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Increasing the Sludge Treatment Efficiency of a Food Processing Industry

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Abstract - ***The Indian food processing industry is one of the largest in the world in terms of production, consumption, export and growth prospects. Increase industrialization with literacy and affluence has given a considerable push to the food processing industry growth. Characteristics of food industry wastewater depict wide variation due to the distinct the type of products manufactured, raw materials used, processing technique etc. Wastewater poses pollution problems due to its high COD, BOD, TSS, excessive nutrient compounds like nitrogen and phosphorous etc.***

The effluents from the food processing industry contain matter in suspension, as well as organic and inorganic compounds in solutions, due to which the load on treatment facility increases leading malfunctioning. It is therefore preferable to provide effective primary treatment, using different coagulant and coagulants aids thus the organic load on secondary biological treatment reduces. Keeping this in view, coagulants, Aluminum Sulfate and Cationic polyelectrolytes were used in the treatment. The resulting Sludge from various treatment process is disposed after suitable treatment and handling which is directly associated on costs. A Bench Scale Model was incorporated and several experiments were carried out to fix a specific dosage which will help in reducing the suspended solids carry over.

Key Words:*Food processing Industry, Chemical Oxygen Demand, Biological Oxygen Demand and Total Suspended Solids*

1. Introduction

Ever increasing industrialization and rapid urbanization have considerably increased the rate of water pollution. The environmental protection agencies have imposed more stringent rules 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. The problem is more severe in developing countries where rapid population growth and industrialization has increased complexity of effluents. In most cases, these effluents are not treated and are simply thrown into rivers where they contribute to eutrophication by addition of phosphorus and nitrogen compounds. Food processing industry wastewater poses pollution problems due to its high COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand). Moreover, the characteristics of wastewater depict wide variation due to the variation in the type of products manufactured and also the different fruits, vegetables and raw materials used. Many preservatives, color, salts, oil, sugar, gelatin etc. are added as per the requirement of production of various products, this adds to the pollution load. Because of these problems, the load on conventional treatment unit which employ anaerobic and aerobic reactors for the treatment generally malfunctions. It is therefore preferable to provide primary physicochemical treatment, using different coagulant and coagulants aids thus the organic load on secondary biological treatment. Keeping this in view, commonly available coagulants like lime, alum, ferrous sulfate, and ferric chloride, and few different polyelectrolytes as a coagulant aid were studied. (Lee et al, 2013)

Almost 50% of the water utilized in food processing industry is for washing and rinsing purposes. Water being the primary ingredient is widely used as a cleaning agent in food processing industry.

Physicochemical wastewater treatment techniques are applied for the removal of heavy metals, greases, suspended matter, organic and inorganic components, difficult to decompose, non-polar organic substances, toxic pollutants or high salt concentrations, phosphorus. The physicochemical wastewater treatment techniques are used as pretreatment, final treatment as well as specific treatment for wastewater reuse as process water.

2.Characteristics of Food Industry Wastewater

The wastewater of the food industry generally contains carbohydrates, inorganic and organic salts, oil, sugar, starch, detergents, cleaning products and high concentration of proteins. These constituents generally exerts load on biological process hence a primary treatment by way of physicochemical treatment is needed to reduce the organic load on secondary treatment.

The food Industry wastewater shows large variation in BOD, COD, total solids, oil and grease, starch, sugar, color, preservatives, total nitrogen, total phosphates, chloride and sodium etc.

Parameters	Concentrations
pH	4.12 – 4.28
Color (Visual)	Brownish Black
Total Acidity/Alkalinity as $CaCO_3$	980 mg/L
Total Suspended Solids	2210 mg/L
Total Dissolved Solids	1620 mg/L
Total Solids	3830 mg/L
COD	11220 mg/L
BOD_5 @ 20^0C	6860 mg/L
Sulfide as (S^{-2})	264 mg/L
Sulphates as (SO_4^{-2})	280 mg/L
Total phosphates as (PO_4^{-2})	3.2 mg/L
Total Nitrogen as N	16.4 mg/L
Oil and Grease	110 mg/L

Table 1: Typical Characteristics of Food Industry Wastewater

2.1Industrial Wastewater Treatment

Biological Treatment technologies have made its mark in the field of wastewater management, since the effluent from these industries is highly rich in nutrients and organic pollutants thus favoring efficient microbial degradation. For the present study, aerobic biological treatment technologies namely; Stabilization

Pond, Activated Sludge Process, Fluidized (Floating) Aerobic Biological Reactor (FABR) and Rotating Biological Contactor, were referred in order to understand their applicability to various food processing industries. Stabilization, Conditioning, Thickening, Dewatering, and Drying are other methods of treating the Effluent in a food Processing Industry. The disposal of sludge always requires careful management but the ease, or difficulty, with which disposal is actually achieved, and the associated costs depend very much on circumstances.

