Chapter II

LITERATURE REVIEW

A. Soya - Bean

Analyis of soya - bean Analysis of soya - bean is as following:

Moisture	10	gm.	per 100 gm soya-bean
Fat	17.7	gm.	"
CHO	33.5	gm.	"
Fiber	4.9	gm.	"
Protein	34.1	gm.	"
Ca	226	mg.	"
P	554	mg.	"
Fe	8.4	mg.	"

Protein is one constituent of soya - bean, others are:-

Carbohydrates are in the form of cellulose and cellulose derivatives, sugars, starch and glycerides.

Organic phosphorus compounds, these phosphorus - containing substances include inorganic phosphates and nucleic phosphorus compounds such as phosphoproteins and nucleic acid derivatives, phosphatides and phytin. The bulk of phosphorus in soya - bean is present in the form of phosphatides and phytin.

Organic acids, various organic acids are presented in the soya - bean in the free or loosely combined form. These acids are tartaric acid, free amino acids, and oxalic acid.

Hydrolysis of soya - bean. Soya - bean can be hydrolysed by

Steam, the results of hydrolysis of soya - bean protein by steam at temperatures from 140 - 195°c for 4 - 5 hours were reported by Nakazima and Ikeda.

Acids

Alkalines

Enzymes

Yeasts, Molds and Bacteria, these organisms attacked both carbohydrates and proteins. Sibata used an activated sludge process to dispose of protein wastes from soya - bean fiber manufacture.

Precipitation of protein The range of minimum solubility of protein is approximately pH 3.5 to 5.0, therefore any acid will precipitate soya - bean protein from aquous or alkalinity solutions if added in sufficient amount to reach this pH range, and any base will precipitate it from acidic solution if added under the same conditions.

Heat has been recommended in conjunction with other precipitants. Metallic salts, including alkaline earth and heavy-metal salts, copper sulfate, copper acetate, zinc sulfate and zinc acetate, salts of copper, magnesium or lead, alum and ferrus sulfate have been used as precipitants. Alcohol, formaldehyde, and acetone have also been suggested as precipitants.

Effect of pH of precipitation Soya - bean pretein precipitated at pH 5.4 has a higher nitrogen content than that precipitated at pH 4.0, the bulk of the impurity being precipitated at the lower pH. This observation is corroborated by Fontaine and co-workers.

B. Plain Sedimentation

Plain sedimentation is most efficient in removing coarse solids and is suitable for wastewater of high settleable and suspended solids. E.W. Steel (1960) suggested that the detention periods ranges from 45 min. to 2 hr., and the BOD_5 and suspended solid removal efficiencies depend on BOD_5 and suspended solid of influent. Fair and Geyer (1954) have shown that BOD_5 and suspended solid removal efficiencies are 24 - 50 and 40 - 70 per cent, respectively, W.A. Hardenbergh (1939) said that if it is allowed to stand quiescent for a period of 1 - 2 hr., about one-fifth to one-fourth of the total solid in sewage will settle out. However in the actual operation of -

treatment plant, it is not possible to prevent movement of the liquid and consequently there is a greater tendency for the solid to remain in suspension.

A rising of gas or sludge to the susface or an appreciable increase in the settleable solids in the effluent from the sedimentation tank indicates that septic action is taking place and that the sludge should be removed more promptly.

C. Biological Treatment

Biological treatment processes are used to convert the finely devided and dissolved organic matter in wastewater into flocculent settled solids that can be removed in sedimentation tank

There are aerobic biological treatment process and anaerobic biological treatment processes. This research included only aerobic biological treatment by activated sludge process, the other processes are not included, the reason will be given in DISCUSSION.

Activated Sludge

Laboratory - scale and pilot plant of activated sludge for particular wastewater are necessary to determine the efficiency of removals and parameters to design and operate. The experiment are generally based on the literature review as the following headings:-

Loading Allowance for Activated Sludge Plant

There are two loading criteria, empirical parameter and rational parameter. The two rational parameters most commonly used are:-

1. Food - to microorganism ratio, and
2. Mean cell residence time

Empirical relationships based on detention time and volume has been used. The Ten States Standards require a sewage detention period of 10.0 hr. for flows greater than 1 mgd and 7.5 hr for flow in the range of 0.2 to 0.8 mgd. The volume required for treatment is thus indirect proportion to the detention time and flow rate. Organic loading has also been expressed in terms of pounds of BOD_5 applied daily per 1000 cuft of aeration tank volume. The Ten States Standards limit the applied BOD_5 to not more than 35 lb /1000 cuft. These standards ignore the concentration of the mixed liquor, the food - to - microorganisms ratio, and the mean cell residence time , which may be considered operating variables as well as design parameters; however they do have the merit of requiring a minimum aeration tank volume that should be adequate for satisfactory treatment, assuming proper selective of the design and operating variables.

