A Comparative Study on Dairy Wastewater Treatment Using Environment Friendly Coagulants

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Abstract—*Industries need huge water demand in their processes and uses fresh water increasing pressure on fresh water resources, however, this demand may be fulfilled by recycled water. Food industries has a vital role in modern industrialization, especially, dairy product industry produces wastewater, which may cause damage to the environment if not properly treated. Dairy wastewater comprises of colloidal suspension along with other organic and inorganic impurities, which requires prior treatment before discharging into the environment. It can be treated by coagulation–flocculation process. In fact, conventional chemical coagulants, which are used in removal of colloidal suspension from the wastewater, are not safe for the environment. Reuse of water treatment sludge is environment friendly as sludge handling a big issue is a big challenge for the environmentalist. The objective of this study is to investigate the coagulative property of environment friendly coagulant, recycled sludge and Moringa Oleifera seed powder for the treatment of dairy wastewater. Acidified recycled sludge and natural Moringa Oleifera seed powder has been prepared and used as coagulant in the treatment of dairy wastewater in batch operations (Laboratory scale). The entire experimentation has been carried at room temperature above 22–26^{0}C with conventional jar test apparatus by using synthetic dairy wastewater prepared of same quality of dairy wastewater. The influence of pH, turbidity, TSS and TDS along with coagulant dosages was studied in batch operations in the lab. The result shows the maximum removal efficiency of colloidal suspension as well as TSS and TDS as compare to natural coagulant. Supernatant of treated dairy wastewater shows removal of TSS and TDS as 85 and 92% respectively in comparison of dairy wastewater. Reuse of water treatment sludge produced better results than natural coagulant. The results provide useful information for treatment of dairy wastewater. This will also contributes a great help in sludge handling of water treatment plant as it can consumed in the treatment of dairy wastewater. Dairy wastewater should be treated properly for the protection of the environmental health and ecological balance. Treatment by environmental friendly coagulant will be an alternative to conventional and expensive coagulants.*

Keywords: *Dairy wastewater, Acidification, Environmental friendly coagulants, Moringa Oleifera Seed, Reuse of Water Treatment Sludge, Turbidity and Optimum dosage, TSS and TDS.*

1. INTRODUCTION

Industries need huge water demand in their processes and uses fresh water increasing pressure on fresh water resources, however, this demand may be fulfilled by recycled water. Food industries has a vital role in modern industrialization, especially, dairy product industry produces wastewater, which may cause damage to the environment if not properly treated. Dairy wastewater comprises of colloidal suspension along with other organic and inorganic impurities, which requires prior treatment before discharging into the environment. The colloidal particles are normally 1nm to 1µm in size and undergo Brownian motion. The energy developed by this motion is enough to prevent the particles from settling under gravity. Colloidal particles are negatively charged. They do not agglomerate also. Particles remain suspended for long periods of time without settling. The time of settlement of colloidal particles takes much longer duration in comparison to coarser particles, which is not possible to provide such long detention period for settling in water treatment plants (Biswas, 1985). It can be treated by coagulation–flocculation process. In fact, conventional chemical coagulants, which are used in removal of colloidal suspension from the wastewater, are not safe for the environment. Coagulation flocculation is the process in which destabilization is achieved by the addition of coagulants. The colloidal particles agglomerate and form flocs and then settle down by gravity. In a study it has been reported by Hong -Zhang Wu. et al, (2007) that Chemical coagulation is one of the most popular and effective methods for removal of colloidal suspended. Reagents may exert a negative impact on health as applied to drinking water treatment because they leave harmful monomer aluminum, and unwanted side products in effluent, especially for excessive usage (Srinivasan and Viraraghavan, 2002). Mostly chemical based coagulants are widely used in water treatment. Coagulants are classified mainly as inorganic, composite of inorganic, synthetic organic

