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SETTLING TANKS & PONDS

Eric Rozema

Introduction

Settling tanks are a straightforward and low-cost wastewater treatment technology that removes solids from wastewater by allowing sufficient time for the water particles to settle out of the water column. This simple technology is used for the treatment of many different types of wastewater. It is often one of the first steps in water treatment processes, although it varies in efficacy depending on the wastewater and design of the settling tanks (XCG Consultants, 2011). Settling tanks are best suited for the removal of solid particles with diameters greater than 2 microns which includes soils classified as sand or silt. Soils with particle sizes less than 2 microns such as clay or muck will not be efficiently removed by settling tanks (Haman and Zazueta, 2014).

Description

Settling tanks can be engineered concrete structures or simple clay-lined ponds (Figure 1). The tanks can be rectangular or circular with varying depths. The main function of settling tanks is simply to store water for a period of time giving the suspended solids an opportunity to sink to the bottom of the tank, leaving clarified water. The amount of time water is stored in the tank is known as the hydraulic retention time (HRT). The treatment efficiency of settling tanks is dependent on the particle size distribution of the solids, the flow dynamics within the tank, and the HRT (MOECC, 2008). Particle size is important as different sized particles will settle out at different rates depending on their shape, weight, and density. Larger, denser particles will sink quickly but smaller, less dense particles will require more time to settle. Sand (50−2000 microns, specific gravity (SG) of 2.64−2.68) and silt (2–50 microns, SG = 2.68−2.72) particles will take seconds to minutes to settle (Ou, 2006; Venkatramaiah, 2006). Clay particles (<2 microns, SG = 2.44−2.92) can take days to weeks, but muck particles (<74 microns, SG = 1.002) may not settle unless given months to do so as the majority of the particles are <5 microns with densities similar to water (Fratta et al., 2010; Ou, 2006; Venkatramaiah, 2006). More information on the unique qualities of muck particles can be found in Factsheet #002 'Impact of Muck Soils on Water Treatment Systems'.

The size of the particle and the rate at which it settles will help to determine what HRT to use. The ideal HRT can be estimated using a 'jar test'. In order to do a jar test, a water sample is collected in a jar and left to stand. The time it takes for the particles to settle to the bottom of the jar estimates the HRT.

Figure 1: An example of a clay-lined settling pond

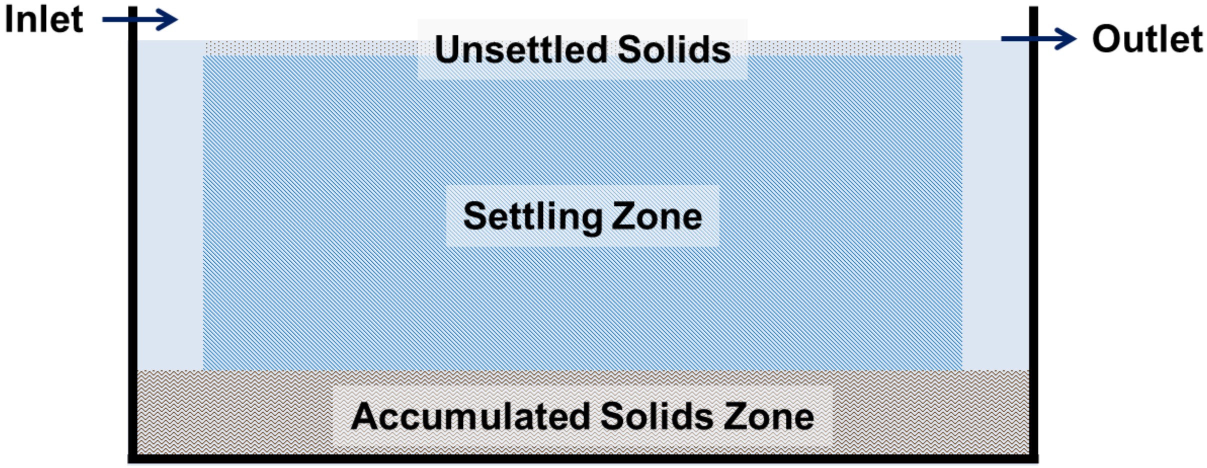

Figure 1: The size of the accumulated solids zone must be considered when determining the necessary depth of a settling tank; the tank must be deep enough to allow for the formation of a sludge zone while not impeding settling above it.

