IMPROVED DESIGN AND OPERATING CRITERIA FOR SLUDGE LAGOONS AND DRYING PANS

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ABSTRACT

Sludge lagoons and conventional sludge drying pans represent a widely used, low cost and effective method of processing sewage sludge. However, the paucity of both design and operating criteria for these processes can, in some circumstances, lead to unexpected performance difficulties. Greenhouse gas emissions are also a concern.

South East Water uses these processes to manage sludge at their plants located in the semi-rural fringe areas of Melbourne. A 5 year study has been undertaken to establish criteria necessary for improved performance of both sludge lagoon and drying pan processes. This information is being used to improve sludge management in the company.

1.0 INTRODUCTION

Sludge is produced as a by-product of sewage treatment. The nature and quantity of sludge produced varies depending on the main treatment process but sewage sludge leaving the main process would typically be highly putrescible and contain large amounts of water. Prior to the sludge being beneficially reused for agricultural purposes South East Water undertakes further treatment to produce a dry, low odour, pathogen free bio-solids material.

Initially sludge is digested. During the digestion phase there is a substantial reduction in the putrescible component of the sludge. SE Water has several different digestion technologies in use at our different sites including aerobic digestion, long sludge age activated sludge, mesophilic anaerobic digestion and sludge lagoons. These digestion processes are all designed and operating within conventional criteria and performing as expected. The sludge is then dried. As part of this strategy sludge drying pans were constructed at SE Water's major plants between 1996 and 1998 for this purpose. Sludge is dried in the pans every summer. The dried sludge cake is stored for up to three years to ensure pathogen removal and sludge meets T1 requirements under the Victorian Environment Protection Authority's *Guidelines for Environmental Management-Biosolids Land Application.*

1.1 Process Description

Sludge lagoons and drying pans are earthen structures lined with impervious clay. Pans are purpose built and are quite shallow at < 1 m in depth. Lagoons are typically deeper. Sludge drying pans operate in 3 phases:

- Filling: Sludge is fed continuously into the pan from the digestion process where the solids settle and form a thick sludge layer at the base of the lagoon. Supernatant is collected and returned to the head of the plant.
- Digestion: Once filling has been completed sludge is further digested by anaerobic processes in the pans. Effectiveness of digestion is historically assessed based on volatile solids destruction.
- Drying: In South East Water's region rainfall exceeds evaporation over the winter period and from April to October sludge drying is not possible in the pans. During October evaporation starts to exceed rainfall.

At this time free water is normally drained from the pan surface. The solids content in the sludge layer at this time would typically be 7.0% wt dry solids. As water evaporates over the summer the sludge dries with the aim of harvesting the sludge cake at 45% wt dry solids by the end of March.

As sludge dries a hard crust forms on the surface of the sludge which provides a barrier to the diffusion of water vapour to atmosphere. It is necessary to break up this crust regularly to expose the wet material so that drying is optimal. South East Water uses a boom towed by tractors operating on the banks of the pan to disrupt the sludge crust. This is effective until the solids reaches about 25% TS when the sludge becomes thick and it is too difficult to pull a boom through the sludge. At this stage a swamp dozer is operated in the pan instead. The practice of not introducing machinery into the pan until the base becomes dry and has some load bearing capacity has been adopted to reduce damage to the expensive clay liner. Figure 1, below, shows a typical process schematic for South East Water's sewage treatment plants.

