Comparative Study of Tilted Plate Interceptor And Air Floatation Technology For Reduction of Oil And Grease From Dairy Effluent

Harsh Shah[1], Vaibhavi Nagar[2]
[1]Dept of Environmental Engineering
[2]Professor, Dept of Environmental Engineering
[1, 2] Venus International College of Technology, Gandhinagar, Gujarat, India

Abstract- *Dairy effluent contains high COD, BOD, Oil and Grease, organic and inorganic compounds. Many technologies such as API (American Petroleum Institute) gravity separator, TPI (Tilted Plate Interceptor), DAF (Dissolved Air Flotation), Hydrocylone and Filtration treatment available for removal oil and grease from industrial effluents. The present paper shows the comparative study of two technologies i.e air floatation and tilted Plate Interceptor, for its removal efficiency, applicability and cost effectiveness. Sample collected on different time interval at same initial wastewater characteristics from dairy effluent.*

Keywords- Bubble Floatation, Coagulation-Flocculation Process, Oil and Grease, Tilted Plate Interceptor

I. INTRODUCTION

Indian dairy industry is one of the leading dairy industries in the world. India is well known as the 'Oyster' of the global dairy industry. The Dairy industry in india however appeared to have weekend during the 90's, a declined in the price of milk being noticed after the year 1992. The Indian dairy sector is characterized by high fragmentation. It is dominated by the unorganized sector comprising of 70 million rural households. The per capita availability of milk in India stands at 289.4 grams per day.

Dairy effluent is most polluting in terms of volume of effluent generated as well as in terms of its characteristics to, 0.2 to 10 L of effluent generated per litre of processed milk. Wastewater generated from several sources like receiving station, bottling plant, cheese plant, butter plant and ice cream plant.[7] Dairy wastewater can be characterised as high chemical oxygen demand, oil and grease, biological oxygen demand, nutrients and organic & inorganic contents. In dairy industries, water has been a key processing medium. Water is used throughout all steps of the dairy industry including cleaning, sanitization, heating, cooling and floor washing — and naturally the requirement of water is huge.

The environmental protection agencies have imposed more stringent regulatory prohibitions and they have started more strict vigil along with some non-governmental organizations to protect the environment. This has made the water treatment more expensive and to comply with the discharge quality standard itself, is becoming a huge burden for the industries.

Oil has two basic forms in wastewater:

- Non-emulsified: Oil that floats on the surface of the water and is more easily removed before wastewater treatment.
- Emulsified: Oil that was subjected to chemical or mechanical action and dispersed into the water. It does not float on the surface and requires more sophisticated techniques for removal before wastewater treatment.

The oil and grease content of domestic and certain industrial waste water is an important in handling and treatment of these materials for ultimate disposal. Oil and grease may influence waste-water system, if presents in excessive amount. They may interfere with an aerobic and anaerobic biological process and lead t decreased waste water treatment efficiency. The knowledge of quantity of oil and grease present in effluent is helpful in proper design and operation of waste water. Industrial waste contains high quantity of oil and grease which may cause a serious problem if discharged into water body without treatment.

Oil and grease causes ecology damages for aquatic organisms. Untreated effluent affect in decreased dissolve oxygen. Oil and grease layer reduces biological activity of treatment process where oil film formation around microbes in suspended matter and water.

The present study focuses on comparison of technology used for reduction of oil and grease from dairy effluent.

Definition Fats, Oil and Grease

Fats, oil and grease (FOG) can be solid or viscous liquid depending on the saturation of carbon chain. Oils and fats are a subsection of lipids that are composed of fatty acids, triacylglycerol, and lipid-soluble hydrocarbons that are minor but important components of FOG. [5]

Physical properties Fats, Oil and Grease

FOG may occur as liquid or solid and is characterized by a greasy texture. FOG is colourless, odourless and tasteless. Moreover, FOG is insoluble in water but soluble in organic solvents such as hexane, ether and chloroform. [5]

FOG has density less than water (<1) and thus, it floats on the water surface. However, FOG will form emulsions with aqueous media in the presence of soap and other emulsifying agents. Generally, FOG has high viscosity that varies based on the fatty acids composition and presence of double bonds. Viscosity of FOG inversely proportional to double bonds presents in carbon chain. [5]

Chemical properties Fats, Oil and Grease

FFAs are chemically active and readily undergo saponification in the presence of sodium hydroxide and potassium hydroxide, which act as strong agents for generating metallic soap. [5]

EXPERIMENTAL SET UP

1. **Materials**

Raw wastewater sample was collected from Sumul Dairy, Surat. Sample collected freshly and treated on pilot scale unit for reduction in oil and grease.

1.1 Reagents

Before Oil and grease removal treatment, coagulation and flocculation process carried out. Poly aluminium chloride (PACl) used as a coagulant and Polyelectrolyte used as a flocculant.

