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Operation and Control of a Wastewater Treatment Plant

Many Plants run numerous tests at their wastewater treatment plant. Are you running tests because it has always been done that way" or are you running useful tests that produce data that is usable and real time. Taking tests that no one can use or access if it is not in one central place that all operators can access again, is pointless. Make sure the data is real time, usable by all operators and is meaningful. Garbage in - Garbage out.

We have been asked to provide a lot of training on standard operator tests. In this newsletter, we are going to take some of the standard tests, how they normally run, and also point out some of the flaws in these basic tests that should not be overlooked. Some of this is standard testing from the EPA, some based on the standards of practice from Metcalf & Eddy and used in many wastewater treatment plants.

Operating data from wastewater treatment plants can be generated to include some useful operational control strategies. Some of these typical control methods might include:

1. Sludge Volume Index
2. Sludge Age: Mean Cell Residence Time (MCRT)
3. Food/Mass Ratio
4. Constant MLSS
5. Return Activated Sludge Control (RAS)
6. **Daily Microscopic Analyses - often overlooked and yet the most reliable and useful!**

Sludge Volume Index (SVI) is an indication of the sludge settleability in the final clarifier. It is a useful test that indicates changes in the sludge settling characteristics and quality.

By definition, the SVI is the volume of settled sludge in millliliters occupied by 1 gram of dry sludge solids after 30 minutes of settling in a 1000 ml graduated cylinder or a settleometer.

A liter of mix liquor sample is collected at or near the outlet of the aeration tank, settled for 30 minutes in a 1 liter graduated cylinder, and the volume of sludge is reported in milliliters.

The SVI is computed by dividing the result of the settling test in ml/liter by the MLSS concentration in mg/L in the aeration tank times 1000.

*Sludge Volume Index (Ratio) = SV30 * 1000 / Aeration Basin MLSS*

The common range for an SVI at a conventional activated sludge plant should be between 50 and 150. Optimum SVI must be determined for each plant experimentally. The SVI has also been used as an indication of the settling characteristics of the sludge. However, the SVI that is characteristic of a good settling sludge varies with the characteristics and concentration of the mixed-liquor solids, so observed values at a given plant should not be compared with those reported for other plants or in the literature. Typical SVI's for a good settling sludge with mixed liquor concentrations in the range of 1500 to 3500 mg/l range from 80 to 120. Plants that run extended air versus an oxidation ditch may have completely different SVI's, with different MLSS values. Filamentous bulking will definitely impact the SVI even if you have the same target MLSS.

One thing that can be done is a dilute 50/50 test. In this test a normal settlometer is run, and then one with 50% water and 50% sludge. This is used along with your microscope to tell if you just have too much MLSS or you have a case of filamentous bulking. If you have filamentous, and your sludge only settles to 900, then in a 50/50 dilute with just too much MLSS, theoretically, it should settle to around 450. If you have filamentous bulking though, it may settle in the 50/50 at 700 or 800, but definitely not at the halfway point.

Sludge density index (SDI) Sludge Density Index is used like the SVI to determine sludge settling characteristics and return sludge pumping rates. It is a measure of the degree of compaction of an activated sludge after performing a settleability test. SDI is equal to 100/SVI, and is expressed in terms of grams per milliliter.

The common operational range for SDI is 1.0 - 2.5. The SVI and SDI indexes relate the weight of sludge to the volume that the sludge occupies and attempts to show how well the activated sludge separates from the mix liquor. Sludges with a low SVI (high SDI) have good settling and compaction characteristics.

Sludge Age

The concentration of the activated sludge solids and the condition of those biological solids determines the effectiveness of an activated sludge process. Too few or too many organisms in a system will cause operational control problems, reducing treatment plant efficiency and causing an added load on the receiving waters. Sludge age is defined as the average time in days the suspended solids remain in the entire system.

To successfully maintain a viable biological population and to maintain the proper concentration of solids, the system requires continuous observation and monitoring by the operator. Sludge age is one of the methods or tools available to the operator to help maintain the desired amount of solids in the aeration tank.

Sludge age is a relatively easy control parameter to monitor because the suspended solids in the aeration tank are easy to measure. Sludge age considers the:

1. solids entering the aerator; measured as primary effluent suspended solids in mg/L, and
2. solids or organisms available to degrade the wastes; measured as Mixed Liquor Suspended Solids, mg/L

**** Be careful of this method. Many operators use this, and are often times off. Sludge age should be determined by microscopic analyses instead of solids mass balance: Worms and rotifers with dark brown floc typically indicate an older sludge. Clear, light fluffy floc structures with tons of amoebae and flagellates indicate a younger sludge. Tons of stalked ciliates and some free swimmers typically indicate medium age sludge.**