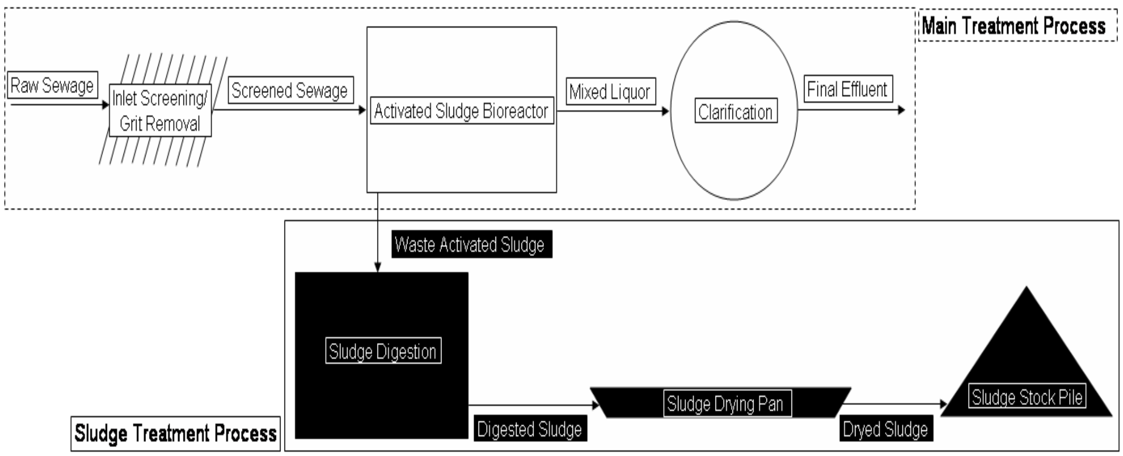


Figure 1: ***Typical process schematic***

1.2 Performance Issues

South East Water has experienced some unexpected difficulties since commissioning the pans despite adopting conventional design and operating criteria.

- Floating sludge: At times digesting sludge floats to the surface and becomes odorous. Floating sludge also reduces the solids capture as sludge particles are carried over into the supernatant. These solids can impact on the main process if returned to the plant.
- Wet sludge cakes: At some sites drying has been inadequate regardless of weather conditions and wet sludge has had to be harvested (down to 20% total solids). This increases the sludge handling requirements and cost of harvesting the sludge significantly.
- Poor sludge digestion: Some sludge batches that have been harvested have been inadequately digested despite apparently achieving good volatile solids removal. These sludge cakes, when later disrupted and moved, can be very odorous. On rare occasions ongoing digestion in these piles can generate heat and steam and release odours.
- Greenhouse gas emissions: There are a lot of gas bubbles generated in the pans during the anaerobic digestion phase of the pan operation. These bubbles contain methane and carbon dioxide and are produced as a by-product of digestion.

SE Water was concerned about the impact of the methane emissions on the plants overall greenhouse gas emissions.

1.3 Investigatory Program

SE Water has undertaken an investigation over the last 5 years to address these concerns. The investigation had 2 components.

The first component involved operating the pan systems at our plants in a range of alternative loading rates and configurations. The second component involved trials using pilot pans. The pilot pans were constructed to allow a wider range of conditions to be considered than was possible on the full scale plants

2.0 DISCUSSION

2.1 Floating Solids

It is apparent that as the organic loading rate increases on the pans the amount of visible gassing in the lagoons increases. The gassing carries sludge particles to the water surface. Figure 2 shows clearly the direct correlation between the supernatant suspended solids and the organic loading rate for lagoons/pans receiving undigested waste activated sludge. When the supernatant solids concentrations are high (>1000mg/L) a sheet of sludge collects over a large area of the pan.