The desirable amount of MLSS in the system is an important factor in the design of activated sludge. Too much MLSS may cause bulking because lack of air, and a deficiency of solid may result in inadequate treatment and may also cause bulking. Minimum MLSS of 1000 mg/l generally are needed to produce good flocculation and good separation, but it is essential that the solid level does not become too large because of high oxygen requirement and it is difficult to remove large amounts of solids from the treatment effluent. W.A. Hardenbergh (1939) suggested that 2000 - 3000 mg/l of MLSS in the diffused air tank was suitable.

It appears that good activated sludge operation are attained at organic loading of between 0.5 and 0.7 lb BOD per lb of active microbial mass per day and high rate systems may operate at loading rate between 1 - 2 lb BOD/lb active solid/day, Ross,E. McKinney and Walter J.O' Brien (1968)

Oxygen Requirement For successful activated sludge, it is essential that an adequate supply of air should be maintained throughout the liquid depth at all times in order to support oxidation reactions. The oxygen uptake of mixed liquor appeared to be correlatable in all cases and the magnitude dependson the applied organic load. The critical oxygen requirement can be computed by knowing the BOD of the waste and the amount of organisms wasted from the system per day. It is known that a portion of the waste is converted to new cells that are subsequently wasted from the system; therefore if the BOD_L of the wasted cells were subtracted from the total, the remaining amount would represent the amount of oxygen that must be supplied to the system.

The BOD_L of a mole of cells can be evaluated as follows:-

$$\text{(cells) } C_5H_7NO_2 + 5O_2 \longrightarrow 5CO_2 + 2H_2O + NH_3$$
$$\quad 113 \qquad 5(32)$$

$$\frac{\text{lb } O_2}{\text{lb Cells}} = \frac{160}{113} = 1.42$$

Therefore, the theoretical oxygen requirements for an activated slydge system can be computed as

$$O_2 \text{ (lb/day)} = \text{food utilized per day} - 1.42 \text{ (organisms wasted per day)}$$

Sorab J. Arceivala (1973) concluded that for conventional activated sludge of domestic sewage, oxygen requirement is 0.7 - 0.8 kg O_2/kg BOD_5 removed for partial nitrification and 1.2 - 1.5 kg O_2/kg BOD_5 removed for full nitrification. Dr Karl Imhoff, Dr W.J. Muller and D.K.B. Thistlethwayte (1956) suggested that the air supply to aeration tank must be abundant enough to maintain a dissolved oxygen concentration throughout the tank of not less than $1\text{-}1\frac{1}{2}$ ppm. The volume of air to be supplied depends primarily on the BOD of the influent waste, loading rate, and also on the efficiency of absorption and utilization of the oxygen from the air, which is usually about 10 per cent but in the same cases may be ashigh as 30 per cent. The Ten States Standards required the air-diffusion system to be capable of delivering 150 per cent of the normal reguirement, which are assumed to be 1000 cuft of air/lb BOD in the wastewater applied to the aeration tank. Over the years of experience, Ross E Mckinney and Walter J.O'Brien have indicated that 700-2000 cuft of air/lb of BOD (43 - 123 cum/kg) treated are required.

Nutrient Requirement In biodegradation of organic matter nitrogen and phosphorus must be required. The new cell synthesis from the degradation of organic matter has been shown to contain 12.3 per cent nitrogen and 2.6 per cent phosphorus at maximum level. Depending upon solids, retention time and proportion of MLVSS and MLSS, the ratio of nitrogen and phosphours can be estimated for conventinal activated sludge. Sorab J. Arceivala (1973) said that BOD:N:P equaled to 100:5:1 are the minimum requirement. According to Helmers et al., the approximate minimum equivalent of BOD:N:P is 150:5:1.

Temperature It has been observed that the rate of reaction for microorganisms increases with increasing temperature, doubling with about very 10°C of rising in temperature. Temperature not only influences the metabolic activities of the microorganisms, but also has a profound effect on such factors as gas transfer rates and settling characteristic of the biological solids. The optimum temperature is approximately 30°C for most acrobic waste system.

pH For efficient aerobic biological treatment the pH of waste should be near neutrality,bacteria predomination and growth can be observed. Below pH 6.5, the fungi will begin to compete with the bacteria, with full predominant at pH 4.5. Above pH 9.0, the rate of metabolism is retarded. Thus it is important that pH should be maintained at the proper level (McKinney, 1962) The optimum pH range for activated sludge process is between 6.5 - 7.5.

