Chapter 3 - Wastewater Treatment Overview

The treatment of wastewater, the processing of solids generated and use or disposal of biosolids must be considered as a system designed to produce two products: clean water that can be reused or released into the environment, and biosolids. Wastewater treatment facility processes have a significant impact on biosolids characteristics. Careful consideration must be given when evaluating changes to either the liquid or solids handling system as one impacts the other. If changes are done correctly, the processes will complement each other.

This manual addresses wastewater treatment as one location on the biosolid value chain. The four primary processes (sections) within this location (chapter) are pretreatment and pollution prevention, liquid stream as it relates to solids management; solids generation; and septage handling.

This chapter is not intended to fully explain each of the process associated with wastewater treatment, but rather to highlight the relationship between influent characteristics, wastewater treatment and biosolids management. The processes associated with wastewater treatment that relate to biosolids management include:

- Pretreatment and pollution prevention programs
- Liquid stream impact on solids management
- Primary solids generation
- Secondary solids generation
- Tertiary solids generation
- Solids processing side stream characteristics
- Septage handling

3.1 Pretreatment and Pollution Prevention Programs

Influent characteristics are crucial to wastewater treatment and solids management. Waste diversion and pretreatment programs are designed to remove pollutants at their source, protecting the public investment in a wastewater treatment facility. Pretreatment also reduces the potential for process upsets and enhances biosolids characteristics.

Pretreatment programs were established by the USEPA in 1978 (requirements were set forth in 40CFR Part 403), requiring industrial users to limit the discharge of certain pollutants. The regulation addresses metals within wastewater along with organic chemicals. Pollution prevention programs are designed to reduce or eliminate the discharge of certain contaminants.

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In addition to protecting the wastewater treatment facilities, pollution prevention often results in savings to the industry implementing the programs.
The implementation of pretreatment and pollution prevention programs have had a significant positive impact on the characteristics of biosolids generated. Table 3.1 compares the results of two surveys conducted

to assess the characteristics of biosolids. The 40-city study was conducted in 1979 and 1980. The study summarizes the results of sampling and analysis performed on solids generated at 40 publicly owned wastewater treatment facilities. In 1989, during the development of the 40CFR Part 503 Rule regulations, the USEPA sponsored a second survey of biosolids. The second survey, the National Sewage Sludge Survey, summarizes the results of testing conducted at over 200 wastewater treatment facilities. (USEPA 1990).

Table 3.1 Pretreatment Impacts – National Trends

Element	40-City Study (1980) mg/kg dry weight	National Sewage Sludge Study (1989) mg/kg dry weight
Arsenic	9.9	6.7
Cadmium	69	6.9
Chromium	429	119
Copper	602	741
Lead	369	134.4
Mercury	2.8	5.2
Molybdenum	17.7	9.2
Nickel	135.1	42.7
Selenium	7.3	5.2
Zinc	1,594	1,202

While dated, the results of the two surveys illustrate the trends occurring within biosolids characteristics. A review of the table indicates that in almost every case, the characteristics found in the National Sewage Sludge Survey are significantly less than those in the 40-city study. In two cases, copper and mercury, the results from the National Sewage Sludge Survey are greater than those from the 40-city study. The copper concentrations are most likely the result of increased use of copper plumbing in new homes. There is not a clear explanation for the increase in the mercury concentration. It may be the result of changes in analytical techniques and an increase in the number of samples collected in the NSSS. The USEPA is in the process of implementing a Biosolids Data Management System (BDMS) that collects biosolids quality data reported by wastewater treatment facilities. The database can be accessed through www.epa.gov/region08/water/wastewater/biohome/biohome.html.

In addition to industrial contributions, the waste stream from individual residences can impact wastewater treatment and biosolids characteristics. Educating the public about the impacts of household hazardous waste on the treatment facility, along with making household hazardous waste recycling and disposal convenient, can result in a marked improvement in biosolids characteristics.

3.2 Liquid Stream Impact on Solids Management

The liquid stream processes in a wastewater treatment facility can impact both solids characteristics and the types of solids handling processes that are appropriate. While it is unlikely that an organization will change its entire wastewater treatment process to improve solids handling, both the liquid and solid stream processes need to be considered when contemplating a change.

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The type of liquid stream treatment process employed impacts the amount, dry weight, and volume of solids generated. To illustrate, consider use of a primary clarifier as part of a conventional activated sludge process and the absence of a primary clarifier in an extended air process. A primary clarifier removes solids from wastewater by gravity settling. Primary solids are a benefit to certain solids management processes including anaerobic digestion and mechanical dewatering. They are not a benefit to other processes such as dissolved air flotation thickening and aerobic digestion.