2. **Air Floatation Treatment**

Floatation is unit operation used to separate solid or liquid particles from a liquid phase. Separation carried out by introducing air bubbles into the liquid phase. The bubbles attach to the particulate matter, and the buoyant force of the combined particle and bubble is great enough to cause the particle to rise to the surface. [9]

The principal advantage of floatation is that very small particles or light particles that settle slowly can be removed more completely in shorter time. In this system, the degree of removal can be enhanced through the use of various chemical additives. Inorganic chemicals and organic polymer can be used to change the nature of either the air-liquid or solid-liquid interface, or both. [9]

Dairy wastewater having high organic matter, in which oil and fats contains 8%-12%. Oil in water may be dispersed, emulsified or soluble oil concentrations usually up to 1000 mg/L.

2.1 Experimental Procedure

Pilot scale air floatation treatment having 90 L capacity to treat dairy effluent. After coagulation and flocculation, effluent passed at constant flow rate in the air floatation tank. Air passed at flow rate of 4 L/min through air pipe. Baffle glass restrain the effluent and treated water collected from other side of baffle glass. Particles start settle down or float.

Figure 1: Pilot Scale Air Floatation Treatment

3. **Tilted Plate Interceptor Treatment**

Tilted Plate interceptor is gravity separator, which utilize the difference in specific gravity between two phases.

The tilted plate interceptor works under less surface area requirement of a separator by introducing multi-layer separation. It is feasible to achieve removal of particles which could not be possible in single large surface separator. In tilted plate interceptor, plates are installed at an angle of 45° to 60° so that separated material can be collected and removed by gravity.

Tilted plate pack type separators are known as corrugated plate interceptor or as CPI separators. In TPI high density will settle and with lower density float to the surface of effluent. Sometimes Chemical coagulation and flocculation is important for removal heavier or lighter suspended particles.

3.1 Experimental Procedure

Pilot scale tilted plate interceptor having 30 L capacity to treat dairy effluent. After coagulation and flocculation, effluent passed at constant flow rate in the tilted plate interceptor. Plates are inclined at 55°. Due to inclination heavy solids settle down and lighter particles start to rise upwards.

Figure 2: Pilot Scale Tilted Plate Interceptor

4. Analytical Procedure

Oil and grease analyses attempt to quantify compounds which have a greater solubility in an organic solvent than in water. The principal types of compounds included in oil and grease analyses are fats, soaps, fatty acids, hydrocarbons, waxes, and oils. The contribution of each of these substances will depend upon the origin of the wastewater being analysed and the type of extracting solvent used.

Initial analysis and after different retention time sample collected from both technologies for analysing of oil and grease. Effluent pH analysed by pH meter. Standard methods described by APHA have been followed for carrying out oil and grease analysis i.e 5520 B: Partition-Gravimetric method.

III. RESULTS AND DISCUSSION

The dairy wastewater collected from Sumul Dairy, Surat varied according to productions. Generally it had bad smell and was light whiteness in colour. Effluent pH was from medium to higher alkaline range.

A. Effect of Coagulant and Flocculant on pH

Coagulation-flocculation is important physicochemical process steps in industrial wastewater treatment. Coagulant destabilizes the particles through chemical reaction and flocculation transport the destabilized particles that will cause collisions with floc.

Table 1 show the effect of PACl dosage on various sample collected from dairy effluent.

Table 1: PACl and Polyelectrolyte dosage effect on pH

Polyelectrolyte (ml/L)	PACl Dosage (ml/L)	Initial pH	After Dosage pH
2.0	2.0	11.6	7.8
2.0	2.5	11.6	6.9
2.0	3.0	11.6	6.0

B. Results of Oil and Grease Reduction at pH 7.8

Table 2: Oil and Grease Reduction by Air Floatation Treatment

Retention Time (min)	Inlet O&G (mg/L)	Outlet O&G (mg/L)
5	308	142
15	308	127
30	308	105
60	308	92
90	308	115
120	308	130

Table 3: Oil and Grease Reduction by Tilted Plate Interceptor

Retention Time (min)	Inlet O&G (mg/L)	Outlet O&G (mg/L)
5	308	181
15	308	155
30	308	132
60	308	121
90	308	129
120	308	145

C. Results of Oil and Grease Reduction at pH 6.9

Table 4: Oil and Grease Reduction by Air Floatation Treatment

Retention Time (min)	Inlet O&G (mg/L)	Outlet O&G (mg/L)
5	308	130
15	308	103
30	308	60
60	308	72
90	308	110
120	308	121

Table 5: Oil and Grease Reduction by Tilted Plate Interceptor

Retention Time (min)	Inlet O&G (mg/L)	Outlet O&G (mg/L)
5	308	171
15	308	150
30	308	124
60	308	107
90	308	127
120	308	141