2.2Industrial Sludge

Sludge is produced from the biological decomposition of the organic discharges from food processing industry. Higher contents of carbon (C), hydrogen (H) and oxygen (O) is seen in the food processing sludge. The dried bio sludge had abundant in lignocelluloses, lipids, proteins, ash, and other components. As a consequence, the bio sludge had lower carbon, hydrogen, and heating content. Compared to values of 75.3% C, 5.4% H and 15.6% O for coal, these bio solids have much higher oxygen contents and lower carbon contents than those of coal, while the hydrogen contents in both biomass and coal are comparable.

3. Chemical Treatment of Sludge

Conventional chemical additives include aluminum sulfate, ferric chloride, polyelectrolyte, enzymes and surfactants etc. Surfactants are a group of compounds which can lower the surface tension between liquid/liquid or liquid/solid interface. They could alter microbial cell structure by detaching cell materials from sludge surfaces and thus affect sludge properties. Several studies suggest that addition of surfactants could substantially reduce the water content of sludge, making it possible to serve as dewatering agents. Nevertheless, the application of surfactants in sludge dewatering is still very limited and the mechanism of surfactant action has not been well clarified. In the present work, the surfactants used are Aluminum Sulphate and Cationic Polyelectrolyte (Lee et. al, 2013).

3.1Coagulation with Aluminum Sulphate

The most common and economical is alum ($Al_2(SO_4).nH_2O$) and widely used as a coagulant in the water treatment. The aqueous chemistry of aluminum is complex and upon addition of an aluminum coagulant in water treatment, multiple reaction pathways are possible. The mechanism with which aluminum functions depends on which aluminum species react to remove dissolved or colloidal contaminants.

Destabilization involving aluminum monomers is referred to as charge neutralization or coagulation of colloidal particles in the presence of $Al(OH)_3$ is termed as enmeshment or sweep floc. Dissolved organic can be removed by adsorption of aluminum precipitation. From the numerous reviews of the fundamental theory and mechanism of coagulation, various mechanisms for destabilizing contaminants using chemical coagulants have been identified. These mechanisms include double layer compression, adsorption charge neutralization, sweep coagulation, and inter particle bridging. The type of inter actions between the chemical coagulant and contaminants determine the mechanism of coagulation. The predominance mechanisms observed during conventional coagulation with metal coagulants are adsorption charge neutralization and sweep coagulation (Sahu et al, 2013).

3.2 Coagulation with Cationic Polyelectrolyte

Polyelectrolyte's or polymers consist of simple monomers that are polymerized into high molecular weight substances with molecular weights varying from 10^4 to 10^6 Daltons. Polymers can vary in molecular weight, the structure, and amount of charge, charge type, and composition. With respect to charge, organic polymers can be cationic, anionic, or non-ionic. Polymers in solution generally exhibit low diffusion rates and raised viscosities, thus, it is necessary to mechanically disperse the polymer into water. This is accomplished with short, vigorous mixing to maximize dispersion, but not so vigorous to degrade the polymer or the flocs as the form.

Lower coagulant dose requirements, a smaller volume of sludge, a smaller increase in the ionic load of the treated water, reduced level of aluminum in treated water, cost savings up to 25-30%. Since wastewater particles are normally charged negatively, low molecular weight, cationic polyelectrolyte's can act as a coagulant that neutralizes or reduces the negative charge of the particles, similar to the effect of alum or ferric chloride (Sahu et. al., 2013).

4. Materials and Methodology

The present was carried out in a food processing industry located in Mysore, Karnataka.

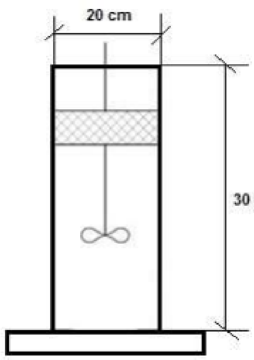

Figure 1: Bench Scale Model Setup

A Reactor was fabricated in order to carry out the experiments. It was manufactured using Plexy Glass. It has a fixed stirrer for agitating the sludge sample. It has a height of 30cm and diameter of 20cm.The pH meter calibration was done using sulfuric acid and sodium hydroxide. The sludge sample without adding any coagulant was taken in the reactor. The sample was thoroughly agitated with the stirrer in the reactor and allowed to settle for half an hour. The settlement of sludge was recorded graphically.920ml of suspended solids was settled in that 1L of sludge sample. Several trials were carried out with sludge sample without adding coagulants.