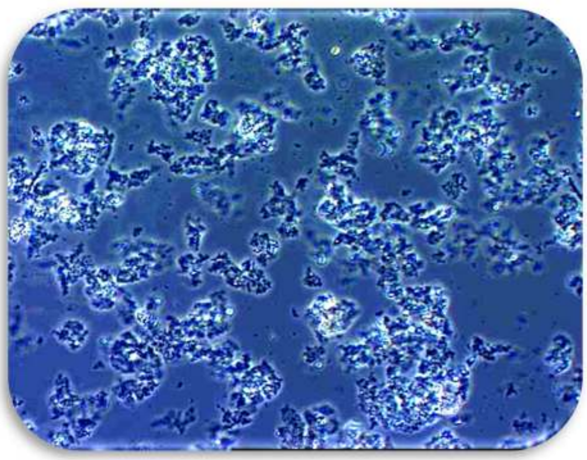
The problems with using mathematical calculations typical of engineers are that it does not really take into account the quality of the biomass, only the quantity. Filamentous sludge takes up more volume than floc forming bacteria. That will not help you determine if it is young or old.

The common range for sludge age for a conventional activated sludge plant is between 3 and 15 days. For extended aeration activated sludge plants the range is between about 15 and 30 days. Generally during the winter months, higher sludge ages are required to maintain a sufficient biological mass. In the summer time, biological activity increases and lower sludge ages normally produce a higher quality effluent. Thus, the sludge age should be adjusted at least twice a year to accommodate seasonal variations. The operator must realize, however, that the optimum sludge age may not fall in the common ranges given here. This is due to the fact that the waste characteristics, process design, flexibility in operation, and process control equipment are different for all facilities. The operator, by trial and error, can find the optimum sludge age for that particular plant and specific conditions. If there are wide swings in loading, then the MLSS needs to be adjusted according to the loading.

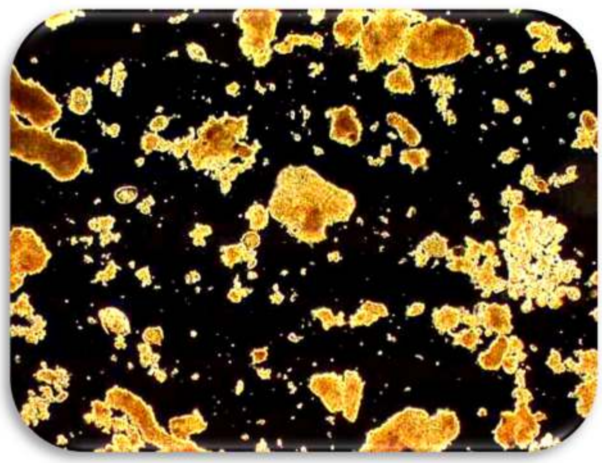
A low sludge age tends to produce a light, fluffy, buoyant type of sludge particle commonly referred to as straggler floc, which settles slowly in a final clarifier. This will be witnessed in a clarifier when these buoyant, fluffy sludge particles are being pulled over the weirs even though the effluent may be crystal clear.

A high sludge age or too many solids in the system tends to produce a darker, more granular type of sludge particle, commonly called pin floc, which settles too fast in a final clarifier. Pin floc is observed as many fine tiny floc particles coming over the final clarifier weirs leaving a very turbid effluent.

Young, fluffy sludge



Older, more compact sludge



Mean Cell Residence Time (MCRT)

Another operational approach for solids control, like the sludge age, is the mean cell residence time (MCRT) or Solids Retention Time (SRT). This parameter is a refinement of the sludge age and takes into consideration the total solids inventory in the secondary or biological system.

Again, the desired MCRT for a given plant must be found experimentally just like the sludge age.

The MCRT is calculated as:

MCRT (Days) = (Aeration Basin Volume + Clarifier Volume) * MLSS * 8.34 /
(2nd Clarifier WAS * WAS Solids * 8.34) + 2nd Clarifier Solids Out

or

$$\text{MCRT} = \frac{\text{pounds of Solids in Inventory}^{*}}{\text{pounds of Solids Lost per Day}^{**}}$$

* Solids Inventory = pounds of MLSS in aeration basin *plus* pounds of SS in secondary clarifier.

** Solids lost per day includes both, the pounds of TSS lost in the effluent from the secondary clarifier *plus* the solids wasted intentionally from the secondary clarifier. **Many operators overlook the TSS that goes out in the effluent when making calculations!**

Food/Mass Ratio

The Food/Mass or the Food/Microorganism ratio commonly referred to as F/M is based upon the ratio of food fed to the microorganisms each day to the mass of microorganisms held under aeration. It is a simple calculation, using the results from the influent BOD test to the aerator and the mixed liquor suspended solids test. Using the COD test may be preferred because the results are available sooner than the five day BOD.