polymer and natural coagulants. Different methods of treatments are available for the treatment of dairy waste water. A novel horizontal-flow biofilm system was designed, constructed and tested in the laboratory for removal of organic carbon and nitrogen from a synthetic dairy wastewater. When the reactor process reached pseudo steady-state, about 96% COD, 71% TN and 100% ammonium nitrogen were removed and low solids production was noticed. The system was simple and easy to construct and operate (M. Rodgers et al. 2006).dairy waste water can be treated by electro chemical treatment using aluminium electrode (Jai Prakash Kushwaha et al. 2010). The ferrous sulphate and alum are used as coagulant in chemical treatment of dairy waste water (Kokila et al. 2011). Alum is more effective than ferrous sulphate in the treatment of synthetic dairy waste water (Mahshid Loloei et al.2013).Coir is used as a support media in fixed film bed reactor to treat the dairy waste water and found that it is low cost treatment and helpful to industries (Bharati et al.2013). ECORTIE PAC 2010 is used as coagulant to reduce sludge volume and residual aluminium in water treatment. It produces larger and more rapidly settle able flocs than alum.(Juneja et al. 2011). Alum is the most common coagulant used for the treatment of water and waste water treatment. The chemical coagulants produce voluminous sludge production and causative agent for some health problems. Also, Chemical needs to be added for the pH adjustment. This lead to alternative of conventional chemical based coagulants by use of natural, locally available, safe and reliable, low cost coagulant for treatment of water and wastewater.

The coagulation with conventional coagulants can easily remove colloidal suspensions but the major drawback of the process is the production of voluminous sludge, which poses difficulty in handling and disposal to environmental engineers. According to environmental protection regulation, it is required to minimize the waste production. Therefore, the substitute of conventional coagulants, which produces lesser amount of sludge and treats the water more effectively, is the major area of research for environmental scientists. Therefore, use of produced sludge should be recycled and reused as far as possible. Acidification of sludge produced from water treatment plant by any acid is used as coagulant for treatment of dairy wastewater in laboratory in batch operations. The aluminum recovery efficiency by acidification for poly aluminium chloride-based sludge is higher than that of aluminum sulphate-based sludge (Y.J. Chen et al. 2011).The aluminum recovery efficiency by acidification was affected by the type of sediments in the water sources. The coagulation mechanism is the combination of floc sweeping and physical adsorption (Babatunde et al.2007).

Moringa oleifera plant is the most inexpensive credible alternative for providing good nutrition and to cure and prevent a lot of diseases. The coagulant in the seed is a protein that acts as a cationic polyelectrolyte. Coagulation mechanism of the Moringa oleifera coagulant protein has been described as adsorption, charge neutralization and inter particle bridging. It is mainly characteristic of high molecular weight polyelectrolyte. Moringa Oleifera has been used for the treatment of hard waters and as a bactericidal agent too. The low cost, biodegradable sludge which can later used as bio fertilizer (Vijay Kumar et al.2012) , compact sludge production (Muyibi et . al 1995) ,removes heavy metals from water,makes this coagulant a environmental friendly . It does not change the pH of the water. Natural coagulant Moringa Oleifera is used for the treatment of effluent from dairy plant. Optimum MO seed powder as coagulant was found to be 0.6gm/100ml and optimum time required for the reduction turbidity and optical density of absorbance and transmittance agitation was found to 1 hour (Harush et al.2011).

In this paper we are comparing the coagulation performance of locally available, natural Moringa Oleifera solution and acidified water treatment sludge to be used as coagulant for dairy waste water treatment using conventional jar test apparatus. The removal of turbidity, TDS and TSS has been investigated in this study.

2. MATERIALS AND METHODS

Preparation of synthetic dairy waste water

Synthetic dairy waste water has been prepared at environmental laboratory, Jamia Millia Islamia, New Delhi. It is prepared by mixing 3ml of milk (full cream mother dairy) and 1g kaolin powder per litre of water. It is then mixing properly to get uniform solution. This synthetic dairy waste water is used for experimental purpose.

Preparation of Natural Coagulant using Moringa Oleifera Seed Powder

Dry Moringa Oleifera pods those which were good and not infected with disease, were selected are collected from Munirka, New Delhi. Pod shells were removed and were dried for 48 hours. Hulls and wings from the kernels were removed manually. Kernals were grounded in a domestic mixer grinder and sieved through 600 micrometer stainless sieve. The fine powder of Moringa seeds are stored in an airtight container and kept in refrigerator to prevent the loss of its action. 6gm of Moringa powder added to one litre of distilled water and mixed well by a magnetic stirrer and finally filtered through 20µm paper filter. This solution is ready to use for the treatment of synthetic dairy wastewater.

