Effluent Treatment Plant Manual Works Description

Section 4. Works Description:

4.1 Unit Operations:

The Plant comprises the following unit operations:

- Raw Effluent Pumping.
- Inlet Screening.
- Fat Removal.
- pH Correction.
- Pre-treatment Pumping.
- Balancing / Aeration.
- Forward Feed Pumping.
- Aeration.
- Final Settling.
- Return / Excess Sludge System.
- Phosphate Removal System.
- Sludge Thickening.
- Dewatering Feed Pumps.
- Dewatering.
- Sludge Cake Holding / Disposal.
- Tertiary Filter Feed Pumps.
- Tertiary Filter.
- Outlet Flow Measurement and Sampling.

4.2 Raw Effluent Pumping:

Two effluent lines are routed to the Plant from the factory premises.

One caters for the domestic sewage and terminates at the septic tank, which in turn is connected to the adjacent raw effluent sump by an overflow pipe.

The other caters for the industrial effluent and outflows directly into the raw effluent sump.

Two (2) submersible pumps are installed in the raw effluent sump from where effluent is pumped through the inlet screening and fat removal systems and into the pre-treatment sump. These pumps operate on a duty / standby basis.

Level sensors are provided for pump on / off control.

4.3 Inlet Screening:

A self-cleaning pressure infeed rotary drum screen is fitted onto the fat removal tank.

The screen is designed to continuously separate any grit / debris from the raw effluent. The screenings are collected on the inside surface of the rotating drum and discharged through an outlet chute into a skip / container beside the fat removal tank. The screened effluent is then normally directed into the fat removal tank or can be diverted to the pre-treatment sump.

4.4 Fat Removal:

Fat removal consists of a dissolved air flotation plant (DAF) which is composed of three (3) seperate systems:-

(a) Flotation Tank
(b) Float Removal System
(c) Pressurisation System

In essence, the pressurisation system provides a stream of fine micro-bubbles of air to the flotation tank. These bubbles attach themselves to any particles of oil, fat or grease and cause them to rise to the surface as float.

The float removal system skims this float from the surface of the effluent and deposits it into a float holding tank.

The de-fatted effluent is then withdrawn to the pre-treatment sump using an adjustable weir.

A tandem air compressor is provided and is located in the dewatering room.

4.5 pH Correction:

The pH correction system comprising of a pH sensor, a proportional pH monitor / controller, 1 No. acid storage I.B.C., 1 No. caustic storage I.B.C. and 3 No. dosing pumps, c/w piping and ancillaries. Dosing pumps are on a duty / duty / standby basis.

The pH is monitored and controlled at the pre-treatment sump.

4.6 Pre-treatment Pumping:

Two (2) submersible pumps are installed in the pre-treatment sump from where effluent is pumped to the balance tanks on a duty / assist basis.

An ultrasonic level monitor is provided for pump on / off control.

4.7 Balancing / Aeration:

The two (2) balance tanks are each equipped with a 15kW high speed floating aerator for aeration and mixing. The tank effluent level is maintained by an ultrasonic level monitor.

4.8 Forward Feed Pumping:

Two (duty/standby) progressive cavity P.D. pumps are provided to deliver effluent from the balancing tanks to the aeration tanks at a variable flow rate. Electronic level sensors in each tank control electronic inverters which are used to vary the forward feed pumping rates. Thus a volume of effluent can be maintained in the balance tanks for draw-down over the weekends to maintain plant loading.

Flow sensors are tapped into the pump suction to ensure that the pumps will not run dry.

The pumps discharge into a local break tank to avoid any seepage through the pumps when idle.

4.9 Aeration:

The aeration systems consist of two (2) aeration tanks, access walkway, splitter box and local pipework.

Effluent enters the aeration tanks via a local splitter box which can direct the flow into either aeration tank or both.

Each aeration tank is provided with a 15kW variable speed aerator plant speed is varied by the plant control system in response to signals received from a dissolved oxygen sensor mounted in each aeration tank.

The mixed liquor from each aeration tank exits to the settlement tanks by overflowing an outlet box / baffle assembly.

4.10 Final Settling:

There are two (2) final settling tanks. Each tank is equipped with an inlet diffusion drum, centre drive scraper, vee-notch launder channel with scumboard, access walkway and a scum removal system. The supernatent is decanted and drains into the tertiary filter feed-sump. The scum is collected and drained to a local concrete tank which must be periodically emptied.

4.11 Return / Excess Sludge System:

Sludge is returned from the bottom of the final settling tanks via three (3) progressing cavity P.D. pumps. Operation is on a duty / duty / standby basis.

The return sludge is pumped into the splitter box, where it is mixed with the forward feed effluent and returned to the aeration tanks. An automatically actuated valve is provided which, when opened, diverts sludge to the sludge thickening tank.

4.12 Phosphate Removal System:

Ferric sulphate is added to the reactor tanks to reduce phosphorus levels in the effluent.

The phosphate removal system comprises of a bulk storage tank, two dosing pumps and ancillaries. Operation is on a duty / standby basis.

The ferric solution is mixed with the incoming forward feed effluent in the splitter box and is discharged into the aeration system.

4.13 Sludge Thickening:

The excess sludge is thickened prior to dewatering. The sludge thickening system consists sludge holding / thickening tank equipped with a centre drive scraper / picket fence frame, inlet diffusion drum, outlet launder and access walkway. The supernatent is decanted into the outlet launder and returned to the aeration system via the splitter box.

4.14 Dewatering Feed Pumps:

Two (2) processive cavity P.D. pumps are provided to deliver sludge from the bottom of the sludge thickening tank to the dewatering system. These P.D. pumps are fitted with mechanically variable speed units.

4.15 Dewatering:

The dewatering system comprises of a filter press unit and a sludge conditioning facility.

The sludge conditioning assembly consists of a poly make-up tank c/w mixer, two (2) poly dosing pumps duty / standby and a flocculation tank c/w agitator.

4.16 Sludge Cake Holding / Disposal:

A wide throat pump is located at the filter press to deliver solids cake into either a removable skip (provided by others) or the sludge holding tank.

4.17 Tertiary Filter Feed Pumps:

Two (2) submersible pumps are provided, in the tertiary filter feed sump, to pump settled effluent from the settling tanks to the tertiary filter. Operation is on a duty / standby basis.

An ultrasonic level monitor is provided for pump on / off control.

4.18 Tertiary Filter:

Tertiary filtration consists of a continuously backwashed filter. There is no need to take the filter out of operation for backwashing or cleaning. The incoming effluent is filtered upstream through the sand bed inside the filter while the sand in moving downwards. Simultaneously with the filtration process, fouled sand is pumped into a sand washer by using an air-lift and any suspended solids are discharged with the washwater.

The effluent can flow into the flow measurement chamber prior to ourfall or it can be diverted to the pre-treatment sump to complete a recycle loop. The washwater is returned to the aeration process via the splitter box.

