD (biological oxygen demand), TDS (total dissolved solids) and pH value. The same characteristics were determined for wastewater samples collected after coagulation process. The standard jar testing procedure was employed in a laboratory test of coagulation process of examined wastewater.

Visual evaluation of coagulation process of examined wastewater samples was focused on floc formation and sedimentation. The influence of coagulant both on wastewater colour as well as removal of turbidity was also studied.

RESULTS AND DISCUSSION

Table-1 shows the average values of the determined parameters of the raw wastewater originated from dairy plant. The values are typical for dairy industry effluents and indicated relative high variability between examined samples. High load of organic pollutants resulted in values of BOD_5, COD and other wastewater characteristics and correspond well with literature data[4,5].

The biggest problem in the chemical treatment of wastewater is the selection of the chemicals, which must be added to the wastewater in order to separate the

dispersed pollutants. The problem nearly always cumulates in finding a suitable coagulant as this must be easy to handle store and prepare. Another key question is always coagulant dose selection ensuring the required degree of the pollutants removal. Ferric sulphate trihydrate is a widely used coagulant. It has been used for the treatment of wastewater of industry that is concerned with the production of potato chips and food processing industry[6]. Iron-based coagulant in the form of ferrous sulfate ($FeSO_4 \cdot 7H_2O$), ferric sulfate [$Fe_2(SO_4)_3$], ferric chloride ($FeCl_3$) and the mixture of $Fe_2(SO_4)_3$ and $FeCl_3$ are also commonly used in water treatment. In commercial product, ferric sulfate is available in the form of a reddish-brown granular material and it is readily soluble in water. In the present study, two iron compounds *i.e.*, are investigated for the coagulation study of dairy industry wastewater. The performance of coagulants was primarily based on pH, TDS, BOD_5, COD and turbidity of treated water. In the present work the coagulation study with ferric chloride and ferrous sulfate is carried out at constant pH[7].

TABLE-1
PHYSICO-CHEMICAL CHARACTERISTICS OF EXAMINED RAW WASTEWATER

Parameters (unit)	Number of samples	Range	Average value
pH	80	6.8-8.2	7.6
Turbidity (NTU)	80	15-30	22
TDS (mg/L)	80	2400-4180	3440
COD (mg/L)	40	1500-2900	2200
BOD_5 (mg/L)	40	750-1980	1110

In a physical/chemical process for dairy industry wastewater both the ferric sulfate and ferric chloride acted on almost all characteristics.

The effluent has a pH value of 7.6, which makes it alkaline. The turbidity of 22 NTU shows that the colloidal matter in the wastewater was high and by implication, the wastewater contains high solids concentration. The total dissolved solids was 3440 mg/L which is not within the Gujarat pollution control board limits for effluent discharge in Gujarat, India. The value of biological oxygen demand (BOD) and chemical oxygen demand (COD) were rather high, this mean that the wastewater has high pollution potentials and therefore should be treated before discharge into the environment.

Results of coagulation studies with ferric chloride shows the optimum dose of 200 mg/L at pH 4.5. The turbidity, after treatment is around 5.1 even at optimal conditions. Ferric chloride when added in water yields ferric and chloride ions. ferric ions neutralize negatively charged colloidal particles and agglomerization of the colloidal particles can occur or it may combine with hydroxide ions to form ferric hydroxide which adsorbs colloidal particles, providing clarification of effluent.

Varying ferric sulfate concentration keeping pH constant 4.5 were applied for the treatment of wastewater. Results of coagulation studies with ferric sulfate shows the optimum dose of ferric sulfate to be 400 mg/L.

Application of both the coagulants resulted in achieving high removal efficiencies for almost all wastewater characteristics as can be seen in Figs. 1-6. The varying concentration of solids in tested wastewater, together with the size of particulate materials and the differences in particle charge are the main factors influencing the parameter. Markedly reduction of individual pollutants concentrations was observed in each analytical variant corresponding well with other literature data[8,9].