Preparation of Acidified Recycled Sludge as coagulant (ARS)

Delhi Jal Board is using Poly Aluminum Chloride (PAC) for treatment of surface water at Chandrawal Water treatment plant. Sludge produced from treatment of water has been collected for recycle and reuse in treatment of dairy wastewater. Sulphuric acid of different normality 1N, 1.5N,

2N, 2.5N, 3N, 3.5N and 4N has been prepared as per the standard practice. The sulphuric acid of required normality is added at the rate of 0.02ml/l of water treatment sludge and mix swiftly and allowed to stand for 40 minutes. The Acidified Recycled Sludge (ARS) is ready for use as coagulant. Following this procedure ARS is prepared for 1N, 1.5N, 2N, 2.5N, 3N, 3.5N and 4N. ARS is added in the conventional jar test to find out the optimum dose of coagulant.

Colloidal suspension removal using jar test

One litre of synthetic dairy water sample was collected in a 2000ml jar and added 5ml to 30ml of WTS of 1N with an increment of 5ml to each beaker respectively. After a flash mixing of 2 minutes and then 20 minutes of slow mixing the sample containing coagulant were allowed to kept undisturbed for another 30 minutes to settle the flocs formed. The turbidity of the supernatant has been measured using digital Nephlo Turbidity Meter to find out the colloidal suspension removal from water. Perform the jar test for 1.5N, 2N, 2.5N, 3N, 3.5N and 4N also.

The jar test is repeated for natural coagulant using Moringa seed. Various doses of natural coagulant ranging from 10 to 80 ml/l with an increment of 10 ml/l have been added to Jar test beaker.

The percentage turbidity removal can be evaluated by the expression

$$\text{Percentage turbidity} = \frac{(\text{Initial} - \text{Final})}{(\text{Initial Turbidity})} * 100$$

Determination of total dissolved solids and total suspended solids

The characteristics parameters of the synthetic dairy waste water have been analyzed using standard methods. Total Dissolved solids are the portion of solids that passes through a nominal pore size under specified conditions. Suspended solids are the portion retained on the filter. Gravimetric method is used for determination of TSS and TDS. The procedure is as follows. Take initial weights of Whatman filter paper no 44 or 41 and crucibles. Take 50 ml of sample and filter the sample through filter paper. Keep the filter paper with residue in oven at 105^0C for 24 hours. Measure the volume of filter water and transfer it to empty crucible. Keep the filled crucible in oven at 180^0C for 24 hours. After 24 hours measure the weight of dried filter paper and crucibles.

$$\text{TSS (mg/l)} = \frac{(\text{Final weight} - \text{Initial weight}}{\text{ml of sample used}} \times 1000$$

$$\text{TDS(mg/l)} = \frac{(\text{Final weight, crucible} - \text{Initial weight, crucible}}{\text{ml of sample used}} \times 1000$$

3. RESULTS AND DISCUSSION

The synthetic dairy wastewater was tested for turbidity, TSS and TDS. Sample was observed as 372 NTU, 348 mg/l and 1183 mg/l as initial turbidity, TSS and TDS respectively.

Turbidity Removal by Environmental Friendly Coagulants:

a) ARS: Conventional Jar test was performed to examine turbidity removal efficiency from synthetic wastewater using ARS and natural coagulant, which was carried out in the Environmental Engineering Laboratory of Jamia Millia Islamia University, New Delhi. ARS of different normality applied for to determine the optimum dose for effective and efficient removal of turbidity. ARS prepared from sulfuric acid of 1N to 4N normality doses started from 5 ml/L to 30 ml/L with an increment of 5 ml/l was applied in jar test and results presented in Table 1.