In addition, the impact a solids handling process can have on the liquid stream should be considered. For example, mechanical dewatering with a belt filter press generates significantly more sidestream volume than centrifuge dewatering. The impact of these sidestreams on the liquid stream process should be considered when evaluating these alternatives.

3.3 Solids Generation

Understanding solids generation within the facility helps optimize the operation of subsequent solids handling processes. The most effective method to establish the treatment efficiency of primary, secondary, and tertiary processes is to measure wastewater characteristics entering and leaving each process. For solids production, the total suspended solids and the biochemical oxygen demand are typically monitored. If historical data is not available, limited analysis and some “rules of thumb” can be used to establish an estimate of solids generation.

3.3.1 Primary Solids Generation

Primary clarifiers, the principle means of wastewater treatment in the U.S. prior to the passage of the Clean Water Act, remove suspended solids within the wastewater by the use of gravity. They also reduce the organic load, measured as biochemical oxygen demand (BOD), which enters the secondary treatment process.

The most effective way to determine the performance of a primary clarifier is to monitor the influent and effluent total suspended solids and biochemical oxygen demand.

Efficiently designed and operated primary clarifiers can remove 50 to 70 percent of the suspended solids that enter the process. During the removal of theses suspended solids, 25 to 40 percent of the 5-day BOD is also removed. (Metcalf & Eddy, 1991). The most effective way to determine the performance of a primary clarifier is to monitor the influent and effluent total suspended solids and BOD. This will allow the organization to closely estimate the removal efficiency of their process.

Recording the surface overflow and weir overflow rate in addition to the removal rates will allow the organization to predict the performance at various hydraulic loading rates.

3.3.2 Secondary Solids Generation

The secondary process includes a fixed film or suspended growth biological treatment along with secondary clarification. Parameters that will impact secondary solids generation include:

- Presence or absence of primary clarification
- Type of secondary treatment process employed
- Secondary clarifier loading rates

Similar to primary solids generation, it is necessary to establish the characteristics of the influent and effluent to understand the solids and organic removal through the process. To establish performance, an organization needs to determine the solids generated per unit of organics removed. This is typically referred to as the pounds of solids generated per pound of BOD removed (lb/lb BODr). This generation rate is best determined over time with actual operating data. If data is not available, a generation rate of 0.75 to 0.85 lb/lb BODr can be used for facilities that do not nitrify. Nitrification increases the solids generation rate. If the facility does nitrify, the solids generation will approach 1.0 lb/lb BODr. In addition to the biological solids generated through secondary treatment, the suspended solids entering and leaving the secondary treatment process should be monitored. The suspended solids removed in the secondary treatment process should be added to the biological solids to determine the total secondary solids. [(3) WEF Design of Municipal Wastewater Treatment Plants WEF MOP, 8]

3.3.3 Tertiary Treatment and Solids Generation

Advanced secondary and tertiary treatment impacts the solids generated during wastewater treatment, but the manner in which the performance is monitored and the solids generation is estimated will not change. Nitrification will increase the biosolids generated in the secondary treatment process. Chemical addition for phosphorus removal will enhance settling and increase the generation of primary and/or secondary solids. Biological nutrient removal also impacts the volume and characteristics of the solids generated.

It is important to estimate the characteristics of any sidestreams that will be generated from a new unit process.

3.3.4 Impact of Sidestreams on Solids Generation

Sidestream generated from solids handling unit process have an impact on the liquid stream of a wastewater treatment facility and subsequently the solids generation. It is important to estimate the characteristics of any sidestreams that will be generated from a new unit process. The sidestreams can be “modeled” to determine their impact on the hydraulic and organic capacity of a wastewater treatment facility.

The characteristics of the sidestreams should be considered when determining where they will enter the stream. Because a number of solids handling process have extremely high solids capture rates, it may not be necessary to introduce the sidestream upstream of a primary clarifier, thereby maintaining as much reserve hydraulic capacity in the primary treatment process as possible.

3.3.5 Solids Generation for Lagoon Systems

A number of small wastewater treatment facilities employ lagoon treatment technology. These systems include either a facultative or aerated lagoon. In the majority of these systems, wastewater that has undergone preliminary treatment is discharged directly into a lagoon. Lagoon systems typically include baffles or a series of lagoons to minimize the opportunity for short-circuiting. All solids (suspended and biological) generated within the lagoon treatment system remain within the lagoon and are periodically removed. The method to estimate the solids generation within the lagoon system is similar to that of an extended aeration activated sludge process, starting with monitoring the suspended solids and BOD entering and leaving the lagoon system. Due to the endogenous respiration that occurs within the solids settled in the lagoon, the solids generation rate per pound of BOD removed is significantly lower than that experienced in an extended air activated sludge system. It should be anticipated that 40 percent of the volatile solids estimated within the lagoon solids will be destroyed through endogenous respiration, resulting in a solids generation rate of approximately 0.5 lb/lb BODr.

