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Study of Starch based Coagulant in the Treatment of Dairy Waste Water in Coimbatore, Tamil Nadu

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Abstract- **The usage of alum in the coagulation process of water and waste water is well known. Due to the extensive use, the sludge and sometimes also the effluent contains higher percentage of Aluminum ions. In order to prevent the same and also in reducing the cost of the chemical dosage, starch based compounds are being studied throughout the world for different kinds of water and waste water. This paper aims in studying the efficiency of starch in minimum combination with alum as a coagulant in the treatment of dairy waste water in Coimbatore, Tamil Nadu. The optimal coagulant dosage, the stirring time and the settling time is varied to find the efficient combination that results in maximum reduction in Total Dissolved Solids, Total Suspended Solids, Total carbon and Total Nitrogen.**

Key Words - Coagulation, Starch, dairy waste water, Coimbatore.

I. INTRODUCTION

The use of Almonds to clarify water was in practice in the early years of 2000 BC by the Egyptians and the usage of Alum was noticed by early Romans even though it was not specifically used for waste water treatment [1]. The work on flocculation reported that the agglomeration of colloidal particles bridge together to form microflocs which turned into visible floc masses [2].The purpose of adding coagulant aids was repotted to increase the density to slow-settling flocs and toughness to the flocs so that they will not break up during the mixing and settling processes [3].Organic removal increased with an increasing alum dose and alum doses higher than the normally used for turbidity removal, are needed to obtain the best organic removal [4]. In an experimental setup a sample of sea water is taken and the parameters are analyzed. It was found that the sample is alkaline in nature and three different coagulants namely alum ($Al_2(SO_4)_3.18H_2O$), Ferric Chloride($FeCl_3$) and Ferrous Sulphate($FeSO_4$) are chosen and the jar test is carried out. Here Alum was found to be more efficient (98.9%) than Ferric Chloride and Ferrous Sulphate for the same sample under the same experimental conditions. The optimum pH and dosage were observed to be 7.0 and 120 mg/l respectively [5].

The colloids commonly found in wastewater are stable because of the electrical charge that they carry. The charge of colloids can be positive or negative. However, most colloidal particles in wastewater have a negative charge [6].Electro-coagulation also may be considered as an alternative treatment method of oily wastewaters, as it has been applied successfully to oil and greasy wastewaters [7-8]. In order to evaluate and compare the effectiveness of ferric chloride and poly aluminum chloride (PAC) as coagulant in the pre-treatment of petroleum wastewater, an experiment was conducted on various dosages of coagulant and in different pH. The color removal efficiency, effect of pH, removal of COD and TSS with respect to different coagulants at pH 7.5 was studied. Under optimal conditions of process parameters, a coagulant dose of 10 mg/L was efficient to remove 78 and 88% of the effluents' color by ferric chloride and PAC, respectively. Varying of pH in this work showed negligible differences in the color removal efficiencies and this suggests that the solution pH can be used as optimum pH. The results obtained indicated that the best color removal was achieved at dose concentration of 10 mg/L and pH=7 [9]. The whole treatment process of coagulation – flocculation can be divided into two distinct procedures, which should be applied consecutively. The first one termed coagulation, is the process whereby destabilization of a given colloidal suspension or solution is taking place. The function of coagulation is to overcome the factors that promote the stability of a given system. It is achieved with the use of appropriate chemicals, usually aluminum or iron salts, the so-called coagulant agents. The second sub-process, termed flocculation, refers to the induction of destabilized particles in order to come together, to make contact and thereby, to form large agglomerates, which can be separated easier usually through gravity settling [10-11].

In order to accelerate the settling time, destabilization is required, denoting the importance of coagulation. The destabilization can be achieved with one, or a combination of two or more of the following mechanisms, after the addition of a coagulant agent [12-13]:

1) Compression of the electrical double layer.
2) Adsorption and charge neutralization.
3) Adsorption and inter-particle bridging.
4) Enmeshment in precipitate [11].

The application of simple metal coagulants (conventional) is widespread, especially due to the relatively low cost and the simpler application route. However, they exhibit several disadvantages, such as the need for pH adjustment before or after treatment, the sensitivity to temperature changes, the need for higher dosages because the charge neutralization is not usually sufficient, the sensitivity to sample specific characteristics and composition, as well as the excessive sludge production [11].

II. APPLICATION OF STARCH IN COAGULATION:

An area of research that has can be further explored is application of starch and starch based compounds in dairy waste water treatment. As already researched, the dairy waste water usually comprises of wash water in the transport lines, cleaning of equipments in the production cycles, washing silos, spillages of milk and other dairy constituents which constitute high organic loading. The first stage of effluent treatment involves screening and skimming. The screening helps to remove any milk packets, containers and bulk sludge blocks if any. Then the process of skimming is usually carried out by slow moving scraper blades in a tank that removes excess grease and oil. Sometimes coagulants like alum mixed with lime are added along with chlorine so that efficient settling occurs in the subsequent secondary clarifiers.

This paper aims to study the effect of alum Vs STRAL (starch + alum) in coagulation under different concentration, at different stirring and settling time. Subsequently it also aims in pointing out the significant reduction of Total Dissolved Solids (TDS), Total Organic carbon (TOC), Total carbon (TC), Inorganic Carbon (IC) and Total Nitrogen (TN).

III. METHODOLOGY

The dairy waste water is collected from the raw effluent collection chamber of a dairy unit in Coimbatore, Tamil Nadu in ten liter poly ethylene cans. The pH was made up to 4.25 at the outlet of the dairy unit in order to prevent putrefaction in the Effluent Treatment Plant (ETP). The sample is then characterized as per standards and the results are tabulated in **Table 1**. Then optimum flocculent dosage test was performed in Jar Test Apparatus.