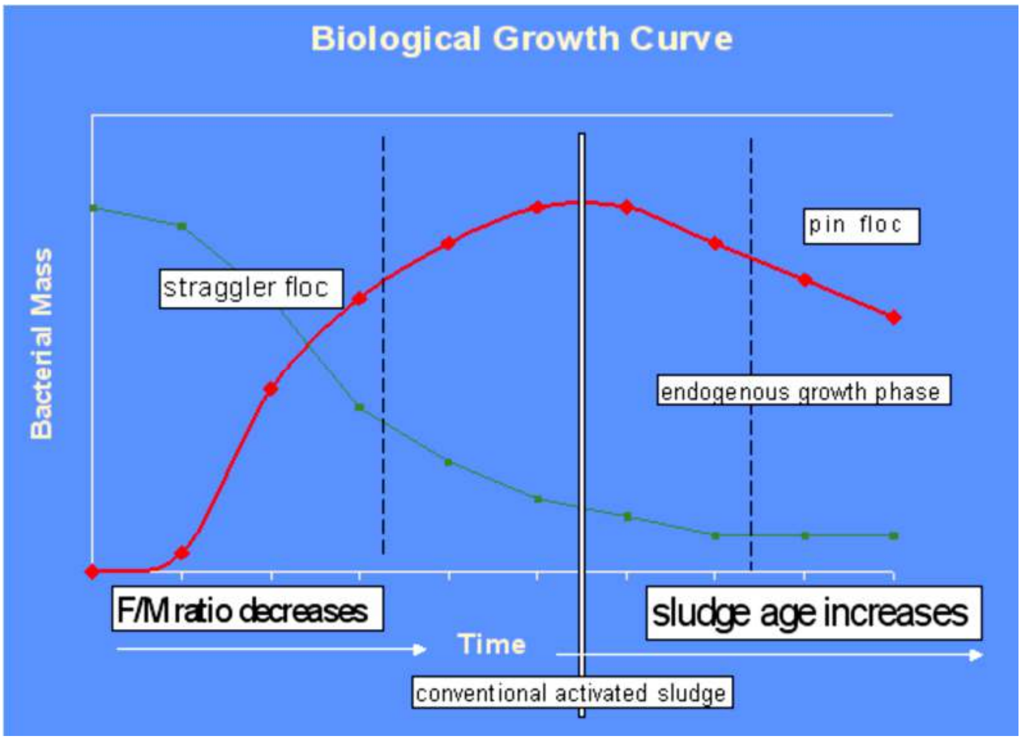
Common ranges for F/M for a conventional activated sludge plant are from 0.15 to 0.5. These values refer to calculations based on the 5 day BOD test. The optimum F/M varies from plant to plant and can be determined by trial and error. Generally, low F/M ratios should be carried during the colder months.

The F/M ratio is calculated as follows:

F/M (Ratio) = Flow In * BOD In * 8.34 / Volume * MLVSS * 8.34

*The mixed liquor volatile suspended solids (MLVSS) may be a more accurate estimate of the mass of microorganisms than MLSS.

Paper mills cannot use MLVSS, since paper fibers may make up part of the biomass, and will burn off easily. Keep in mind, again, filaments vs. floc. You may think you have an older sludge if you just use mass balance numbers. All of the operational guidelines were determined by engineers, who love math! They were afraid of the microbiology aspect. Looking under the microscope was black magic and harder, so let's uses numbers!



Remember, you are running a bug factory, check the bugs!

Constant Mixed Liquor Suspended Solids

One of the easiest and most often used control procedures for activated sludge systems is the Constant Mixed Liquor Suspended Solids method.

In this method, the operator selects a certain MLSS concentration or range of mixed liquor concentrations that produce the best effluent and the highest removal efficiencies. This specific value or range must be determined experimentally based upon loading, size of the plant and desired final effluent results based upon permit limitations. When the operator finds the optimum MLSS concentration for each plant, he attempts to maintain this value by adjusting the sludge-wasting rate.

One rule of thumb for activated sludge systems is that for every pound of BOD removed in the secondary system a half pound of new solids is generated through reproduction of the organisms and addition of new organisms from the influent wastes. So, the operator tries to waste the proper amount of solids to keep his selected optimum mix liquor concentration constant. Again, quantity vs. quality if you use this method. Check the microscopic analyses for optimization even on this test! Solids balance is not always the optimum way to go unless you have a very stable influent.

Solids Mass Balance

The Law - Matter is neither created nor destroyed (this goes for biodegradation too). For X pounds of BOD degraded, Y pounds of solids are formed. X:Y ratio varies from plant to plant, as well as condition to condition at a given plant (ie; by process design and by nature of sludge generated.)

Some Average Solids Generation Ratios To Use As Benchmarks

	BOD:Sludge
• Basic Steel (coke):	1.0:0.15
• Petroleum Refining	1.0:0.35
• Chemical Process	1.0:0.35
• Sanitary (Municipal)	1.0:0.3-0.5
• Pulp & Paper	1.0:0.5
• Brewing	1.0:0.6
• Food Processing	1.0:0.7

If the MLSS concentration is above the desired concentration, wasting of the excess solids will have to be started or increased.