3.4 Septage Handling at a Wastewater Treatment Facility

Cotreatment of septage with wastewater at a municipal treatment facility is a viable option for septage management. Septage, however, has several significant effects on the conventional wastewater treatment process. It exerts a load on both the liquid and solids stream treatment systems, with resulting increases in solids production and operating costs. It can also have an effect on facility performance and, ultimately, on the quality of effluent and biosolids produced. The latter effect depends on a number of factors, including the proportion of septage loading being treated compared to total facility loading, and the manner in which septage is introduced into the treatment facility.

3.4.1 Characteristics of Septage

The characteristics of septage are similar to wastewater, though significantly higher in strength. In addition to the organic loading, septic tanks concentrate rags, plastics, and other nondegradable materials, which can cause operational and aesthetic problems at the wastewater treatment facility and in the resulting biosolids. Odors may be the most significant factor to consider when dealing with septage.

Septage can be managed as high strength wastewater or as a dilute solid.

Septage strength varies, but can be characterized based on an average composition. Septage can be managed as high strength wastewater or as a dilute solid. Data collected at the King County, Washington East Division Reclamation Plant since the mid-1970s indicate total solids concentrations averaging approximately 23,000 mg/L, with suspended solids averaging 22,000 mg/L. The concentration of oil and grease average approximately 1,400 mg/L. Total BOD values have averaged approximately 7,400 mg/L, whereas soluble BOD values have averaged approximately 800 mg/L. The solids concentration is approximately 100 times greater, and BOD approximately 30 times greater, than for domestic wastewater being received at this facility. [(2)WEF MOP 24, 1997)].

3.4.2 Incorporation with the Liquid Stream

A number of factors must be considered when deciding to add septage to the liquid stream process. These include where in the process the septage will be introduced; how it will be introduced; and its impact on both the liquid and solids stream unit operations. The solids and organic loading to the WWTF from the septage must be considered in each unit process, including the size of the facility, the unit process sequence, and the manner in which the septage is fed into the facility.

Primary Treatment

Because septage has a much higher solids content than typical domestic wastewater, the effects of septage discharges on liquid stream processes such as primary treatment are more significant from a solids loading viewpoint than from a hydraulic viewpoint. Because the solids contained in the septage have already been removed by settling in the septage system, they should be effectively removed during the primary treatment process. These additional solids subsequently would be discharged to the solids stream process for additional treatment and management. Because the loading is predominantly solids, it is important to ensure that the solids collection and pumping capacity for the primary solids are adequate to handle the increased loading that septage represents. Peak loading conditions will be of the greatest concern.

Secondary Treatment

While most of the BOD in the septage is associated with the solids, there is some BOD that will be discharged to the secondary process. This will result in higher aeration requirements and an increase in secondary solids production. The actual effect will be dependent on the specific facility because factors such as type of aeration diffuser, mean cell residence time (MCRT) at which the system is operated, and ambient temperature can affect both air demand and solids production.

Odors associated with septage must be addressed to reduce the potential for odor complaints at the facility. Even if odors have been addressed at the receiving station, it is possible to have additional odors released during liquid stream processing.

3.4.3 Septage Treatment and the Solids Process Stream

It may be possible to discharge the septage directly to the solids process stream to reduce effects on the liquid stream processing facilities. For this approach to be successful, it is important that a mechanism be present, either as a part of the septage receiving station or as a part of the solids processing system, to remove grit and screenings. Failure to provide this treatment will result in grit and materials such as rags and plastics in the final biosolids product and can have such adverse effects on the solids processing units as ragging and accumulation of grit, which require periodic draining and cleaning of process units. Some agencies have reported success with the use of a rotary screen device; however, the screened materials represent an additional sidestream that requires disposal.

Solids Processing

Consideration also must be given to the effects of the septage on the solids processing units when determining the point in the process at which the solids will be introduced. As an example, unless the septage is prethickened, it may not be desirable to feed it directly into a digestion process because of the dilution and resulting reduction in solids retention time. Similarly, the direct introduction of the septage solids to the dewatering processing system could have adverse effects on the resultant biosolids quality and may create compliance issues with regard to vector -- attraction reduction and pathogen reduction requirements.

Solids Stream Effects

The solids stream effects of septage are primarily related to the solids loading on the processing units and the resultant increase in biosolids production. It is probable that the loading will be comparable to that assumed for the solids stream loading under the previous liquid stream treatment scheme.

Liquid Stream Effects

Although the septage stream would be discharged to the solids processing area under this treatment scheme, the liquid fraction would still need to be treated in the liquid stream processing unit as a portion of the solids recycle stream.

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