4.19 Outlet Flow Measurement and Sampling:

A vee-notch weir chamber is provided on the outlet line and is equipped with an ultrasonic flowmeter and automatic wastewater sampler.

Another automtic wastewater sampler and a flow recorder are provided in the instrumentation house adjacent to outfall into the local river.

Appendix F.2.3 Effluent Treatment Plant Process Description Manual

Section 3. The Activated Sludge System:

This chapter is intended to provide an overview of the activated sludge working system which is adequately detailed for the non-specialist. It also includes intuitive guidelines to anyone responsible for plant operation to achieve required plant performance both at process start-up, malfunction of a working system and uprating of a system proven to be biologically slow or lazy in action.

3.1 Process Terms and Definitions:

<u>Note:</u> Where a laboratory method is noted the specifics related may be confirmed by reference to the latest edition of "Standard Methods for the Examination of Water and Wastewater" - published by APHA-AWWA-WPCF.

The following terms are commonly used in evaluating activated sludge systems.

3.1.1 Biological Oxygen Demand (BOD):

A standard laboratory test which measures the amount of dissolved oxygen required to oxidise the organic matter in the wastewater over a period normally five (5) days at 20 degrees Centigrade. The test indicates the oxygen required by the micro-organisms in the wastewater to oxidise the organic matter present based on biochemical oxygen uptake.

3.1.2 Chemical Oxygen Demand (COD):

A standard laboratory test which equates oxygen demand to the quantity of a strong chemical oxidising agent required to oxidise the organic matter present in the water.

3.1.3 Suspended Solids (S.S.):

Suspended solids are solids in the wastewater which are not soluble. Mixed liquor suspended solids (MLSS) is a term commonly used to quantify the concentration of the activated sludge in the mixed liquor in terms of suspended solids. Mixed liquor volatile suspended solids (MLVSS) gives a closer indication of the microbial population in the mixed liquor since it measures organic suspended solids.

3.1.4 Settleable Solids (Cone Reading):

The settleable solids test gives an indication of the settleability of a mixed liquor and is determined by allowing a one litre sample of mixed liquor settle in a one litre Imhoff cone or graduated cylinder for 30 minutes. The volume occupied by the activated sludge after settling is recorded as millilitres per litre. It is a valuable indicator of performance variation on a day to day basis.

The procedure used to determine the settleable solids in the mixed liquor is as follows:

Fill a one litre graduated cylinder to it's litre mark with a well agitated mixed liquor sample. Allow undisturbed settling for 30 minutes and then read the volume occupied by settled sludge in millimetres. This result is reported in ml/1.

3.1.5 Sludge Volume Index (S.V.I):

This is defined as the volume in millilitres occupied by 1 gramme of activated sludge after settlement of the mixed liquor for 30 minutes.

$$S.V.I. = \frac{V \times 1000}{MLSS}$$

S.V.I. = Sludge Volume Index ml/g.

V. = Settleable Solids ml/l.

MLSS = Mixed Liquor Suspended Solids mg/l.

3.1.6 Food to Mass Ratio (F/M) or Sludge Loading Rate:

This is the ratio of organic food measured as kg BOD/day to the activated sludge mass measured in the aeration tank as kg.

$$F/M = \frac{Q \times BOD}{V \times MLSS}$$

F/M = Expressed as g BOD/g MLSS

Q = Wastewater flow (m^3/day)

BOD = Wastewater BOD (mg/l)

V = Aeration basin volume (m^3)

MLSS = Mixed liquor Suspended Solids (mg/l)

3.1.7 Dissolved Oxygen (D.O.):

Dissolved oxygen can be measured as mg/l or as % saturation. The level of D.O. in water is dependent on temperature, pressure and dissolved salts. For plant operating procedures a standard rule of thumb is that 100% saturation of a liquid is 10 mg/l dissolved oxygen. The normal operating D.O. level in an aeration tank should be 1 to 2 mg/l or 10-20% saturation.

3.1.8 Ph:

The Ph is a logarithmic scale indicating the concentration of the hydrogen ion in solution. Normal Ph requirements for an activated sludge system should be between 6.5 and 8.0.

3.1.9 Organic Loading Rate (OL):

This is a secondary system design parameter which relates the level of loading of organics per unit volume per day, for example, kg BOD per m^3 aeration volume per day.

3.1.10 Food to Mass Ratio (F/M):

This is in like manner a measure of the extent of organic load in an aerobic reactor per kg of activated sludge solids per day. It is the prime parameter used in aerobic plant design.

3.1.11 Sludge Retention Time (SRT):

This is a measure of the total time the sludge remains in the working process and is usually expressed in days. It is related to F/M and dependent on respiration rate which is in turn temperature dependent.

3.2 Process Description:

3.2.1 Principle of Operation:

The principle of the activated sludge process is that micro-organisms grow and reproduce using the food and nutrients in the wastewater as a food source and thereby remove the potentially pollutant content by converting it into cell matter which can be separated from the treated wastewater in the downstream sedimentation stage. The extent of waste load in the reactor volume determines the category of operation viz, extended aeration, conventional aeration or high rate.

3.2.2 Nutrients:

In order to survive and grow in any medium the microbes need a sufficient supply of all nutrients necessary for cell synthesis. The major elemental requirements are carbon, nitrogen, phosphorous, sulphur, hydrogen and oxygen and these account for approximately 95% of the cellular dry weight. These are normally all available in municipal domestic sewage in sufficient quantities in the form of carbohydrates, proteins, water and inorganic nitrogen and sulphur. However, some wastewater such as industrial effluents and mixed municipal and industrial effluents can be deficient in nitrogen and phosphorous. These deficiencies can be supplemented by adding inorganic nitrogen and/or phosphorous to the wastewater stream and this is generally termed 'nutrient addition'. The other elements are not normally limiting and together with the remaining trace elements required are usually abundant in the wastewater. In rare cases levels of iron and zinc may warrant investigation.

Aerobic microbes require oxygen for their normal metabolic processes for the purpose of oxidising the organic matter and therefore it is a requirement that a sufficient supply of oxygen is made available.

It is the capability of microbes to use the nutrients as a food source which is exploited in the activated sludge process. Wastewater is supplied to an aeration tank where it is intimately mixed with the microbes and at the same time aerated. The microbes grow and reproduce and in doing so degrade and mineralise the organic content of the wastewater. This phenomenon is termed "assimilation". As they multiply the individual cells collect together to form 'flocs' resulting in an active mass called 'activated sludge'. The mixture of the activated sludge and the wastewater in the aeration tank is called 'mixed liquor'. The mixed liquor solids simultaneously undergo aerobic breakdown in a stage termed "endogenous respiration".

3.2.3 Mixed Liquor:

The mixed liquor flows from the aeration tank to the settling tank where the activated sludge is settled and returned to the aeration tank and the mineralised or treated wastewater is discharged. The purpose of returning the activated sludge is to maintain a high population of microbes in the mixed liquor for rapid and complete degradation of the organic matter.