If the MLSS concentration is below the desired concentration level, wasting should be decreased or stopped.

Operators should keep in mind that in most cases it is better to waste continuously over 24 hrs/day, seven days a week than to waste intermittently in slugs. Drastic changes in sludge wasting rates are undesirable. Increases or decreases in wasting should be made gradually, i.e., 10 - 20 percent per day.

Return Activated Sludge Control

To properly operate the activated sludge process, a good settling mixed liquor must be achieved and maintained. The MLSS are settled in a clarifier and then returned to the aeration tank as the Return Activated Sludge (RAS). The RAS makes it possible for the microorganisms to be in the treatment system longer than the flowing wastewater. For conventional activated sludge operations, the RAS flow is generally about 20 to 40 percent of the incoming wastewater flow. Changes in the activated sludge quality will require different RAS flow rates due to settling characteristics of the sludge. Filaments can take up large amounts of space, and require more RAS to achieve the desired results. Also filaments do not typically help as much as floc formers with ammonia removal.

There are two basic approaches that can be used to control the RAS flow rate. These approaches are based on the following:

1. Controlling the RAS flow rate independently from the influent flow.
2. Controlling the RAS flow rate as a constant percentage of the influent flow.

Constant RAS Flow Rate Control.

Settling the RAS at a constant flow rate that is independent of the aeration tank influent wastewater flow rate results in a continuously varying MLSS concentration that will be at a minimum during peak influent flows and a maximum during minimum influent flows. This occurs because the MLSS are flowing into the clarifier at a lower rate during peak flow when being removed at a constant rate. Similarly, at minimum influent flow rates, the MLSS are being returned to the aeration tank at a higher rate than are flowing into the clarifier.

The aeration tank and the secondary clarifier must be looked at as a system where the MLSS are stored in the aeration tank during minimum wastewater flow and then transferred to the clarifier as the wastewater flows initially increase. In essence, the clarifier acts as a storage reservoir for the MLSS, and the clarifier has a constantly changing depth of sludge blanket as the MLSS moves from the aeration tank to the clarifier and vice versa. The advantage of using this approach is simplicity, because it minimizes the amount of effort for control. It is also especially advantageous for small plants because of limited flexibility.

Constant Percentage RAS Flow Rate Control

The second approach to controlling RAS flow rate requires a programmed method for maintaining a constant percentage of the aeration tank influent wastewater flow rate. The program may consist of an automatic flow measurement device, a programmed system, or frequent manual adjustments. The programmed method is designed to keep the MLSS more constant through high and low flow periods.

Comparison of Both RAS Control Approaches

The advantages of the constant RAS flow approach are as follows:

1. Simplicity.
2. Maximum solids loading on the clarifier occurs at the initial start of peak flow periods.
3. Requires less operational time.

The advantages of the constant percentage RAS flow are the following:

1. Variations in the MLSS concentration are reduced and the F/M varies less.
2. The MLSS will remain in the clarifier for shorter time periods, which may reduce the possibility of denitrification in the clarifier.

A disadvantage of using the constant flow approach is that the F/M is constantly changing. The range of F/M fluctuation due to the effect of short-term variation in the MLSS (because of hydraulic loading) is generally small enough so that no significant problems arise due to using this approach. The most significant disadvantage of the second approach is that the clarifier is subjected to maximum solids loading when the clarifier contains the maximum amount of sludge. This may result in solids washout with the effluent.

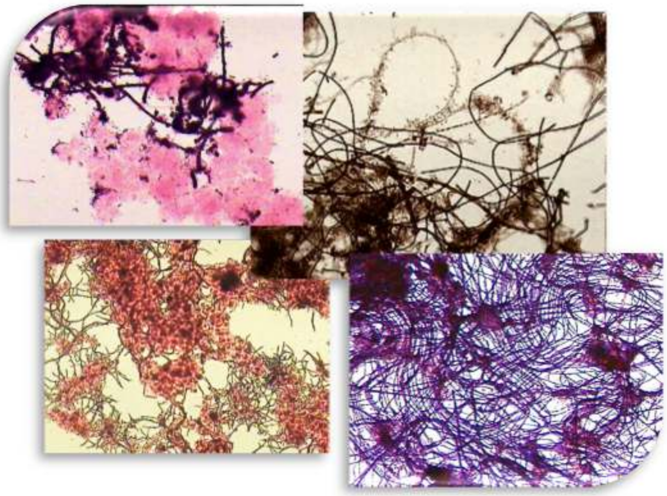
In general, it appears that most activated sludge operations perform well and require less attention when the constant RAS flow rate approach is used. Activated sludge plants with flows of 10 mgd or less are often subject to large hydraulic surges, and performance of these plants will benefit the most from the use of this approach.