D. Results of Oil and Grease Reduction at pH 6.0

Table 6: Oil and Grease Reduction by Air Floatation Treatment

Retention Time (min)	Inlet O&G (mg/L)	Outlet O&G (mg/L)
5	308	122
10	308	110
15	308	100
30	308	106
60	308	130
90	308	136
120	308	122

Table 7: Oil and Grease Reduction by Tilted Plate Interceptor

Retention Time (min)	Inlet O&G (mg/L)	Outlet O&G (mg/L)
5	308	165
15	308	149
30	308	132
60	308	128
90	308	140
120	308	148

E. Percentage Reduction of Oil and Grease

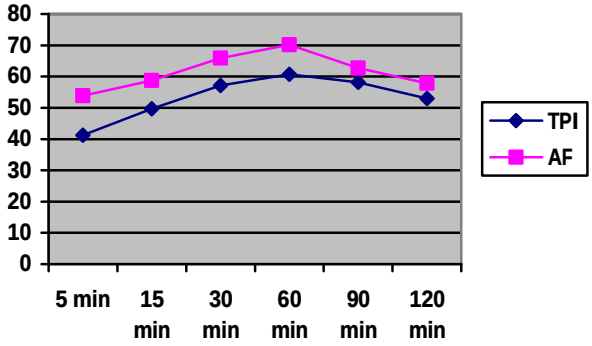

Figure 4: Comparison of % reduction at pH 7.8

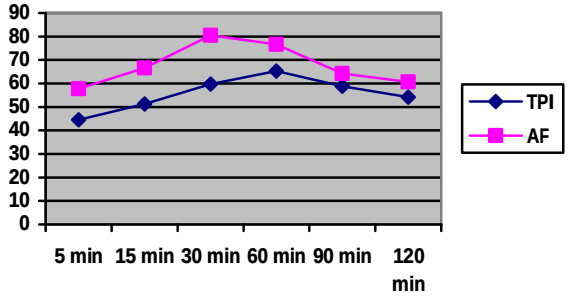

Figure 5: Comparison of % reduction at pH 6.9

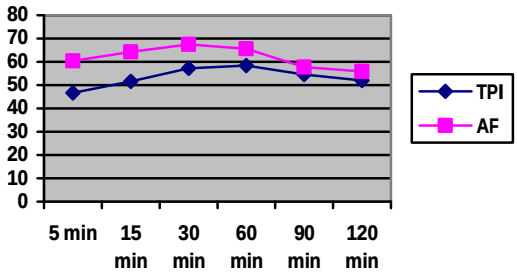

Figure 6: Comparison of % reduction at pH 6.0

As per the results, maximum reduction in oil and grease by Air Floatation at pH 6.9 with 30 min retention time was 80.52% and by Tilted Plate interceptor at pH 6.9 with 60 min retention time was 65.26%.

F. Maximum Reduction of Oil and Grease at different pH

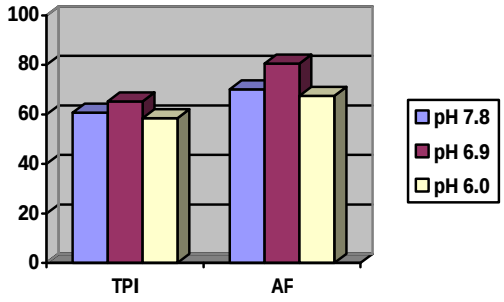

Figure 7: Maximum Reduction at different pH

The maximum reduction at pH 7.8, pH 6.9, and pH 6.0 by TPI was 60.71%, 65.26% and 58.44% at 60 min retention time for all. The maximum reduction at pH 7.8, pH 6.9, and pH 6.0 by AF was 70.13%, 80.52% and 67.53% at 60 min, 30 min and 30 min retention time respectively.

IV. CONCLUSION

This research paper studied Tilted Plate Interceptor and Air Floatation technologies used for removal of oil and grease from industrial effluent. Choice of technology apply is based on effluent flow rate, effluent characteristics, space availability and cost-effectiveness.

2.5 ml/L dosage of Poly Aluminium Chloride (PACl) dosage with 2 ml/L of polyelectrolyte shows good results for both treatments at nearly to neutral pH phase.

Air Floatation treatment works under variable flow rate, installation cost was high, required space was medium and maintenance cost was medium. Maximum O&G reduction by Air Floatation was 80.52% at 30 min retention time.

Tilted Plate Interceptor works under constant flow rate, installation cost was less, required space was less and maintenance cost was high. Maximum O&G reduction by Tilted plate Interceptor was 65.26% at 60 min retention time.
Overall conclusion of this study was that air floatation treatment gives maximum reduction in O&G compared to Tilted Plate Interceptor with medium to high cost ranges.

V. ACKNOWLEDGEMENT

Authors would like to acknowledge Sumul dairy, Mr. Shailendra Gaikwad and Mr. Sunil Pandey for their support and valuable suggestions throughout the study.

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