Since the microbes are continually multiplying and consequently the activated sludge volume is increasing it is necessary to waste excess sludge to maintain an optimum population and to ensure the existence of a young and healthy sludge. The level of sludge wastage varies with waste type, oxygen supply, loading rate of waste onto the reactor (kg BOD.d per m^3) and degree of endogenous respiration.

3.2.4 Types of Plant:

The most common system used is the extended aeration process.

Extended aeration plants use the principle of removing the sludge when the microbes are at the last stage of their growth cycle and endogenous metabolism occurs. Less sludge is produced which is stable and easily dewatered. The SRT is 12-30 days with a wastewater retention time of approximately 24 hours and an F/M ratio of 0.05-0.15 kg BOD/kg solids.

Conventional plants are based on the principle of removing or wasting the sludge when the microbes are young and growing. The SRT is normally only 5-15 days with a wastewater retention time of six to ten hours and an F/M ratio of 0.2-0.4 kg BOD/kg solids. The result is that a large amount of sludge is produced which is unstable and this usually requires further treatment by stabilisation if danger of odorous conditions are to be avoided.

3.3 Plant Control Considerations:

The prime characteristics to control when operating an activated sludge plant are:

- Nutrient Balance and acceptable pH level.
- Dissolved Oxygen Level.
- Reactor solids concentration.

3.3.1 Nutrient Balance & pH Range:

The importance of nutrient requirements has already been insufficiently explained and this is usually accounted for in the design stage. Plants with nutrients may require addition systems to provide a normal working ratio of BOD:N:P = 100:5:1.

In similar manner the pH should not be allowed to vary outside a general range of 6.0 - 8.5. This may depend on buffering conditions of reactor solids but for industrial wastes a pre-treatment system for this purpose should be in working order at all times.

3.3.2 Dissolved Oxygen:

The dissolved oxygen (D.O.) level is normally optimised for each operating plant and, for reasons of process stability, should not be allowed to vary - even with increase or decrease in loading. During commissioning a lower D.O. than normal may be advisable for a period. A normal working value is 2.0 - 2.5 mg/l (20%-25% saturation). In some cases, for example for ammonia removal (nitrification) the working D.O. may sometimes be up to 3.5 mg/l or even 4.0 mg/k.

3.3.3 Solids Concentration (MLSS):

The solids growth in the plant must be:

- in a balanced and healthy condition. This normally means that growth of unwanted species likely to cause problems with settling or foaming should be prevented. As with any such problem the earlier this is observed the easier the means of prevention.

- allowed to develop only within the "working region" of the series of curves (SV1 versus Cone reading versus MLSS) shown on Figure 3.3.1. Should the growth in the reactor be excessive then the normal operation anticipated - including settling - will be impaired and the oxygen balance and resulting effluent quality will be offset.

Sludge volume (Cone Reading ml/l) and SV1 are non precise parameters but they are of major value as an indicator of day-to-day plant operating consistency and - most of all of any deviation from the optimum. Guide values should be set by the operator for his commissioned and properly operating plant.

3.4 Process Problems:

The two most common forms of activated sludge process problems are sludge bulking and nitrification / denitrification - if the latter has not already been taken into account at design stage.

3.4.1 Bulking Sludge:

A bulking sludge is a sludge which will not settle or which settles very poorly and is characterised by an S.V.I. of greater than 200 ml/g. The usual reason for a bulking sludge is the presence of filamentous microbes as a result of changing conditions in the plant.

3.4.2 Nitrification:

Nitrification is the biochemical conversion of ammonia (NH_3) to nitrate (NO_3) and this occurs in the aeration tank. Under certain conditions the extent of nitrification can be extreme but may not effect the treatment process if denitrification does not occur. Denitrification is the process whereby nitrate is reduced to nitrogen gas (N_2) bubbles rising to the surface resulting in sludge flotation and increased S.S. in the final effluent.

The cause of these problems are normally associated with very low or high D.O. levels and bad sludge wasting procedures.

Other problems encountered at commissioning or later stages are typically:

- Foaming, normally caused by growth of Nocardia bacteria, often associated with fats. This is prevalent at commissioning stage as it exhibits a high growth rate.
- As with other filamentor is bacterial strains.
- Reduced alkalinity resulting from conversion of ammonia nitrogen to the nitrate form.
- Over-oxidation of sludge which is displayed by an ashing condition on the sludge surface. This may also sometimes be exhibited by a dark scum. Such conditions indicate underloading and require considerations of process modification to account for the low loading being experienced.
- Process inactivity which may result from on-loading of toxic substance(s) requiring close investigation.

3.5 Process Commissioning and Operation:

Prior to consideration of process commissioning the associated component assemblies should be performance tested to confirm outputs and to ensure that anticipated control strategies are in place.

The prime stages of process commissioning embody:

- Development of a multi-bacterial growth.
- Stabilising the relative populations to achieve working ratios which "hold" with the ongoing waste type and loading. In all cases this ratio is dictated for the plant in question.
- Fine trimming of the attendant parameters to leave the system autogenetic. This leads to ongoing MLSS level growth to the design figure set-out.
- Setting the excess sludge draw-off to maintain solids balance within the system.

The initial bacterial growth should come from a base using fresh aerobic sludge from a similar works on a similar waste. This sludge should not be taken from a picket fence and preferably should come from an aeration tank. The growth rate may be increased from the normal by addition of an appropriate selection. Loading at this stage should be limited within reason to avoid danger of excessive growth rate with bulking conditions as much as possible.

- **Biological Activity:**

Process performance is dramatically affected by the nature of the microorganisms present and their activity. The many conditions affecting biological activity complicate its evaluation. Of the conditions having the most effect on the microorganisms, oxygen and food are foremost. Of course, mixing is essential to bring the microorganisms in contact with the oxygen and food. Toxics, such as heavy metals and pesticides, can inhibit biological activity, or worse, destroy the microorganisms completely. Also, temperature, alkalinity, pH, and nutrients can all individually, or in combination, affect biological activity.

- **Microscopic Examination:**

Microscopic Examination is normally a valuable indicator of level of growth. Figure 3.5.1 shows the relative predominance of the bacterial groupings as related to F/M loading or SRT. The organisms are shown in detail on Figure 3.5.2.

During growth of the microorganisms the Dissolved Oxygen should commence at 1.0 mg/l - 1.5 mg/l regardless of anticipated working level of the commissioned plant. If nitrification is required the D.O. should be increased when more stable conditions are achieved so that nitrification bacteria may generate (2.5mg/l - 3mg/l).

3.5.1 Troubleshooting:

The relative success of bacterial activity may be concluded from any combination of:

- Observations from clarifier performance.
- Microscopic examination.
- Observations of solids in the aeration tank with respect to colour, SVI, Cone Test etc.

Several troubleshooting figures and tables list problems, observations, probable causes, necessary checks to determine the cause, and suggested remedies.