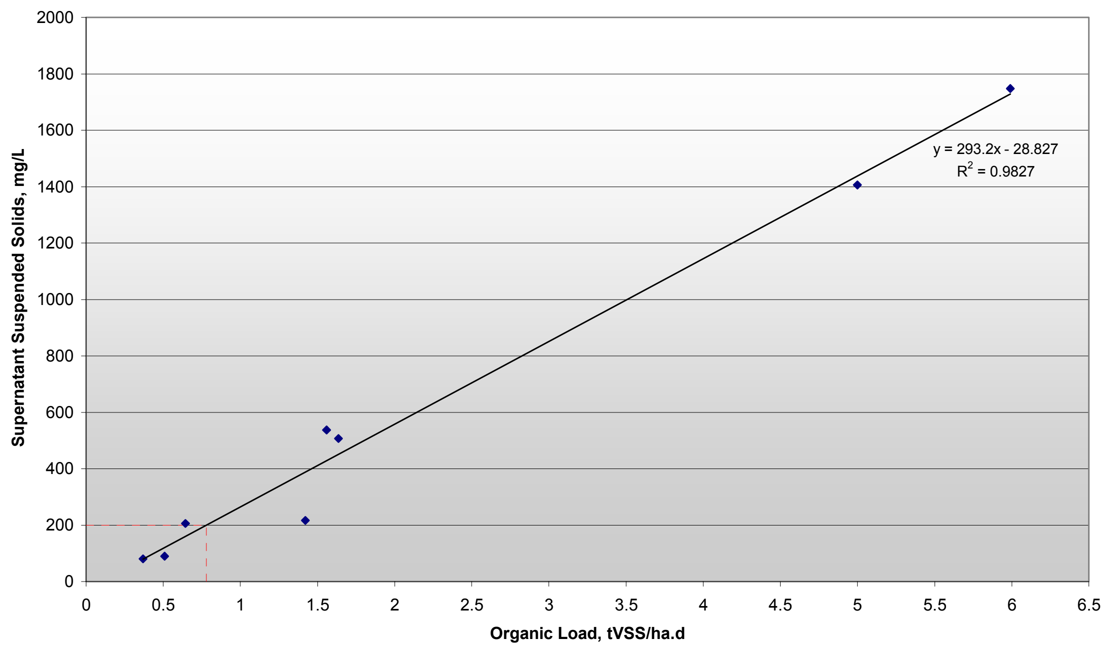


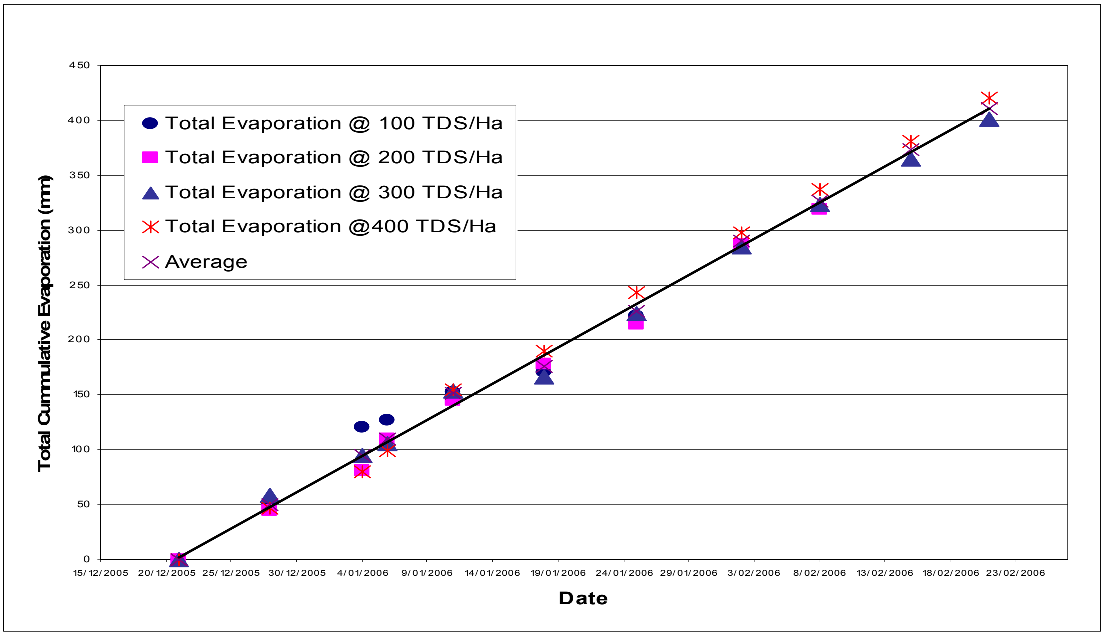
Figure 2: ***Effect of pan organic loading rate on effluent suspended solids***

Olfactometry has been used to assess the impact of the floating sheet on emissions from the pans. Odour emissions are increased 5 – 10 fold when there is floating sludge on the pan surface. Maintaining a liquid supernatant layer of more than 0.5 m over the anaerobically digesting sludge layer at the base of the pan is an effective odour control strategy. This water "cap" allows oxidation of odorous compounds generated during the digestion process as they travel through the water column.

In order to maintain an effective water cap the pan organic loading rate needs to be less than 1 tVS/ha.d. This organic loading rate can be considered to be a monthly average loading rate. In SE Water experience higher short term peaks of up to three times the average load can be accommodated without impacting performance.

2.2 Wet Sludge Cakes

Wet sludge cakes occur when there is insufficient drying area. Based on data collected from the pilot and full scale pans sludge dries at a linear rate which is independent of the solids loading rate on the pan (see Figure 3 below) up to a solids concentration of 45% TS. Above 45% TS the rate of drying is significantly reduced and it is not efficient to operate the pans to achieve dried solids concentrations higher than this level.