There are also mathematical equations that can be used to ensure the tanks are properly engineered (Haman and Zazueta, 2014). For example, to calculate the area required for a properly sized settling tank, you first, calculate the settling velocity (V_p) of the particles (inches/minute) based on particle diameter (d) and their SG:

$$V_p = 0.00135 \times d^2 \times (SG - 1) \quad [1]$$

Then calculate the area (ft^2) required for the settling tank using the following:

$$Area = 1.604 \times \left(\frac{Q}{V_p}\right) \quad [2]$$

where Q is flow rate (gallons/minute) and V_p is the settling velocity (inches/minute).

Additional equations can then be used to calculate the ideal length to width ratio of a settling tank system.

The flow of the water in the settling tanks is also important because if the water flows too quickly through the system, solids may remain suspended in the exiting water. Therefore, certain design features, such as baffles, weirs and plate/tube settlers can be added to settling tanks to slow the flow of the water. By slowing the flow, the HRT can also be controlled to maximize sedimentation. Settling tanks should also be built with an appropriate depth to allow for the formation of sludge at the bottom of the tank that will not be disturbed by the surface flow of the water (Figure 2). The MOECC (2008) recommends depths of 3.0–4.6 m (9.8–15’) when treating municipal sanitary sewage.

It is also common for settling systems to be made of a series of tanks connected by weirs. Multiple tanks in sequence, as shown in Figure 3, allow for more efficient settling by allowing the larger particles an opportunity to settle out in the earlier tanks while leaving the later tanks for the removal of the remaining particles. Additionally, tanks running in parallel give the option to have one tank emptied and cleaned while the other tanks remain operational (MOECC, 2008).

System Placement

Settling tanks are a solids removal system useful for the removal of solid particles greater than 2 microns. They should be placed early in the treatment process and be followed by additional treatment steps to ensure the final water quality will be suitable for reuse or meet discharge standards.

Figure 3: An example of a sequential 3 cell concrete settling tank

Considerations

If settling tanks are used for the treatment of vegetable washwater, the soil characteristics need to be considered. For example, the muck soil found in the Holland Marsh is mostly made up of organic material with very small particles sizes (<5 microns) and low densities close to that of water, meaning that the particles settle very slowly. Clay particles, while having a density similar to that of sand and silt, are more similar in size to muck. This means that this particular type of soil will not easily or quickly settle and additional treatment will almost always be required. Steps can be taken such as coagulation and flocculation to enhance the settling process, but this process can be quite an expensive and adds an ongoing cost. Chemical treatment can also create challenges with managing the solids removed from the system (*i.e.* residual levels of added chemicals may be too high for land application).

Settling tanks will need to be periodically cleaned out. The frequency of required cleaning will depend on the size and design of the tank, for example, an undersized tank will need to be cleaned out much more frequently. A plan also needs to be in place to manage the removal of the accumulated solids. The solids could be composted, land applied, or possibly trucked offsite, however, it is important to design the plan specifically for needs of each site as different rules and regulations under the Nutrient Management Act will determine which of the options are available based on what is contained in the sludge.

Performance

Settling tanks are often used as primary or secondary treatment units in municipal water treatment plants, but in some agricultural applications they are a stand-alone treatment system. The quality of effluent that the settling tank must produce will be determined by what follows in the treatment series. In situations where a settling tank is the only treatment step prior to environmental discharge, the treatment efficiencies of settling tanks will need to be high. However, settling tanks generally do not produce high quality effluent (XCG Consultants, 2011). The MOECC (2008) reports treatment efficiencies of 35 and 65% for organic matter (BOD_5) and total suspended solids (TSS) removal, respectively, when settling tanks are used for the treatment of normal strength municipal sewage. Therefore, settling tanks alone will not be able to effectively treat vegetable washwater, which contains a high solids load, and as a result, additional treatment technologies will most likely need to be employed in order to meet discharge standards.

Cost

The creation of new settling ponds is a capital cost, the size of which depends on the requirements of the system. The type of the tanks will also affect the cost, whether the tanks are concrete, have a synthetic liner, or a simple clay lined system. There are also on-going maintenance costs associated with the removal and disposal of the settled solids.

Conclusion

Settling tanks provide a low-cost and simple way to remove solids from washwater. However, they should only be used a primary or secondary treatment step followed by additional treatment technologies.

References

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Factsheet #002 'Impact of Muck Soils on Water Treatment Systems' can be found at www.hmgawater.ca/factsheets

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