The operator must determine the probable cause and select one or more of the corrective measures to restore the process to full efficiency with the least adverse effect on the final effluent quality and at the lowest cost. To do this, the operator needs a thorough knowledge of the plant's activated sludge process and how it fits into the overall plant operation. The operator must determine the probable cause and select one or more of the corrective measures to restore the process to full efficiency with the least adverse effect on the final effluent quality and at the lowest cost. To dot this, the operator needs a thorough knowledge of the plant's activated sludge process and how it fits into the overall plant operation. The operator should review the preceding sections of this chapter before trying to use the troubleshooting guides.

Remember that deficiencies in sludge wasting capability, process flexibility, process controllability (inability to measure or adjust the process), secondary clarifier design, sludge treatment capacity or operating ease, aeration capability, and other design factors may limit performance or the ability to respond to problems. Therefore, before troubleshooting a problem, determine the plant's capabilities and limitations.

Operational must be approached based on logical combinations of experience, trial and error.

Operation Problems and Possible Remedies:

In general, these problems can be grouped as follows by conditions that the operator can observe in the aeration tank and secondary clarifier:

- Aeration tank problems that include aeration system problems (low DO, inadequate mixing, violent turbulence, and surging) and foaming problems, and
- Clarifier problems that include solids washout, bulking sludge, clumping or rising sludge, cloudy secondary effluent, ashing, pinpoint floc, and straggler floc.

Aeration tank and clarifier problems can be corrected by using sound operational control practices and by maintaining proper equipment operation. Troubleshooting guides that cover these problems are provided later in this chapter in an easy-to-follow format. When trobleshooting operational problems, however, keep the following mind: do not try to correct a problem unless it is certain that the problem is the cause of, or will lead to poor effluent quality. One of the most common causes of poor effluent quality is reacting to "problems" when one should not. In other words, when dealing with process conditions - "If it ain't broke, don't fix it".

Within the troubleshooting guides that follow are lists of remedies that include:

- Increasing or decreasing aeration.
- Balancing influent and return sludge flows.
- Adjusting return rates.
- Adjusting wasting rates.
- Adding chemical settling aids.
- Adding supplemental nutrients.
- Chlorinating return sludge.
- reducing or controlling recycle flows, and
- Increasing alkalinity.

Some remedies produce quick results, some produce changes only after many days, and some can be somewhat drastic with potentially adverse side-effects. The troubleshooting information presented here is generally oriented towards remedies that minimize the potential for overcorrection and adverse side-effects. The stronger the remedy, the more judgment and experience are required in applying it.

In most cases, aeration adjustments, flow balancing, and return rate adjustments will produce quick, mild results. Generally, the impact of altering sludge wasting takes longer and is less reversible, that is, more prone to over-correcting. Chlorinating mixed liquor or return sludge produces quick results at moderate or greater application rates, but poses significant risks if done at moderate or greater application rates, but poses significant risks if done improperly. (It is considered by some a remedy of last resort, while others consider it a standard remedy if done properly.) Applying polymers or metal salts (such as alum or ferric chloride) is normally effective quickly, but can be quite expensive and may increase sludge wasting requirements. Correcting nutrient deficiencies can produce quick positive results, but requires purchasing chemicals and chemical feed equipment. Reducing or controlling recycle flows produces quick positive results, but may require changes in the operation of sludge treatment processes or the addition of off-line storage or treatment facilities.

Novices should take only one corrective action at a time to avoid confusing the effects of multiple changes. As troubleshooting expertise is gained, applying remedies more directly may be possible. The beginner, however, should be cautious. Major changes may result in overcorrecting, which can create additional problems just as severe as the initial problems they were intended to cure.

If operating problems cannot be solved in-house, help should be obtained from others, such as operators at other plants, state regulatory agencies, operations consultants, and local colleges. Some problems are complex and difficult to solve because there may be several contributing factors. Consult only qualified individuals having first-hand knowledge and experience. Second guessing by well-intentioned people can waste time and money, divert attention from the correct solution, and possibly make matters worse. Also, solutions that worked once may not work again because conditions may have changed as a result of the biological nature of the process. If multiple treatment trains are available, try the changes on one unit first.

Before making a change, collect as much data as possible and experiment with possible solutions in the laboratory. If a mistake is made, the results can be easily dumped and another solution tried. If a big mistake is made within the plant, it is not as easily corrected.

When attempting to solve a problem, avoid treating only the symptoms. For example, chlorinating return sludge for a filamentous bulking problem will temporarily solve the problem, but the underlying cause (such as insufficient DO) must be corrected or the problem will return. However, in some cases the underlying cause cannot be readily corrected because of design deficiencies or budgetary restraints. Under such circumstances, the operator may be forced to deal with the symptom (for example, chlorinating return sludge) until the underlying problem can be permanently solved.

After attempting a remedy, be sure to allow enough time for the process to respond before trying something else. Although the effects of many remedies are apparent within a day or two, some adjustments may require 2 to 3 SRTx before a positive change becomes apparent. Being impatient can result in chasing various solutions before the process has been allowed to respond to any, including the best solution. But do not wait too long before deciding that a remedy does not work.

3.5.2 Filamentous Bulking:

This results from predominant growth of any grouping of a number of causes. This results in no or very poor settleability with solids carry-over. Figure 3.5.3 shows typical filamentous growth in varying abundance. The Sphaerotilus group of bacteria are primarily noted for such abundance. More specifically the following conditions have been identified to relate to the organisms noted:

Filament types as indicators of conditions causing activated sludge bulking.

Suggested causative condition	Indicated filament types.
Low DO (for the applied organic loading)	S. natans, Type 1701, and H. hydrossis.
Low organic loading rate (F:M) in completely mixed aeration basins.	M. parvicella, Nocardia spp., H. hydrossis, Types 021N, 0441 0675, 0092, 0581, 0961 and 0803.
Septic wastes and sulfides.	Thiothrix spp., Beggiatoa spp., and Type 021N.
Nutrient deficiency; nitrogen or phosphorus (industrial and mixed industrial -domestic wastes).	Thiothrix spp. and Types 021N 0041, and 0675.
Low pH (below 6.5)	Fungi.

A practical approach to control filamentous bulking includes:

- Confirming that the problem is indeed caused by filaments;
- Identifying the filaments involved;
- Determining the specific set of appropriate remedies (both short - and long-term) for the filaments involved:
    - Short-term solutions involve treating the symptoms (changing influent feed points, changing RAS rates, adding

settling aids, and chlorinating).

- Long-term solutions involve treating the cause (controlling mixed liquor pH, controlling influent septicity, adding nutrients, changing aeration rates, and changing the F:M ration).

The use of chlorine to control filamentous bulking warrants particular attention. (It also should be mentioned that chlorination does not satisfactorily control poor settling due to viscous activated sludge caused by nutrient deficiency nor does it control idpersed growth bulking). Chlorinating activated sludge should expose the filaments that extend from the floc to damaging concentrations of chlorine while leaving the organisms within the floc largely untouched.