<u>Figure 3</u>: ***Effect of solids loading rate on rate of evaporation in sludge drying pans***

Furthermore the rate of drying is directly proportional to net evaporation and as such is site specific. Provided the sludge crust is disturbed weekly the rate of drying can be predicted by the following formula:

Water evaporated, mm= 0.8* [Evaporation (Nov to -Mar) - Rainfall (Nov to Mar)]

This rate of evaporation is common to all SE Water sites and is independent of the volatile solids content of the sludge, the initial sludge dryness, sludge depth and the degree of shelter, for instance in the form of trees, provided around the pan area. However, if the sludge crust is not disturbed the rate of drying is much slower- typically half of the above.

Local rainfall and evaporation data must to be used to determine the pan drying capacity. Though all of SE Water's plants are geographically close there is a large variation in their drying capacity. Figure 4 below summarises the capacity of the pans in average weather conditions. The design basis at all these sites was 400 tds/ha.yr. Consideration needs to given to sludge management arrangements in a wet summer.

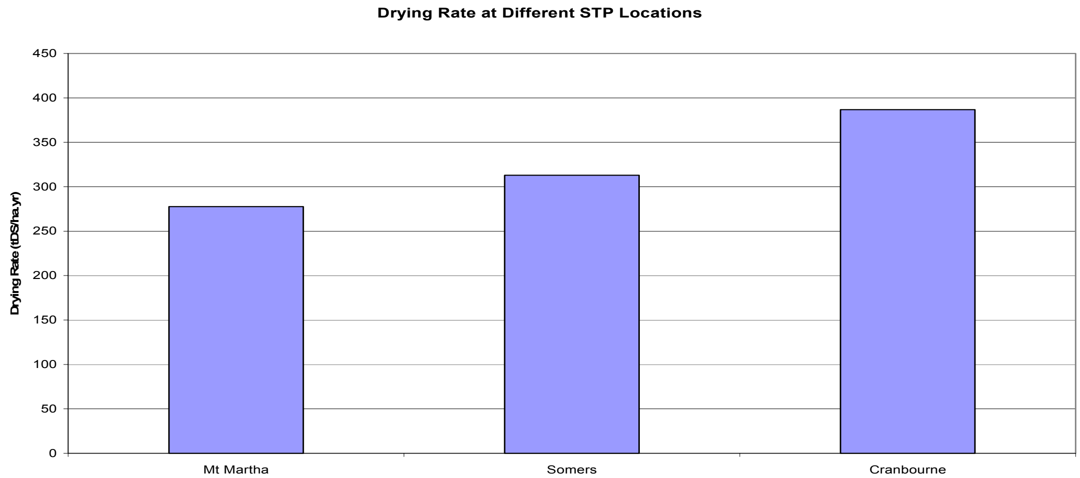


Figure 4: ***Sludge drying pan capacity- average rainfall year***

2.3 Poor Sludge Digestion

As SE Water operates sludge digestion facilities upstream of the drying pans it was anticipated that any additional digestion time required in the pans would be short. However, the investigatory work has shown this is not the case. Substantial further digestion is achieved in the pans and is necessary to produce a low odour, biosolids product. Sludge can only be considered well digested and, as such, likely to produce low odours when stockpiled if the sludge volatile solids content is less than 60- 65% and the BOD/VSS in the digested sludge is 0.05 to 0.08.

The rate of digestion in the pans is slow and, regardless of the upstream digestion process, this can be achieved with an average anaerobic sludge digestion time at ambient temperature of 200 to 250 days in lagoons/pans for undigested waste activated sludge. Provided this detention time is maintained the harvested dry sludge cake will behave effectively as an inert material and will be of friable soil like consistency.

2.4 Greenhouse Gas Emissions

The methane emission from the surface of actively digesting lagoons and pans has been measured on several occasions using a hood. Provided a water "cap" is maintained over the sludge the majority of the methane generated by anaerobic processes in the sludge layer will be oxidized. On this basis calculations have indicated that even for our largest plants the contributions of lagoons/pans to overall greenhouse gas emissions, including power consumption for the activated sludge process, is low and less than 10% of overall emissions.

3.0 CONCLUSIONS

Sludge lagoons and pans can be used to effectively process sludge. The biosolids product produced is a high quality and appropriate for a range of beneficial reuse options. Criteria have been developed that can be used to ensure the processes perform reliably and without excessive odour.