Microscopic analyses

This is the most under utilized test that is available to any operator. With today's technology, you can buy a microscope for $200.00 and a great digital microscope with a camera that stores photos for $1500.00. Daily testing should be done and when properly trained, using standard excel log sheets, should only take 10-15 minutes a day! Yet the information gained can be far more valuable than any of the other tests available!

Here is a perfect example. This photo shows four different plants with dark foam. Without looking under the microscope, most people assume that it is Nocardia or Microthrix parvicella, and treat accordingly!

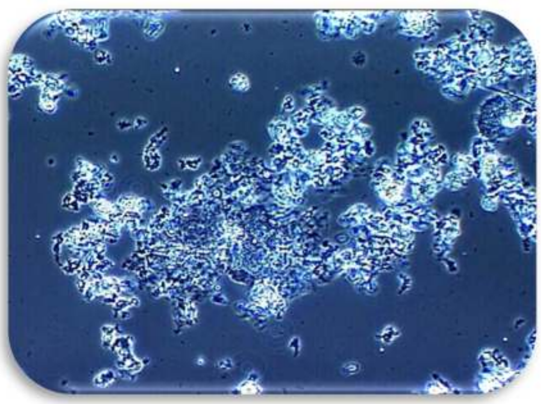
This is a wrong assumption; all four plants in image have totally different causes and controls.

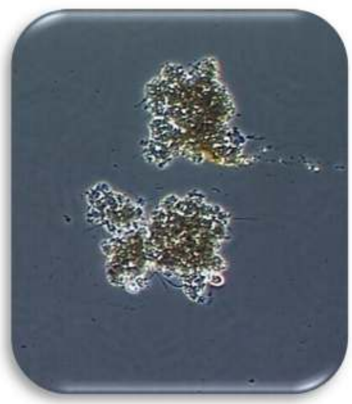


One plant had Zoogleal Bulking due to Nutrient Deficiency and needed to increase Nitrogen addition. One had Nocardia and N. limicola, due to excess grease, low D.O. and holding solids too long in the clarifier; so increasing D.O, lowering clarifier solids and primary grease control was the changes made to this plant. The third was Microthrix due to excess grease in the primaries and holding clarifier solids too long. Changes to primaries and secondary clarifiers were necessary. The fourth was Low DO, and septicity in the digestor and clarifier. All four plants had totally different filaments present, and totally different process changes that needed to be made in order to correct the plant. Without looking under the microscope, none of the correct changes would have been made!

Another example of why mass balance on the MLSS does not always work.

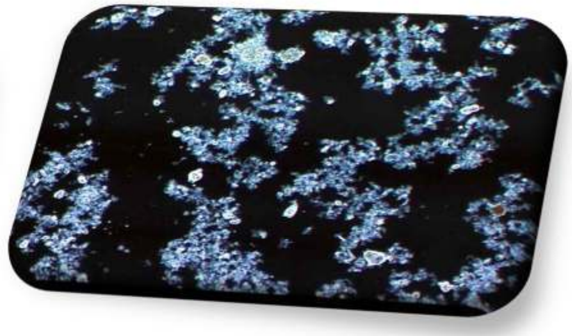
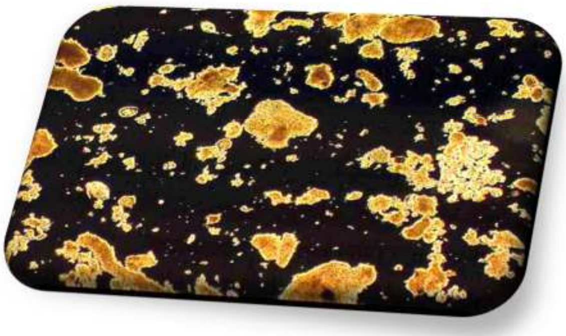
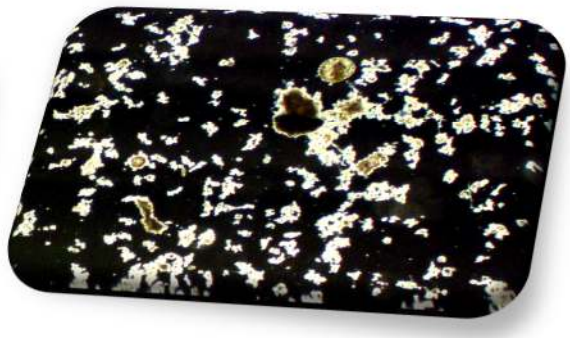
Say you normally carry a MLSS of 2000. You get hit in the middle of the night with a high BOD loading, double or triple your normal flow. The floc will be young, fluffy and take up quite a bit more space than normal, stable floc. Your solids immediately jump up overnight to 3000. If you were doing a mass balance, normally you would waste some of the MLSS to get down back to 2000, which in turn would make your MLSS even younger, and fluffier, and unable to keep up with the BOD, thus defeating the purpose. Quantity is not the best way to go, quality is. Had you looked under the microscope, you would have seen tons of amoebae and possibly flagellates, known you were hit with a high BOD and cut back on wasting temporarily until you plant recovered from the hit and thus recovered quicker from a small spill by making the correct process adjustment!