One approach is to set a target SVI (or some other measure of settleability) for satisfactory operation of the secondary clarifiers and sludge processing units and only chlorinate when this target is significantly and consistently exceeded. This treats the symptom, not the underlying problem.

The selection of the chlorine application point is critical. the point should be located where there is excellent mixing, where the sludge is concentrated, and where the wastewater concentration is at a minimum (to reduce unwanted reactions with the chlorine). The three common application points are in the RAS stream, directly into the aeration tank at each aerator, and in an installed sidestream which recirculates mixed liquor within the aeration tank.

The chlorine dose and the frequency at which the organisms are exposed to chlorine are the two most important parameters. The dosage is adjusted so that concentrations are lethal at the floc surface but not within the floc. The chlorine dose should be based on the sludge solids inventory in the process (aeration tanks plus clarifiers). This is called the "overall chlorine mass dose," and effective dosages are in the range of 1 to 10 lb chlorine / 1000 lb MLVSS / day. The dosage must be accurately measured, preferably by using a chlorinator dedicated for this purpose. Initially start at a lower dose and gradually increase until it is effective.

Frequency of exposure is a measure of how often the entire solids inventory is subjected to chlorine. If the frequency is too low, only a portion of the solids may be subjected to an excessively high chlorine dosage. The required frequency of exposure depends on the relative growth rates of the filamentous and floc-forming organisms as well as the effectiveness of each dose. While the frequency of exposure is plant-specific, three times or more per day was reported a sufficient and success has been reported at frequencies as low as once per day.

Control tests should be performed during chlorination to assess the effects of chlorine on both the filamentous and floc-forming organisms. The tests should measure sludge settleability (for example SVI), effluent quality (turbidity), and sludge quality (microscopic exam). An adequate chlorine dose should start to improve settleability within 1 to 3 days. A turbid, milky effluent and a reduction in BOD removal are signs of overchlorination, although a small increase in effluent suspended solids and BOD are normal during chlorination for bulking control. The microscopically visible effects of chlorine on filaments include, in order:

- Intracellular sulphur granules (if present) disappear;
- Cells deform and cytoplasm shrinks; and
- The filaments break-up and dissolve.

Chlorine does not destroy the sheath of sheathed filaments, and this causes poor sludge settling until they are wasted from the system. Chlorination should be stopped when only empty sheaths remain, and not continued until the SVI falls. Adding chlorine beyond this point may overchlorinate. Since the effects of chlorine on filaments can be detected microscopically before settleability improves, microscopic exams can provide an early indication of filament control.

3.5.3 Filamentous Foaming:

This may be caused by Nocardia or Microthris - the former being most prevalent and is water repellant with resulting floatation effect.

The best way to deal with Nocardia foaming is to prevent the conditions from developing that encourage Nocardia growth. Once established, Nocardia forming can be extremely difficult to eliminate because:

- The foam is difficult to knock down with water sprays;
- The foam generally does not respond to chemical antifoamants;
- Chlorinating return sludge, although often helpful, does not eliminate Nocardia since most of it is in the floc particle and not exposed to chlorine; and
- Increased wasting has its limitations since:
  - Foaming is not wasted with the sludge.
  - Even if foam and scum are removed from the process, they can cause problems in downstream units like digesters and also can be recycled back with decant or supernatant to the activated sludge process.
  - Reducing the SRT to less than 9 days (the "classic" cure for - Nocardia growth and foaming) may be inadequate. Many plants must reduce the SRT to less than 2 days which may conflict with other process goals, such as nitrification or

sludge handling capabilities. Numerous Nocardia species are involved in foaming. Of the two most dominant, one is slow growing and the other fast. The SRT needed to control Nocardia foaming may depend on which species is involved.

A positive way to treat severe Nocardia foaming is to correct the cause (control greases and fats and increase wasting) while also physically removing (with a vacuum truck, for example) the aeration tank foam and clarifier scum. Once removed, this material is separated so it will not recycle through the plant.

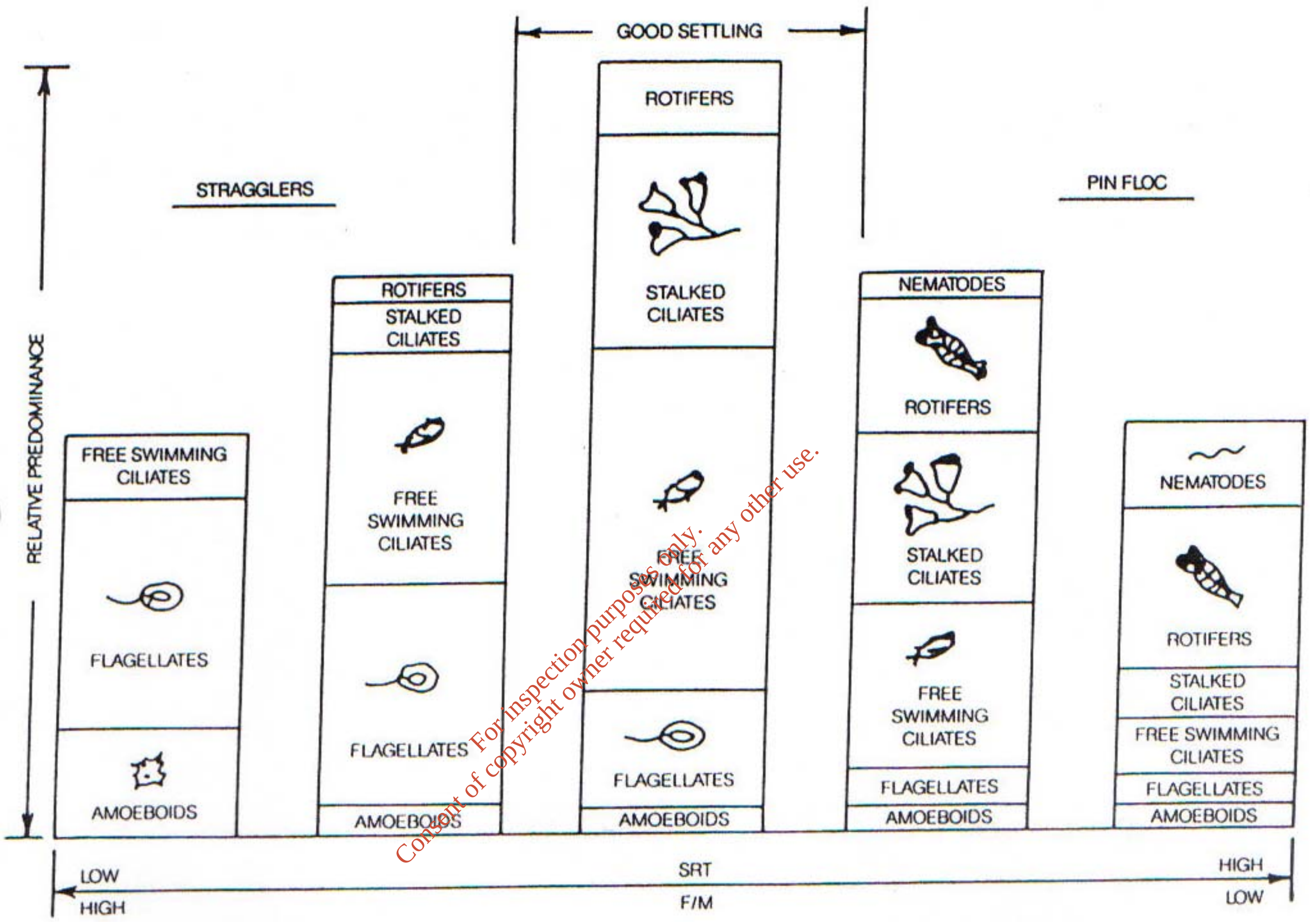


FIGURE 3.5.1: RELATIVE PREDOMINANCE OF MICROORGANISMS VERSUS F/M AND SRT.