Later another sample of 1L of sludge was taken and 2gm of Aluminum Sulphate and 0.008gm of Cationic polyelectrolyte was added to the sludge sample. The result taken after 30mins was 700mgof suspended solids were formed in that 1L sludge. Later both the coagulant dosages were added with a rate of 1% Aluminum Sulphate and 0.05% of Cationic polyelectrolyte. After so many trials carried out in the reactor, an optimum dosage was fixed which reduced the suspended solids carry over. The dosage was, 0.68gm of Aluminum Sulphate and 0.034gm of Cationic Polyelectrolyte for the 1L of sludge sample.

5. Effect of coagulant Dosage

Industrial Coagulant and coagulant aid dosage was found to be not effective. Hence, the Bench Scale Study were conducted and new dosage were found as 8Kg/day Aluminum Sulphate and 200gm/day Cationic Polyelectrolyte. Without using any of the coagulants, the result of Variation of Sludge Volume Index with Time (without coagulants) is 920ml/l as shown in the Chart 1.This was because of high density of colloidal particles.

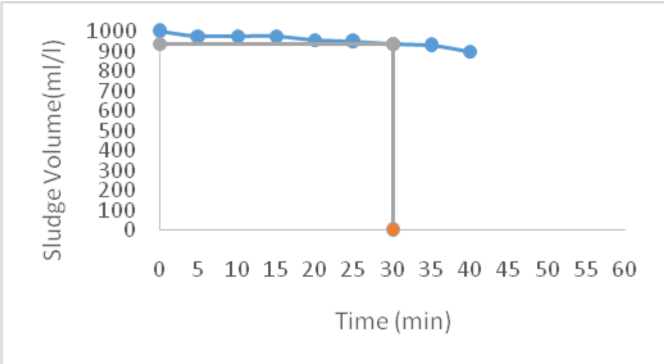

Chart -1:Variation of Sludge Volume Index with Time (without coagulants)

The industrial dosage was, 25Kg Aluminum Sulphate and 100gm Cationic Polyelectrolyte. When this dosage was used, the quantity of water dewatered is 300ml. It indicates that the industrial dosage is not so efficient to attain appreciable dewatering. The result of Variation of

Sludge Volume with Time (Industry Dose) is 700ml/l as shown in the Chart 2. This was due to destabilization of colloidal particles and agglomeration of the particles with subsequent settling.

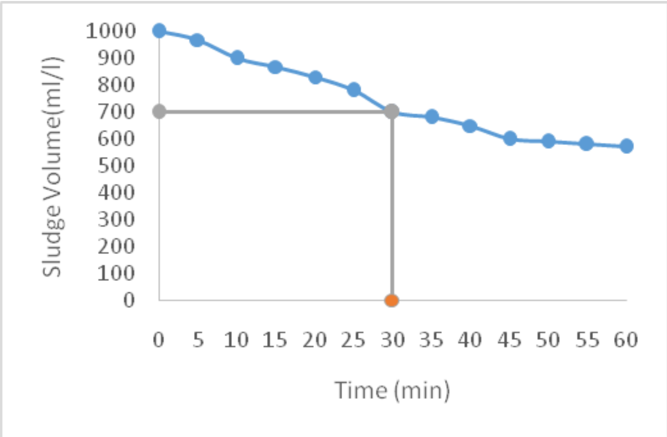

Chart -2:Variation of Sludge Volume with Time (Industry Dose)

When the optimum quantity of coagulant was used, i.e., 8kg Aluminum Sulphate and 200gm Cationic Polyelectrolyte, the quantity of water dewatered was 590ml. It indicates more quantity of dewatering is attained due to the usage of optimum dosage. When more quantity is dewatered, the sludge removal is easy and also efficient. The result of Variation of Sludge Volume with Time (Optimized Dose) was 410ml/lis as shown in Chart 3.

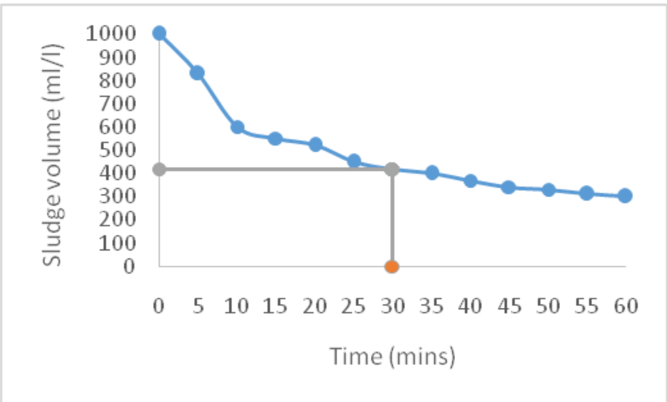

Chart -3:Sludge Volume Index with Time (Optimum Dosage)

6. CONCLUSIONS

The Optimized coagulant dosage was more effective which reduced the suspended solids carry over. It was also observed that there was reduction in the per day cost of coagulant usage. The Aluminum Sulphate and Cationic Polyelectrolyte dosage per batch was fixed to 8Kg and 200gm respectively.

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