Young, fluffy floc vs. "Goldilocks" stable compact floc in the above photographs.

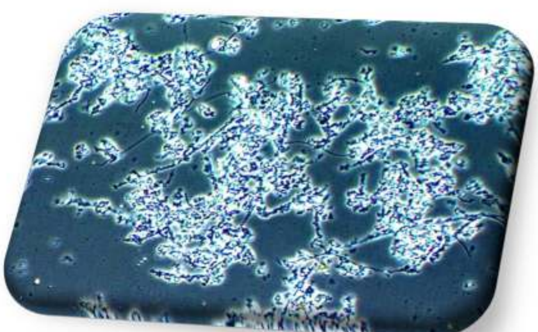
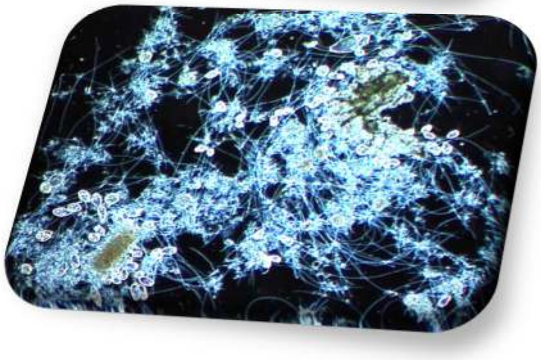
Here is the reverse scenario, you typically carry a MLSS of 2000, your sludge actually is getting quite old and digesting in the clarifiers, so now it is down to 1500, you think you need more sludge, so you quit wasting, and you try to build up more. The sludge gets older and older and you again defeat the purpose. You probably wind up with ashing and gassing on the clarifier and TSS problems and possibly nitrification problems. Had you looked under the microscope, you would have probably seen very dark, if not black floc, some rotifers and many worms. What you should have done is the reverse, and increase wasting a bit, turn the sludge a bit younger, and then you would have had the correct volume, hit your targets on BOD and had no problems!

Notice the change in size, shape and color with age. Very young, small and clear, typically indicate high BOD. As it gets older, the floc is fluffy, large and clear. Medium to older sludge - Goldilocks in color, compact and very little TSS. Starting to get very old, smaller, more compact and dark brown spots.

Here is a third scenario with filaments-

Floc that has filaments is going to take up 3-5 times the volume of mass that floc formers take up. You are not getting 3-5 times the treatment; there are holes and spaces in the volume. Imagine a sponge - so if you use volume or mass balance as a way of measuring MLSS, keep that in mind. Check under the microscope. You may need more mass to do the same amount of work! …………………………**Use your microscope daily, it is more accurate than any numbers can ever get close to!** The bugs will change quickly in hours and react to any spill, and will tell you long before there are major problems. Think about it, their life span is many times 20 minutes to 2 hours. They will react quickly and indicate changes needed.

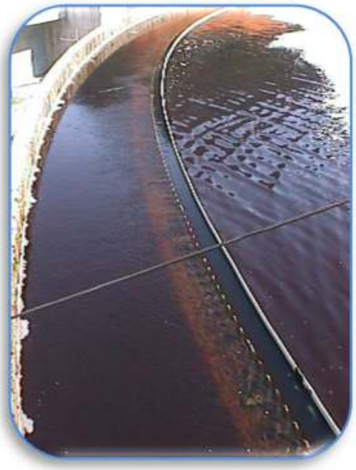
Your wastewater treatment plant is a Bug Factory. Look under the microscope! It is the most powerful tool you have to run your plant! 5 minutes a day is all it takes once you get practice! Be proactive vs. reactive! Significant cost savings can be achieved and it is easier to run your plant when you know what is going on and how to react correctly to issues instead of guessing!!

Operational Guidelines Though the standard operating parameters are widely used, the details of the operating procedure will vary at different activated sludge plants, depending on the type of facilities available, strength and character of the wastewater, temperatures, requirements of the receiving waters, etc. The best operating procedure for each plant must be determined by experience. Some guidelines that may be applied to a conventional activated sludge plant are:

0. There must be sufficient aeration to maintain a dissolved oxygen concentration of at least two mg/L at all times throughout the aeration tanks. The reason you measure a residual of 2 ppm at the back end, is to make sure that there is sufficient DO in the clarifier so that the returned sludge has not run out of air, turned septic, caused the growth of filaments, TSS due to ashing or gassing or worse yet, killed your nitrifiers.
1. Dissolved oxygen should be present at all times in the treated wastewater in the final settling tanks. Don't forget Digestors if they are aerobic or sludge holding tanks.
2. Activated sludge should be returned continuously from the final settling tanks to the aeration tanks.
3. Optimum rate of returning activated sludge will vary with each installation and with different load factors. In general, it will range from 20 to 40 percent of the influent wastewater flow for diffused air and 10 to 40 percent for mechanical aeration units.
4. Optimum MLSS concentrations should be determined experimentally for each plant. The optimum mix liquor suspended solids concentration in the aeration tanks may vary considerably, but usually is in the range of 600 to 3000 mg/L unless high rate oxygen systems. Again, remember if there are filaments, they may take up more volume, but won't really give you more treatment, so use the microscope to determine the correct age, and sufficient amount of sludge needed.
5. A sludge volume index of about 100 and a sludge age of three to fifteen days are normal for most plants. When the optimum sludge volume index is established for a plant, it should be maintained within a reasonably narrow range. A substantial increase in SVI is a warning of trouble ahead.
6. The suspended solids content in the aeration tanks may partially be controlled by the amount of sludge returned to them. All sludge in excess of that needed in the aeration tanks must be removed from the system. It should be removed in small amounts continuously or at frequent intervals rather than in large amounts at any one time. Sludge held too long in the final settling tank will become septic, lose its activity and deplete the necessary dissolved oxygen content in the tank.
7. Septic conditions in the primary sedimentation tanks will adversely affect the function of the activated sludge process. Prechlorination or pre-aeration may be used to forestall septic conditions in the wastewater entering the aeration tanks. Septic primaries have been shown to cause filamentous bulking. Septic clarifiers, digestors and sludge dewatering supernatant also are areas where septicity occur, but are often overlooked.
8. Periodic or sudden organic overloads that may result from large amounts of sludge digestor overflow to the primary tanks or from doses of industrial wastes having an excessive BOD or containing toxic chemicals will usually cause operating difficulties. Whenever possible, overloading should be minimized by controlling the discharge or by pretreatment of such wastes. High grease that breaks off from pipes and sewers during high rains also can cause overloads of BOD, and growth of Nocardia and M. Parvicella.

The basic indicator of normal plant operation is the quality of the plant effluent. Failure of plant efficiency may be due to either of the two most common problems encountered in the operation of an activated sludge plant, namely, rising sludge and bulking sludge.

Final Clarification: For an activated sludge process to achieve optimum plant efficiency the final clarification unit must effectively separate the biological solids from the mixed liquor. If these solids are not separated properly and removed from the clarifier in a relatively short period of time, operating problems will result, causing an increased load on the receiving waters and a decline in plant efficiency.



The most important function of the final clarifier is to maintain the wastewater quality produced by the preceding processes.

Design Considerations

Final clarifiers should be designed with rapid sludge withdrawal systems to inhibit the tendency of the sludge to become anaerobic if not removed quickly.

Weirs should be of the saw-tooth type to allow for better weir overflow and flow distribution. Weirs should be level and fee from scum and algae to prevent short-circuiting within the clarifier.

The tanks should be sufficiently baffled to reduce velocities and to disperse the flow evenly to reduce short-circuiting.

Short-circuiting will tend to increase the solids losses over the clarifier weirs. Also, final clarifiers should include some type of surface skimming device to remove floating solids and scum. Final clarifiers should be designed with a hydraulic detention time from 1 - 2 hours.

Operational Problems with Final Clarifiers

The operator must keep in mind that many operating problems in the final clarifier can be associated with operating problems in the preceding processes, i.e. mainly the aeration system.

Floating Solids: This is commonly referred to as "clumping", "ashing" or "rising sludge". Floating solids are usually due to a high sludge age (too many solids in the system) or too long of a solids detention time in the final clarifier.

Gassing** (image below left)* ***vs.
Ashing** (image below right) **on Secondary Clarifiers

Remedies:

Decrease solids inventory (increase wasting rate)

Remove solids from final clarifier quicker

Check for any dead spots in clarifier where solids are not being collected and removed.

A heavy accumulation of solids on the surface of a clarifier may be alleviated by spraying the surface with a high-pressure hose to knock the solids down.

Solids Losses over Effluent Weirs: Excessive solids losses in the final clarifier can be the result of hydraulic overload or due to the type and characteristics of the biological solids present.

Straggler Floc is indicative of a young sludge, which tends to settle slowly. This type of floc consists of light, fluffy, buoyant particles. This situation can be intensified by short-circuiting and hydraulic overloads.

Remedies:

=Increase solids inventory by decreasing the wasting rate to produce an older sludge, which tends to settle faster.

=Check clarifier for short-circuiting.

=Calculate detention time and check for hydraulic overloading.

Pin Floc is indicative of an older sludge, which tends to settle too fast, leaving many fine suspended particles in the supernatant and a turbid effluent. The sludge particles are usually darker, heavier and more granular in appearance.

Remedies:

=Increase sludge wasting rate to decrease solids inventory.

=Check for short-circuiting and hydraulic overload.