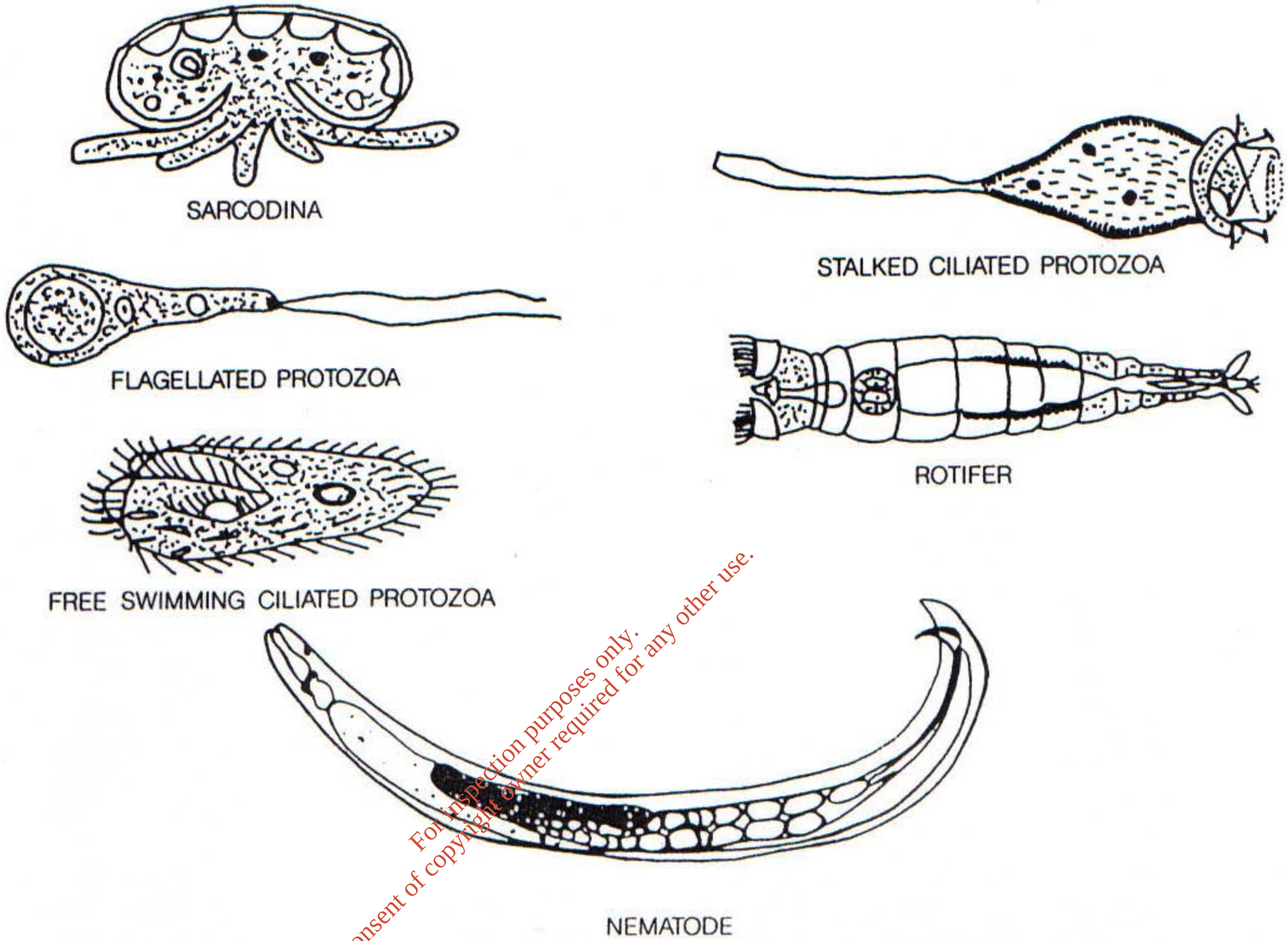


FIGURE 3.5.2: INDICATOR MICROORGANISMS IN ACTIVATED SLUDGE.

