DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ)

FOSTERING AND ADVANCING SUSTAINABLE BUSINESS AND RESPONSIBLE INDUSTRIAL PRACTICES IN THE CLOTHING INDUSTRY IN ASIA

TRAINING PROGRAM FOR OEPRATORS OF EFFLUENT TREATMENT PLANTS
DAY 4

Operation Control of Biological Treatments

Anaerobic treatment

There are mainly three reactions happening in an anaerobic treatment system. The first is called hydrolysis and fermentation in which long chain organic compounds like proteins, carbohydrates etc. are converted to low chain fatty acids, alcohol etc. The process can be regarded as a cutting down of organic material into smaller pieces.

In the next stage, the low chain organic compounds formed in the previous reaction such as acids and alcohol will be converted into acetate , hydrogen and carbon dioxide.

In the final stage, a portion of carbon dioxide formed is reduced to methane by hydrogen ions and acetates are decarboxylated to methane gas.

The first step of reaction is carried out by a certain set of micro-organisms, generally called fermenters and the final stage reaction is brought about by another set of bacteria called methenogens.

For the control of anaerobic treatment, the following factors are to be closely monitored:

- pH
- alkalinity
- nutrients

pH

For the anaerobic treatment system to function efficiently, the system should be maintained in the proper range. It has been noted that the favourable range of pH value is 6.5 - 7.5 for most anaerobic organisms. While it is agreed that some anaerobic micro-organisms can function beyond the pH limits, it is recommended to maintain the pH of the anaerobic lagoon/reactor at a slightly alkaline range.

Alkalinity

The alkalinity of the system, mainly the bicarbonate alkalinity, is the dominant buffering factor in an anaerobic treatment system.

As explained earlier, the first phase of anaerobic reaction produces fatty acids, which will reduce the pH of the tank contents. The maintenance of sufficient alkalinity will guard against failure of the system due to the drop in pH.

Since the fermentation process in anaerobic reaction is faster to the methenogenation reaction, unless sufficient buffering capacity is maintained in the system, pH of the tank contents may fall drastically resulting in failure of the system.

As a rule, acidity:alkalinity ratio can be preferably maintained at around 4. An alkalinity of 1,000 ppm is generally adequate to ensure good anaerobic reaction in tannery effluent.

Nutrients

Nitrogen and phosphorous are the prime nutrients required for the biological reaction and trace concentrations of metals such as iron, cobalt and nickel and low concentrations of sulphides, generally called micro-nutrients are required for the anaerobic process.

Generally these components are there as per the characteristic of tannery effluent. However, it is advantageous to check up these components occasionally to ensure this.

Aerobic treatment

Like the anaerobic reaction, the aerobic biological process also is carried out in stages. The two important steps of reaction are:

- Breakdown of complex organic matter into cell matter
- Conversion of this cell matter into carbon dioxide and water**.**

The cell matter concentration is generally measured as MLSS concentration.

As can be presumed from the previous section, monitoring of aerobic biological treatment systems involves:

- The population of micro-organisms
- Activity of micro-organisms
- Environmental conditions favourable for effective micro-biological metabolism.

Population of micro-organisms

The micro-organisms present in an activated sludge process reactor get themselves attached to cell matter. The cell matter concentration is measured as the suspended solids in the system (MLSS).

It may not be always possible in an effluent treatment plant to check the presence of micro-organisms in the system by bacteriological studies using a microscope, colony counter etc. (Even if this is attempted, it may not be of much use due to the large variety of useful and useless micro-organisms present in the aeration tanks. Hence, the simpler method is to check the MLSS level.

Hence, the first step in monitoring of the aeration tank is the measurement of MLSS in the tank and this will give an idea whether sufficient population of bacteria is there in the system.

Generally, aeration tanks are designed for an MLSS level of 3,500 – 4,500 mg/l. A low level of MLSS can be due to the following:

- Low dissolved oxygen
- Low feeding
- Insufficient sludge re-circulation
- Low concentration of nutrients

A low MLSS level is also observed when the system, for whatever reason, for example overloading etc., collapses. When a low MLSS level is observed, the possible reason must be found out and necessary corrective measures are to be taken at the earliest. Needless to say, the MLSS level in the aeration tank must be checked every day.

Activity of micro-organisms

An MLSS level may not always give the right indication about the concentration of micro-organisms in the system since the suspended solids measured can include the mineralised organic matter - which is inactive - remaining in the tank (due to the return sludge pumping).

Normally, another parameters called MLVSS is checked to estimate the percentage of organic portion of the total MLSS which will give an idea regarding the 'active part' of MLSS.

An MLVSS percentage in MLSS of around 60-80% is considered as the indication of a healthy microbiological population.

If the MLVSS concentration is less than 60%, it indicates that the sludge wasting must be increased. If the value is above 80%, it indicates insufficient digestion and (a) any sludge wasting should be reduced and (b) the sludge recirculation rate should be increased.