Fouling of Weirs: An accumulation of solids and/or on the weir surfaces can cause short-circuiting within the tank, creating excessive velocity currents that pull solids over the effluent weirs.

Remedies:

=A thorough scrubbing of weir surfaces to remove solids build-up.

=Strong chlorine solutions applied to the weirs is also effective.

Plugging of Withdrawal Ports is usually caused by too high of a solids concentration in the return sludge.

Remedy:

=Withdraw sludge faster and/or more frequently.

Rising Sludge: Unlike bulking, the problem of rising sludge is only seen in the final settling tank and has definite operational causes and it can be corrected through an understanding of the system and defined management practices.

The biological oxidation of a wastewater has been described as a two-phase reaction where organic carbon oxidation occurs first and is usually followed by the biological oxidation of ammonia or nitrification. Domestic wastewaters, as already noted, besides having organic, carbon containing compounds always contain ammonia. Generally, prolonged aeration or organic underloading of a biological wastewater treatment plant can result in a condition where oxidation of most of the organic matter occurs (that is, carbon is converted to carbon dioxide) and nitrification follows. This process of nitrification involves the conversion of ammonia, nitrogen and organic nitrogen to nitrate nitrogen.

The nitrates that are formed in the aeration tank then flow into the final settling tank where quiescent settling and solids removal will take place. If the dissolved oxygen levels are sufficiently low in the settling tank and there is some organic matter available, denitrificaton will take place.

Rising sludge is caused by denitrification in which nitrites and nitrates in the wastewater are reduced to nitrogen gas. Denitrification occurs in the sludge layer in the secondary clarifier when conditions become anaerobic or nearly anaerobic. As the nitrogen gas accumulates, the sludge mass becomes buoyant and rises or floats to the surface. Rising sludge can easily be differentiated from a bulking sludge by noting the presence of small gas bubbles attached to the floating solids and by microscopic examination. This problem can be overcome by increasing the removal rate of the sludge from sludge-collecting mechanism, by regulation of the flows (loading) and monitoring of the dissolved oxygen levels in the final settling tank.

Filamentous Bulking: Generally, non-flocculent or non-settling microbial growth is the result of either suppressing the normal wastewater treatment bacteria or promoting conditions favorable to filamentous microorganisms, such as fungi or actinomycetes which cannot be settled readily. The presence of filamentous microorganisms to the point where they interfere with settling is called bulking. This condition may be seen in the aeration tanks of activated sludge processes and is sometimes accompanied by frothing. The solids do not settle in the final settling tank and a homogeneous blanket of solids will pour out over the effluent weirs, especially during diurnal peak flow variations. Filamentous bulking can be recognized through a microscopic examination of the mix liquor and observing the presence of these microorganisms in the flocculent material that does not settle. Under filamentous bulking conditions the presence of filaments is obvious and the filaments can be seen preventing more normal looking flocs from coming together.

The conditions associated with filamentous bulking are not always well understood, but have been associated with high organic loadings, pH changes, low pH wastewaters, inputs of industrial wastes, low dissolved oxygen levels, seasonal variations, septic primaries, and an improper balance between carbon, nitrogen and phosphorous in the waste. The problem of bulking is not easy to deal with since its causes cannot always be identified. However, a careful review of the operating records with respect to pH, loading, and aeration tank DO, MLSS, etc. is always useful in attempting to develop relationships between poor operating conditions and bulking. Careful records and trending as well as a close control over operating conditions and a knowledge of inputs into the wastewater system is useful.

When bulking of activated sludge is caused by overloading, prechlorination to reduce the load on the aeration process has been tried with some success. Prechlorination of the primary tank influent to produce a residual of about 0.1 mg/L in the primary tank effluent is used. Prechlorination of the primary tank influent is particularly useful in controlling septicity. Chlorination of the return activated sludge can control filamentous bulking. The point of application should be where the return sludge will be in contact with the chlorine solution for about one minute before the sludge is mixed with the aerator influent. The chlorine dose is varied according to the variations in the sludge volume index and may be estimated as follows:

SVI x F x W x 8.34 x 10^6 = pounds of chlorine per day where:

SVI = Sludge Volume Index
F = Return sludge rate in million gallons per day
W = Suspended solids in return sludge in mg/L

Chlorine dosages can better be determined by trial and error. In general, chlorination of a bulking sludge will reduce the sludge volume index, thus the dose is reduced daily until bulking is corrected. In some plants intermittent chlorination will maintain a low sludge volume index, and in others continuous chlorination of the return sludge has proven more satisfactory. Generally, when chlorination of the return sludge is started, the turbidity of the plant effluent will increase, but after a few days of operation the turbidity will again decrease to that of normal conditions.

Extensive wasting of the biological sludge to reduce the filamentous organisms also has proven to be somewhat effective in alternating a bulking situation.

The operator must realize that these measures are only temporary steps to alleviate bulking and that the problem may reappear if the cause is not identified and corrected.