Table 1: Turbidity Removal by ARS of different Normalities

ARS Dose ml/l	Turbidity removal, % by Acidified Recycled Sludge of							pH
	1 N	1.5 N	2 N	2.5 N	3 N	3.5 N	4 N	
5	7.7	8.2	23.8	54.6	74.2	66.2	35.7	7.85
10	10.5	13.7	32.5	62.5	80.6	68.5	38.7	7.9
15	14.8	16.8	38.9	71.6	84.6	72.6	40.1	7.82
20	20	22.6	45.7	73.6	89.7	78.2	41.2	7.95
25	27	25.5	58.6	78.4	92.8	72.9	42.1	7.23
30	32	24.8	60.5	82.2	91.3	72.2	40.4	7.75

The all test are performed at normal pH condition and also presented along with results. Table 1 shows the optimum turbidity removal efficiency 92.80% at 25/l dose of ARS 3N normality and same is reflected in the figure 1 below:

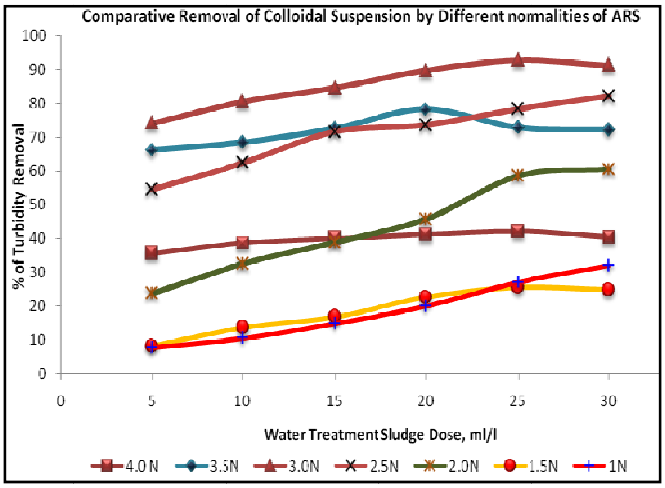

Fig. 1: Turbidity Removal efficiency by ARS

b) Natural Coagulant prepared by Moringa Oleifera Seed powder: Moringa Oleifera (MO) seed powder solution used as coagulant to determine the turbidity removal efficiency from synthetic dairy wastewater. Natural coagulant doses started from 10 ml/L to 80 ml/L with an increment of 10 ml/l was used in jar test apparatus to determine the optimum dose. Turbidity, pH and TDS were measured before and after treatment in application of both coagulants. The results are presented in table 2 which shows the maximum 91.5% turbidity removal efficiency is obtained at 60 ml/l dose of natural coagulant and same is presented in figure 2.

Table 2: Turbidity Removal by Natural Coagulant

Sr. No.	Dose ml/l	pH	Turbidity Removal Efficiency %
1	10	7.22	13.71
2	20	7.42	29.57
3	30	7.4	42.47
4	40	7.28	55.65
5	50	7.6	72.85
6	60	7.5	91.48
7	70	7.7	81.99
8	80	7.78	76.08

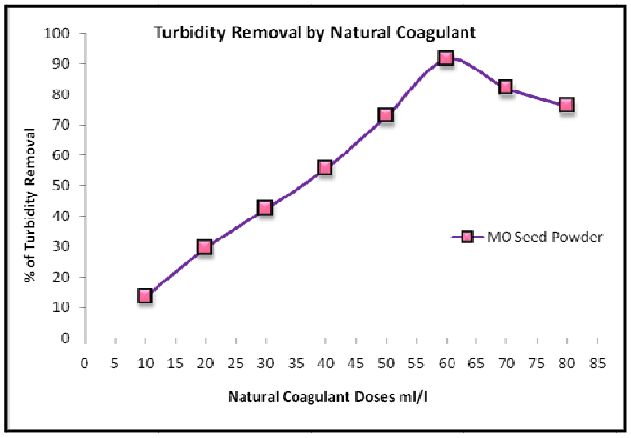

Fig. 2: Turbidity Removal efficiency by Natural Coagulant

From the above results it has been observed that ARS is more efficient in removal of turbidity as compare to natural coagulant of 25 ml/l dose of 3 N normality. Natural coagulant optimum turbidity removal efficiency is 91.48% at 60ml/l doses as compare to ARS is 92.80% at 25 ml doses of 3 N.

TSS and TDS Removal:

By using optimum doses, samples had been tested to check the removal efficiency of TSS and TDS from the dairy wastewater in the laboratory initially and finally after the jar test. Table 3 and 4 present the average of initial and final TSS and TDS respectively measured from the synthetic dairy wastewater.