Favourable environmental conditions

For optimum biological reaction, we have to maintain the specific conditions promoting the biological metabolism and prevent conditions which retard the reactions. Basically the important environmental conditions are :

- pH
- Dissolved oxygen
- Temperature
- Nutrients

pH: Generally the effluent entering the aeration tank should have a pH of 6.5 - 7.5. As in most of the treatment systems the aeration tank is preceded by a chemical treatment system, maintenance of correct pH range should be comparatively easy.

Dissolved oxygen: The aerobic micro-organisms require continuous supply of oxygen. When the population of micro-organisms in the aeration tanks increase, the oxygen uptake also increases and the D.O. level should be maintained by increasing the aeration.

As a rule, the D.O. level in the aeration tank should be maintained around 2.0 mg/l.

Temperature: Temperature is an important aspect in the rate of bacteriological reactions. It is generally considered that every 10ºC raise in temperature doubles the biological activity.

Though the effect of temperature in an extended aeration activated sludge system (the most common system in our ETPs) is lower compared to other biological systems, a regular monitoring of temperature in the system will help the plant operator to control the loading rate into the system.

Nutrients: For the biological metabolism to proceed satisfactorily, we have to maintain certain nutrients and micro-nutrients in the aeration tanks. Nitrogen and phosphorous are the principal nutrients and trace concentration of metals like iron, cobalt, nickel etc. are required for the reaction.

The concentrations of nitrogen and phosphorous in the effluent admitted into the Aeration Tank are to be maintained in the ratio with the BOD load as BOD : N : P = 100 : 5 : 1 where N stands for nitrogen and P represents phosphates.

Generally, tannery effluent has been found to contain these nutrients in this ratio and therefore, practically no nutrient addition is required. However, in some cases less concentration of phosphorous is noted.

A regular monitoring of nutrients is required to ensure the smooth functioning of the effluent treatment plant.

Control of aerobic treatment

The relevant parameters in control of aerobic treatment are:

- Control of optimum F/M level.
- Maintenance of D.O. level
- Maintenance of Nutrient level
- Control of Return Activated Sludge (RAS) flow rate
- Control of Waste Activated Sludge (WAS) level.

F/M Control

For control of correct F/M ratio, we require the following data:
Food Concentration i.e., the BOD value of influent into aeration tank, quantity of micro-organisms calculated as MLVSS (or MLSS, if MLVSS data is not available).

Note: The data for calculation of F/M should be a 7 day average and necessary corrections are to be made in accordance with seasonal temperature changes.

Most of the extended aeration systems are designed with the F/M ratio in the range of 0.08 - 0.14

Now let us see how one can calculate F/M ratio for the aeration tank, by going through the following example:
Let us assume the aeration tank has got a volume of 5,000 m^3, inlet BOD to aeration tank is 800 mg/l and the MLSS level proposed is 4,000 mg/l and the daily flow rate is 2,750m^3.

The total quantity of MLSS in the system = 4000 mg/l
= 4 g/l = 4 Kg/M^3 = 4000 Kg/1000 M^3
:. For 5,000 m^3 volume , the total quantity of MLSS = 20,000 Kg.

BOD load = 800 mg/l = 0.8 g/l = 0.8 Kg/M^3 = 800 Kg/1000 M^3 = 2,200 Kg/d

Hence the **F/M ratio**: 2,200/20,000 = 0.11

Now, compare this F/M ratio with the designed F/M ratio. If it is more than the design, reduce the feeding rate to aeration tank or try to reduce the BOD load to aeration tank by some other methods. If it is less you can safely increase the feeding rate or loading a little.

D.O. level: Generally a D.O. level of 2.0 - 2.5 mg/l in the aeration tank is acceptable, a D.O. level above 3.0, apart from wasting money in terms of electricity consumption, retards the activity.

If D.O. level is less than 1.0 mg/l, you have to increase the D.O. level by increasing the aeration, using more aerators or blowers or reduce the organic loading, if this is likely to be high.

Nutrients: Nutrients are required for proper biological metabolism. Nitrogen and phosphorous are the prime Nutrients and trace metals and some elements such as iron, nickel, manganese, sulphur, carbonates etc. are required as micro nutrients.

As mentioned, in the case of tannery effluent the nutrients will generally be there in adequate levels and nutrient addition is seldom necessary. In some cases, there can be insufficient levels of phosphorous and this may be supplemented by the addition of diluted phosphoric acid or sodium phosphate.

The nutrient level in raw effluent has to be checked periodically and maintained at the level mentioned.

Maintenance of Return Activated Sludge level

The activated sludge settled in the clarifier is returned back to the aeration tank to maintain the population of bio mass in it.

A return sludge ratio of 100 - 150% is maintained for an extended aeration activated sludge process. This means that if the raw effluent flow is 1,000 m^3/day, a return sludge flow of 1,000-1,500 m^3/day is required.