Toxicity The presence of toxic substance in a waste may impair biological activity. An organic substance, such as phenol, and inorganic salts and ammonia is toxic at high concentration but heavy metals exhibit a toxicity at low concentration. However, it is difficult to state their lethal concentration. Acclimation of the sludge to toxic substance will increase the toxic threshold considerably.

Microorganisms Since the bacteria activity reflects the biochemical condition of the system and the ciliates are measuring the bacteria activity so the ciliates reflect the efficiency with considerable accuracy. McKinney and Andrew Gram (1956) concluded that the ciliates play very important role in the proper operation of activated sludge.

<u>Difficulties of Sludge Bulking</u> An exceptionally large value for the sludge index generally indicate that bulking is taking place in the secondary sedimentation tank. This means that the sludge particles in the tank are large and fluffy and therefore rise to the surface instead of settling. Bulking is usually due to one of the following causes: the introduction of fermenting waste, sludge into the incoming waste; an unbalanced condition in the life of the microscopic vegetable and animal matter in the aeration tank; or the growth of a thread - like fungus.

The following means are effective remedies.

1. Reduction of the rate of sludge return and rejection of a large quantity of excess sludge
2. Increased aeration
3. If aeration can not be increased, reduction of the amount of waste loading discharged into the aeration tanks.
4. Dilution of the contents of the aeration tanks using fresh water or stormwater.
5. Addition of coagulants such as ferric chloride to the final sedimentation tanks.
6. By application of chlorine, either to influent or to aeration tanks or to returned sludge.

Eddy and Metcalf (1972) stated that activated sludge system can reduce up to 85 - 95 per cent by loading rate ranged from 0.2 - 0.6 lb BOD/lb MLSS - day. Sorab J. Arceivala (1973) concluded some parameters of complete-mixing system for domestic sewage. The substrate removal rates, k (based on BOD_5) are 0.017 - 0.03 mg/l-day^{-1} and 0.038 mg/l-day^{-1} at 23-28°C. The typical organic loadings for conventional activated sludge are 0.40-0.70 and 0.70-0.90 kg of BOD per day per kg of MLVSS at temperate and warm climate, respectively, or, 0.30-0.50 and 0.50-0.70 kg of BOD per day per kg of MLSS at temperate and warm climate, respectively. MLVSS was assumed to be 70 - 80 per cent of MLSS for conventional activated sludge. The value of a, b, a' and b' are 0.5 - 0.73, 0.075 - 0.125, 0.3 - 0.52 and 0.05 - 0.14, respectively. Surplus solids produced are 0.55 - 0.65 kg/kg BOD removed. Oxygen required is 0.7 - 0.8 kg O_2/kg BOD_5 removed for partial nitrification and 1.2 - 1.5 kg O_2 per kg BOD_5 removed for full nitritication. Oxygen uptake rates are 30 - 40 and 50 - 60 mg/hour/litre of aeration tank for partial and full nitrification, respectively. MLSS desired is 2000 - 2500 mg/l.

Theoretical Consideration

Removal Efficiency

$$\text{COD removal efficiency,\%} = \frac{\text{COD inf.} - \text{COD eff.}}{\text{COD inf.}} \times 100 \quad (1)$$

$$\text{SS. removal efficiency,\%} = \frac{\text{SS.inf} - \text{SS.eff.}}{\text{SS.inf.}} \times 100 \quad (2)$$

Eckenfelder's Mathematical Approach to Activated Sludge Process Design

Aeration only

Substrate removal

$$S_e = \frac{So}{k\ Xvt + 1} \quad (3)$$

Where, S_o = influent substrate concentration, mg/l

S_e = effluent soluble substrate concentraion, mg/l

X_v = Volatile suspended solid concentration, mg/l

t = aeration period, day

k = substrate removal rate, mg/l substrate removed per mg/l VSS per day.

Active mass accumulation

$$\frac{\Delta Xv}{Xv} = a\left(\frac{So - Se}{Xv.t}\right) - b \quad (4)$$

where, ΔX_v = VSS. accumulation rate, mg/l/day

a = mass yield rate, lb VSS produced/lb substrate metabolized

b = endogenous respiration rate, lb VSS oxidized/lb VSS remaining/day