Table 3: TSS in Dairy wastewater and its removal by environment friendly coagulants

Sr. No.	Dairy Waste water TSS per liter in mg	TSS Treatment by Natural Coagulant in mg/l	Treatment by ARS in mg/l
1	321	69.50	51.70
2	332	62.40	46.40
3	348	58.00	54.00
4	352	65.00	59.10
5	341	67.00	53.00
6	354	68.00	50.00
7	358	69.00	54.00
8	344	65.00	54.90
9	375	72.00	52.00
10	354	66.00	49.20
11	342	76.00	55.20
12	355	69.00	53.20
Average	348.00	67.24	52.73
	TSS % Removal	81	85

Table 4: TDS in Dairy wastewater and its removal by environment friendly coagulants

Sr. No.	Dairy Waste water TDS per liter in mg/l	Treatment by Natural Coagulant in mg/l	Treatment by ARS in mg/l
1	1145	220	198
2	1089	225	221
3	1242	210	212
4	1205	208	197
5	1184	213	187
6	1209	229	205
7	1169	221	212
8	1201	221	211
9	1225	231	209
10	1169	205	204
11	1174	241	198
12	1236	233	189
Mean	1187	221	204
TDS % Removal		81	83

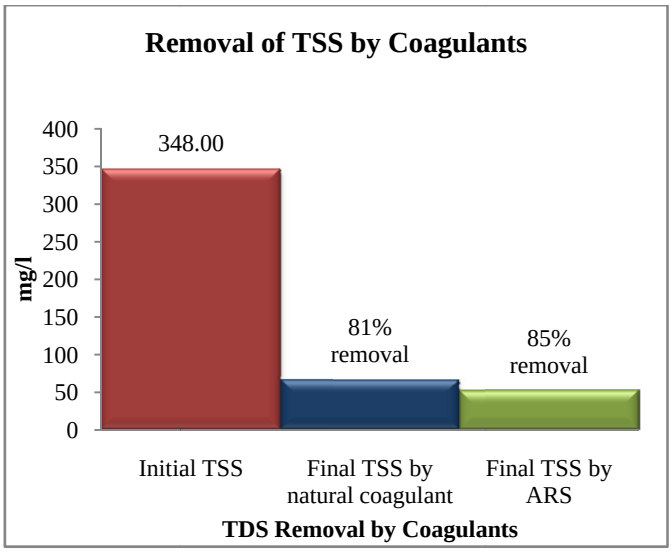

Fig. 3: Removal of TSS by Environmental Friendly Coagulant

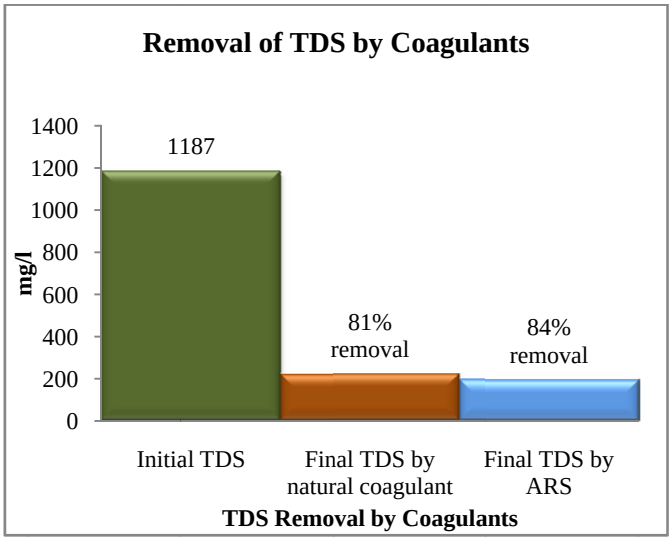

Fig. 4: Removal of TDS by Environmental Friendly Coagulant

4. CONCLUSIONS

The results show that the ARS is more efficient than Moringa Oleifera seeds powder solution in terms of removal of turbidity, TSS and TDS from synthetic dairy industrial wastewater. Moringa Oleifera seeds powder being natural product–non- toxic is safer to the environment than conventional coagulants. ARS prepared from recycling of water treatment sludge which is also safe to the environment by recycling. Sludge handling problems can be sorted out by reuse of water treatment sludge. This will be an alternative to conventional and expensive coagulants

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