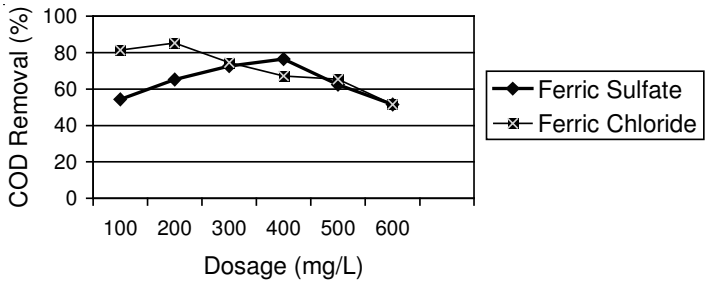

Fig. 1. Effect of coagulant treatment on COD

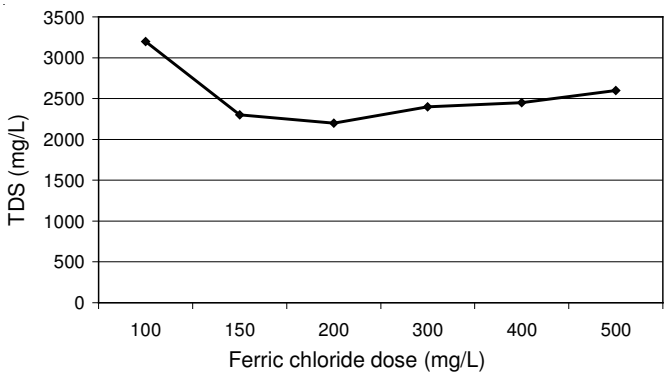

Fig. 2. Variation of TDS with ferric chloride

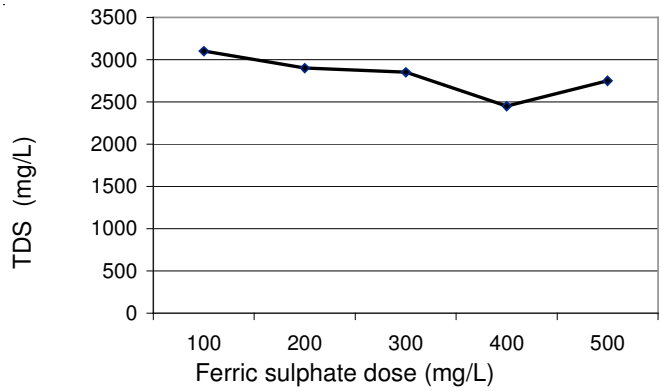

Fig. 3. Variation of TDS with ferric sulphate

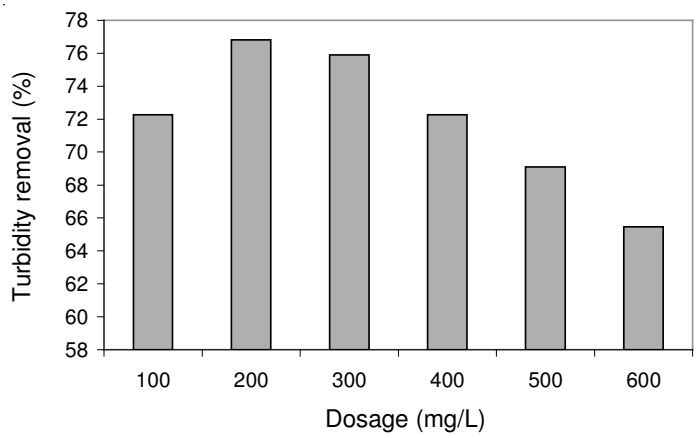

Fig. 4. Effect of ferric chloride on turbidity removal

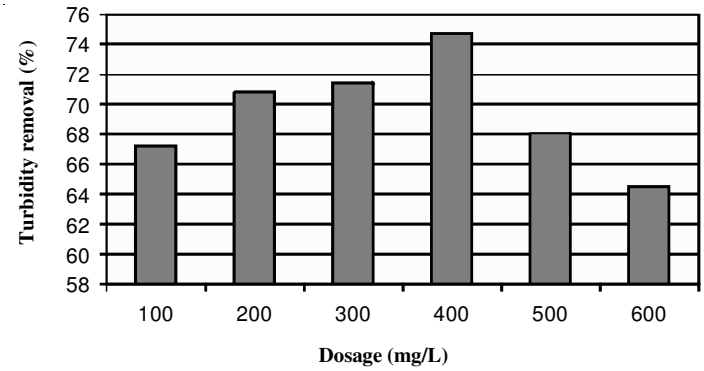

Fig. 5. Effect of ferric sulphate on turbidity removal

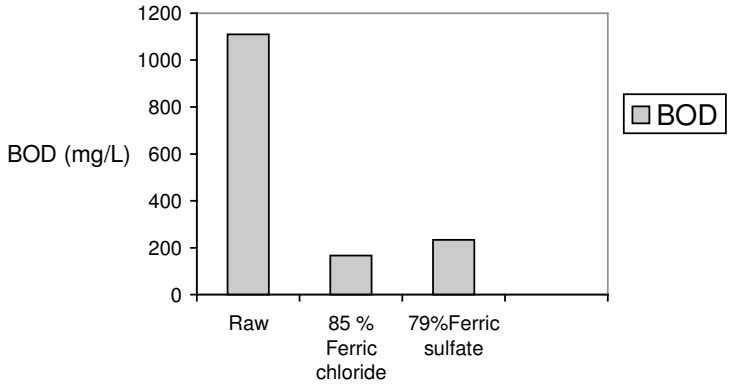

Fig. 6. Removal efficiency of BOD

Results obtained in present study indicate however that the discharge of coagulated wastewater to municipal sewage system would not be possible without correction

of some parameters. For example the achieved values of COD (520 and 324 mg/L) and BOD_5 (234 and 167 mg/L) in coagulated wastewater with ferric sulfate and ferric chloride, respectively, still exceeded discharge limits (COD-250 and BOD-100 mg/L, respectively).

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