Maintenance of Waste Activated Sludge level

As the organic matter retained in the cell mass layer, i.e., MLSS gets mineralised as reaction proceeds, we have to 'waste' some quantity of return activated sludge to increase the volatile matter (measured as MLVSS) content in MLSS. Generally MLVSS portion in MLSS should be in between 60 - 80%.

Whenever this ratio falls down below 60%, you have to increase the sludge wasting rate so as to maintain the ratio within this level.

To waste the sludge, normally some quantity of return sludge is diverted/pumped to the thickener/sludge drying beds.

Wasting of return activated sludge will help to maintain the retention time of solids inside the system (which is generally measured by a term called 'sludge age') within the specified limit.

Section	**Nature of the Problem**	**Possible reasons**	**Remedial Measures**
Flash Mixer	Excessive foam in flash mixer	Effluent inlet pipeline discharges the effluent above water level in the flash mixer	Lower the pipeline so as to get effluent discharge below the water level.
	Flash mixer overflows during operation	1. Insufficient capacity of flash mixer 2. Low free board	1. Increase the volume of tank. 2. Decrease flow rate 3. Increase the free board.
Clari-flocculator	Solids are floating on the top of the water layer instead of settling.	1. Low pH 2. Sludge removal is not sufficient.	1. Keep proper pH range in chemical treatment. 2. Increase the sludge removal rate.
	Settling is good, but some solids are not settling in some parts of the tank	Poor flocculation of chemicals	Ensure good mixing of chemicals and flocculation.
	Solids are coming up to the surface in the form of globules	Anaerobic digestion of settled sludge.	Increase the frequency of sludge draw out.
	Solids are settling, but after some time rise to the top	Longer detention time inside the tank	1. Increase the flow rate 2. Increase the sludge draw off from the tank

Section	Nature of the Problem	Possible reasons	Remedial Measures
Clari-flocculator (continued.)	Solids settling is not taking place at all	Settling time is not enough	1. Reduce the flow rate 2. Use polyelectrolytes
	Solids rise to the top even with frequent sludge withdrawal	Clarifier mechanism is not functioning properly	Check the mechanism and its operation conditions.
	Solids overflow from one side of the clari-flocculator	Improperly arranged 'V' notch weirs.	Arrange the weirs uniformly.
	Tank surface is unsightly due to accumulation of scum	Scum remover is not working	Install proper scum remover system.

Biological treatment
Anaerobic processes

Section	Nature of Complaints	Possible reasons	Remedial measures
Anaerobic lagoon	Foul odour	1. Low pH resulting in production of hydrogen sulphide gas. 2. High organic load	1. Keep the desired pH range. 2. Keep the organic loading within the designed level.
	Effluent excessively black	High iron content in effluent resulting in production of ferrous/ferric sulphide.	Use non-ferric alum in chemical treatment

Section	Nature of Complaints	Possible reasons	Remedial measures
Anaerobic lagoon (continued)	BOD removal is very poor	1. Microbial activity is minimum 2. System efficiency is reduced due to decreased detention time, absence of proper reaction conditions	1. Proper seeding and cultivation of bacteria to be adopted during commissioning of the system 2. Bring back standard conditions
	High quantity of solids coming to surface as globules	The tank is filled with settled sludge	Desludge the tank.
	Outlet effluent is acidic, even if influent is neutral	System buffering alkalinity is not sufficient	Increase the alkalinity of influent above 1 g/l

Aerobic treatments

Area of trouble	Nature of the problem	Possible reasons	Remedial measures
Aeration Tank	Excessive foam: stiff white foam	1. low MLSS in process start up 2. Excessive wasting of activated sludge 3. Presence of toxic materials or pH changes	1. Reduce sludge wasting 2. Increase RAS rates
	Excessive brown foam	1. Low F/M ratio 2. Too high MLSS concentration	1. Increase the F/M ratio 2. Increase the sludge wasting rate
	Aerators failing	Higher aerator submergence	Adjust the aerator levels

Area of trouble	Nature of the problem	Possible reasons	Remedial measures
Clarifier	Solids washout	1. Equipment malfunction 2. Hydraulic overload 3. Solids overload	1. Check and rectify clarifier. 2. Reduce flow rate 3. Increase WAS rate
	Sludge Bulking	1. Low D.O. 2. Filamentous micro-organisms. 3. Insufficient nutrients 4. Low pH 5. High temperature	1. Increase no. of aerators or blowers 2. Increase the RAS 3. Add nutrients 4. Correct pH range 5. As a last step, use some chemical conditioners like chlorine or $CuSO_4$.
	Clumping/ rising of sludge	1. Low F/M ratio 2. Low D.O. 3. High temperature	1. Increase sludge wasting rate. 2. Increase D.O.
	Ashing of sludge	1. Denitrification reaction 2. Excessive conc. of grease in effluent	Improve the performance of oil and grease trap.
	Pinpoint floc	1. Low F/M ratio 2. Over aeration	1. Increase F/M ratio 2. Decrease aeration time by reducing aerators or blowers.