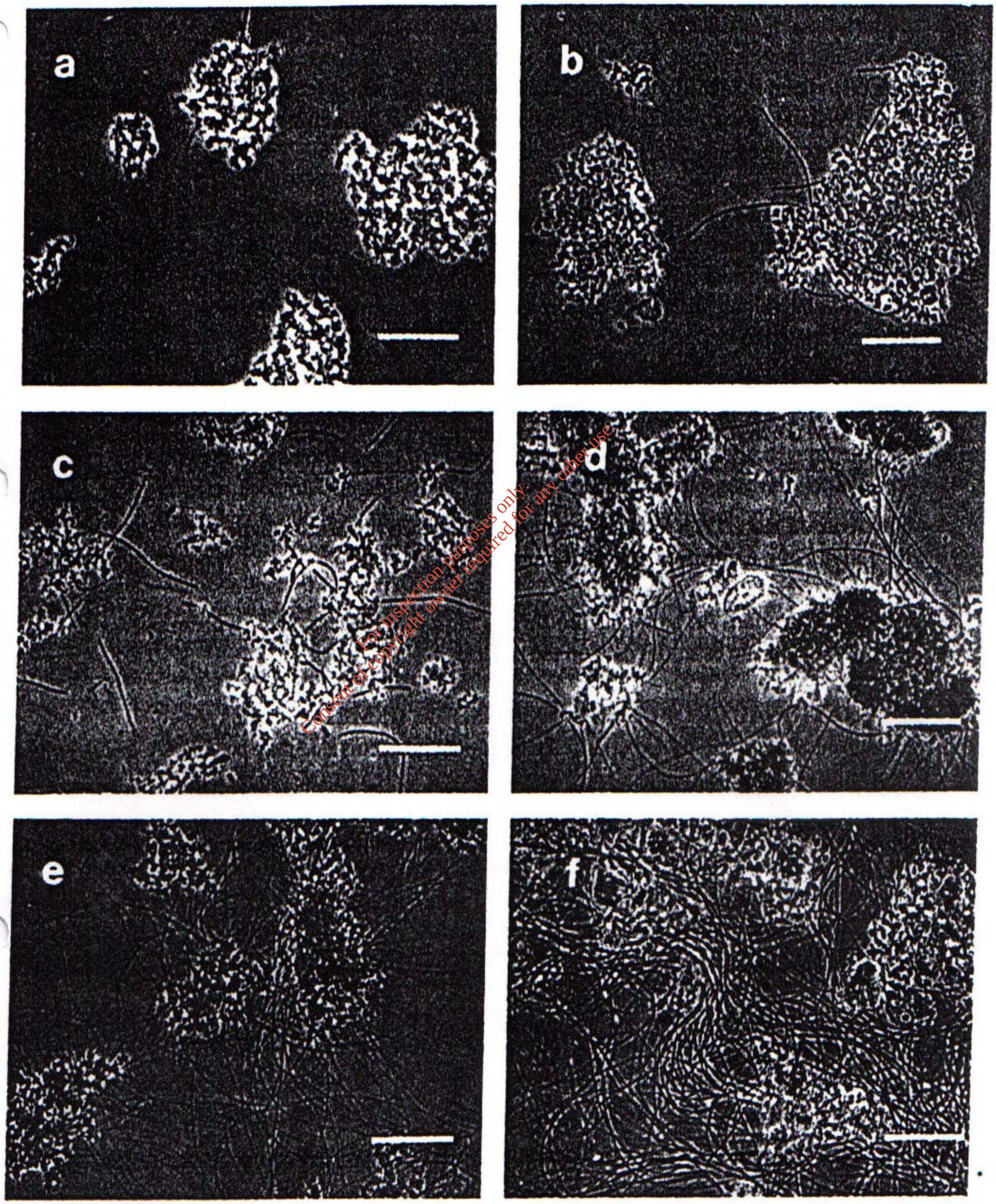
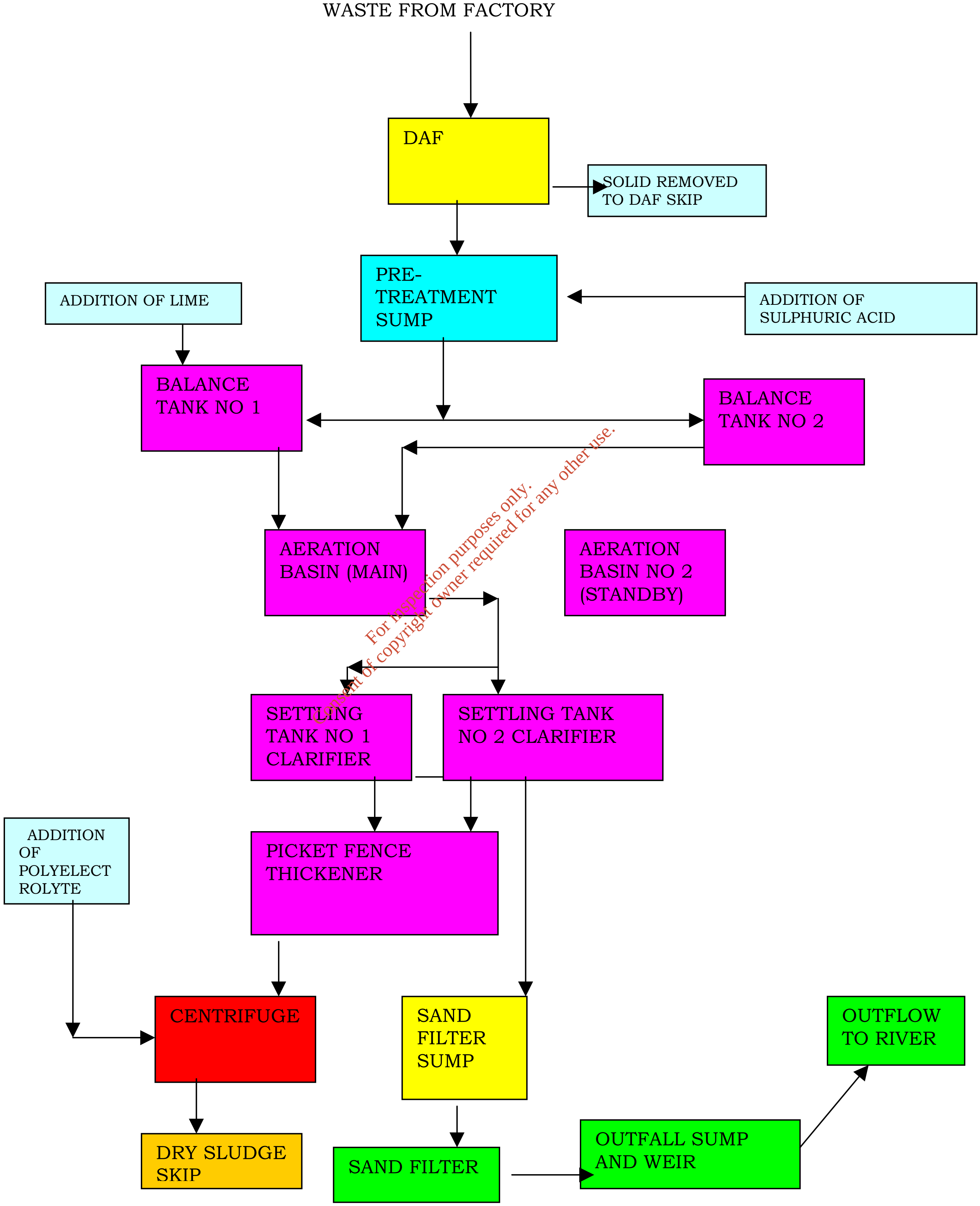
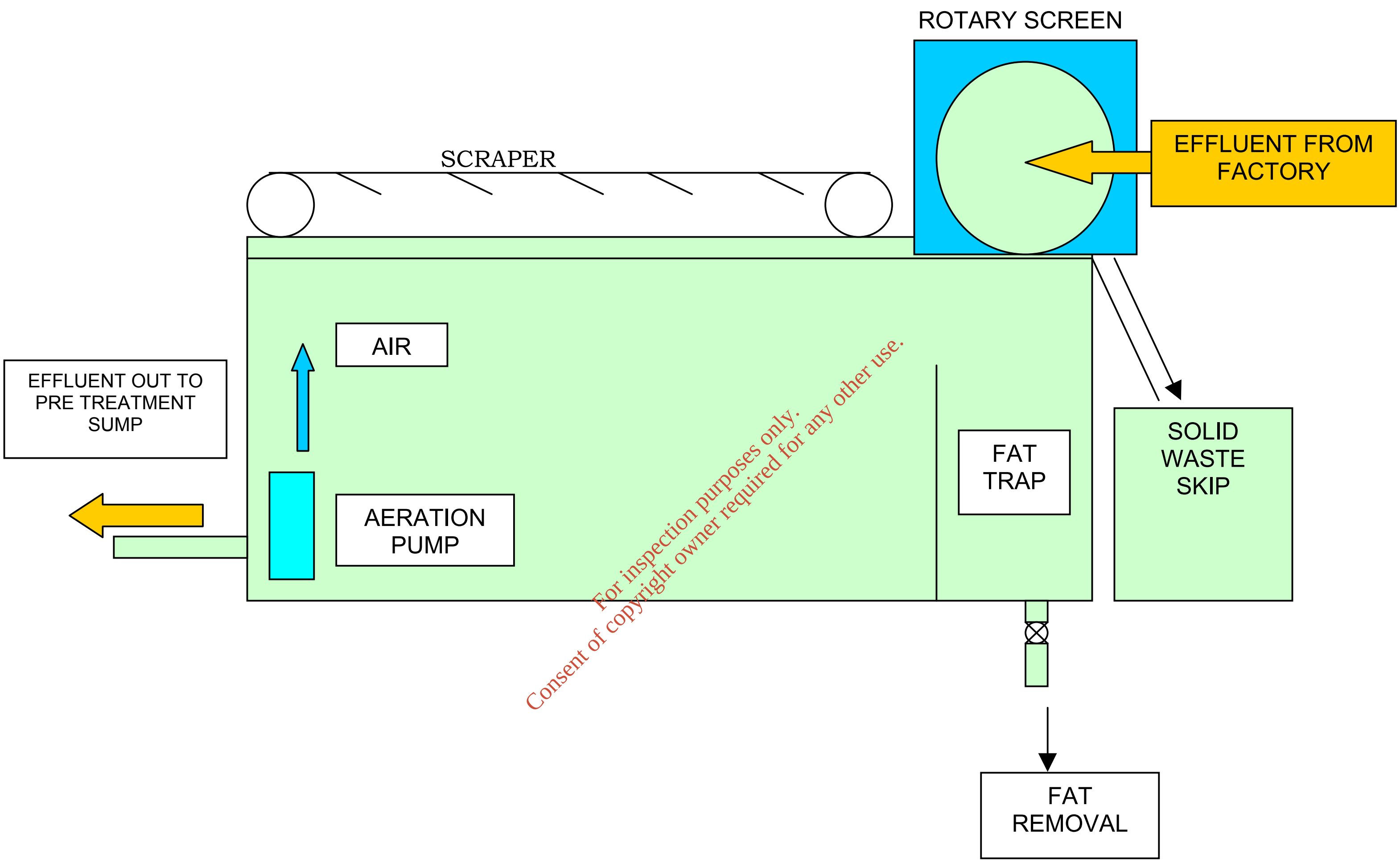