A. Set up of Jar Test Apparatus:

250 ml of sample is taken in a 600 ml beaker after stirring the collected can in order to avoid incomplete mixing of the sample. For the alum test, 1gram of alum is dissolved in 100 ml of distilled water. Therefore 1ml of this stock solution is equal to 10 mg/l of alum dosage. Respective dosages were added according to 250 ml sample taken in the Jar Test Apparatus. For the Starch + Alum test, 1gram of starch + 0.5 gram of Alum is added to 100 ml of distilled water. Therefore 1ml of this stock solution is equal to 10 mg/l of STRAL dosage. The same procedure is followed for the Starch + lime test. Before start up of the experiment the samples are stirred rapidly of 1minute and then stirred as per the required amount of time. The results of settling for different coagulants are tabulated in **Tables 2-4.** The supernatant is pipetted in to separate beakers and they are tested for major parameters that are required only for studying the effect of flocculation. The results for different parameters for alum and STRAL coagulants are tabulated in **Table 5.**

TABLE 1. EFFLUENT CHARACTERISTICS

Characteristics	Pre- treatment
pH	4.25
colour	milky white
odour	putrid milk odour
EC	2.144 mS
TDS	1042
TSS	412
TC	1467
TOC	1426
IC	41
TN	118
Except pH and EC all values are in ppm	

TABLE 2. COAGULATION WITH ALUM

Reagent used	mg/l	stirring time (min)	settling time (min)	settling (%)
alum	40	15	20	9.65
	60	15	60	8.69
	80	15	40	11.11
	40	30	60	11.11
	60	30	40	8.69
	80	30	20	11.60
	40	45	40	8.69
	60	45	20	10.13
	80	45	60	6.38

TABLE 3. COAGULATION WITH STARCH AND LIME

Reagent used	mg/l	stirring time (min)	settling time (min)	settling (%)
Starch + lime	80	15	20	8.69
	160	15	60	13.63
	240	15	40	6.38
	80	30	60	11.11
	160	30	40	6.38
	240	30	20	11.11
	80	45	40	8.69
	160	45	20	8.69
	240	45	60	8.69

TABLE 4. COAGULATION WITH STARCH AND ALUM

Reagent used	mg/l	stirring time (min)	settling time (min)	settling (%)
STRAL (Starch + alum)	40	15	20	11.11
	60	15	60	10.62
	80	15	40	8.69
	40	30	60	6.84
	60	30	40	5.04
	80	30	20	9.17
	40	45	40	6.38
	60	45	20	6.38
	80	45	60	4.20

IV. RESULTS AND DISCUSSION

In the alum dosage test, the settling percentage varies from 6.38 to 11.60 %. The most efficient section is the 15 minute stirring speed where in the sample is stirred for 15 min under different coagulant dosage and left to settle for different time periods. In the Starch + lime test, the dosages of the coagulant are higher in order to achieve the settling that are in the range of alum. The dosages varied from 80 to 24 mg/l. This dosage will lead to carbonate hardness in the resultant supernatant. In the Starch + Alum (STRAL) test, the settling percentage varies from 4.2 to 11.11 %. Again the most efficient section is the 15 minute stirring speed as similar to the alum dosage test. From the table and as per standards we can note that whatever be the coagulant, the longer stirring and settling period the settling tends to reduce. The flocs re appear on the top layer of the settling jar. Also the longer the stirring the greater is the power consumption. Similarly the longer the settling, the lesser the treated effluent discharge from the ETP and thus reduced efficiency. Moreover we are in need of finding a coagulant combination that requires minimum chemical dosage in order to reduce the cost and also the reduction of Al [III] ions in the effluent / sludge. Therefore coagulant dosage 0f 40 mg/l, stirring time of 15 minutes and settling time of 20 minutes is taken as the optimum conditions for checking the supernatant characteristics. The experiment is repeated once again to for the selected condition with both alum and STRAL and the same settling percentage is identified.

Throughout the experiment is pH is constant at 4.25. The colour is milky white and the putrid odour is slightly reduced from the original sample. The EC is reduced from 2.144 mS to 1.813 mS in alum test and to 1.142 mS in STRAL test. The TDS is reduced to 20.92 % in alum test while there is a 30.71 % reduction in STRAL test. While the TSS results in STRAL test show a 30.58 % reduction compared to 20.87 % reduction in alum test. Total carbon (TC) is equal to the sum of Total Organic carbon (TOC) and Inorganic Carbon (IC). There is a 46.76 % reduction in TC when alum is used and there is a 53.85 % reduction in TC when STRAL is used. Also there is a 42.37 % reduction in Total Nitrogen in alum test while there is a 48.31 % reduction in the STRAL coagulant.

TABLE 5. PRE Vs POST TREATMENT

Characteristics	Pre-treatment	Post - treatment	
		Alum	*Starch + Alum*
pH	4.25	4.25	4.25
colour	milky white	milky white	milky white
odour	putrid milk odour	slightly less odour	slightly less odour
EC	2.144 mS	1.813 mS	1.142 mS
TDS	1042	824	722
TSS	412	326	286
TC	1467	781	677
TOC	1426	770	665
IC	41	11	12
TN	118	68	61
Except pH and EC all values are in ppm			

V. CONCLUSION

From the above results we can identify that starch and starch based compounds can be used in the treatment of dairy waste water that is available around Coimbatore, Tamil Nadu. This helps in significant reduction in the alum cost and thereby reducing the trivalent Al [III] ions in the effluent. Since the effluent is discharged to the agricultural lands we can safe and sure that the effluent parameters do not affect the land or the crops that are cultivated in them. Moreover, optimization of stirring and settling time contributes to the reduction in ETP operation and maintenance cost.

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