FIGURE 3.5.3: FILAMENTOUS BACTERIA AND FILAMENT ABUNDANCE CATEGORIES USING SUBJECTIVE SCORING SYSTEM:
(a) few; (b) some; (c) common;
(d) very common; (e) abundant; and

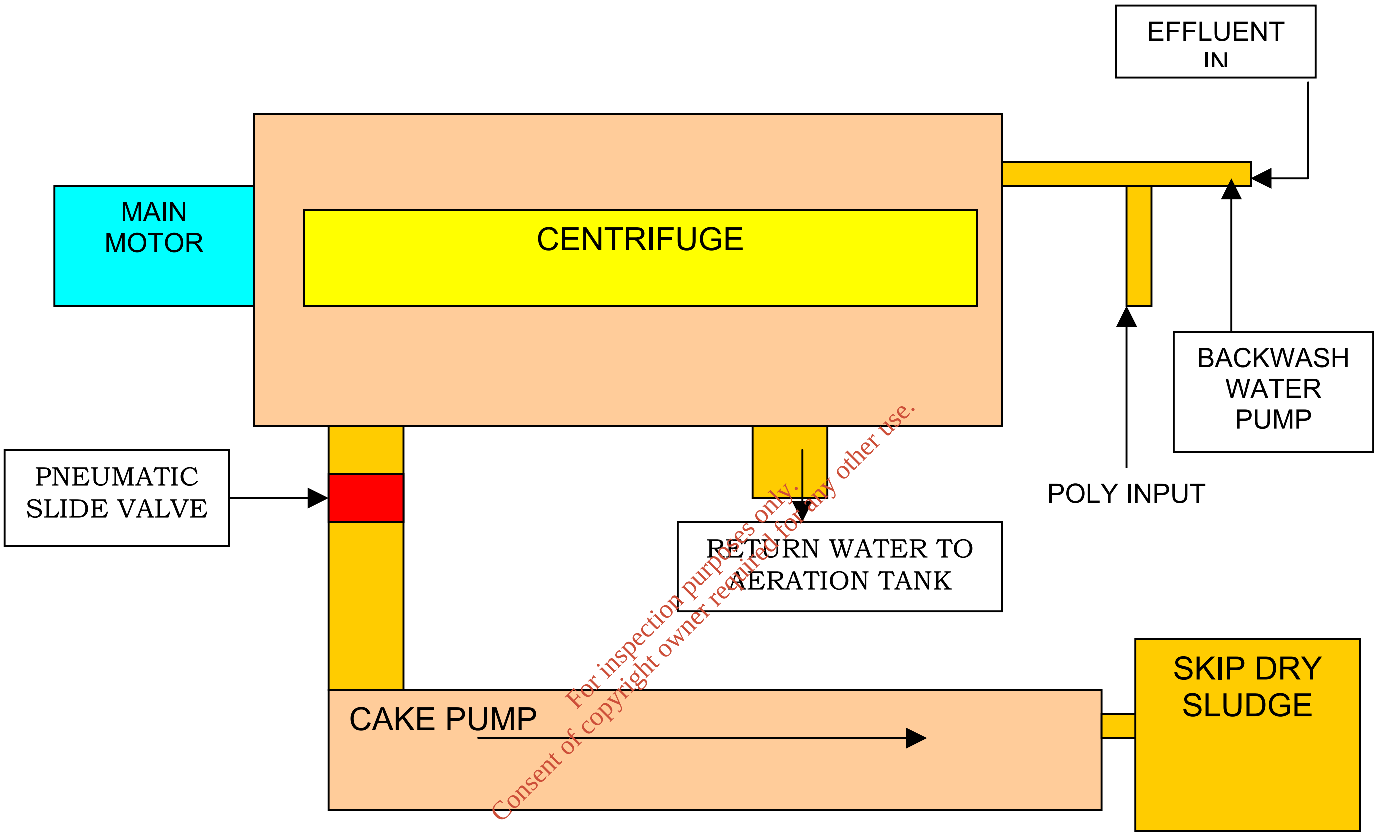
Appendix F.2.4 **Effluent Treatment Plant Process Flow Diagram**



Appendix F.2.5 **Schematic of DAF Unit**



Appendix F.2.6 Schematic of Centrifuge



Appendix F.2.7 Location Map Showing Surface Water Emission Points

See Attachment Appendix F.2.7