URBAN USE OF SLUDGE IN THE GÖTEBORG REGION

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Background information

The wastewater from Göteborg and 5 surrounding suburban municipalities is handled by The Göteborg Regional Sewage Works (GRYAAB) and is treated at the Rya wastewater treatment plant (WWTP). The Rya WWTP has a connection of almost 600,000 persons. If industrial loading is included the connection corresponds to about 700.000 population equivalents. The plant was originally a highly loaded activated sludge plant without pre-settling. In the early 80-ies the plant was extended with primary settling and additional aeration increasing the solids retention time to 3-4 days. In the mid 80-ies phosphorus removal was implemented by simultaneous precipitation with ferrous sulphate. In 1998 an extension for nitrogen removal was taken into operation.

Up to 1990 sludge treatment consisted of gravity thickening, mechanical de-watering and stabilisation with quick-lime. In 1990 anaerobic stabilisation was implemented and the lime stabilisation taken out of operation. With improved wastewater treatment efficiency the amount of sludge gradually increased to 131,000 tons (33,000 tons DS), exclusive of 7600 tons of quick-lime, in 1989. Abandoning quick-lime addition and the effects of anaerobic degradation reduced the amounts of sludge to 62,000 tons (18,000 tons DS). Disconnection of some industries and increased dewatering efficiency has since then decreased the amount of sludge to 50,600 tons (14,400 tons DS) in the year 2000.

Sludge disposal

When the plant operation started in 1972 it was intended to dry and incinerate the sludge. The equipment had tremendous operational difficulties and was never commissioned. Unstabilised sludge was disposed of in lagoons on the regional landfill creating severe odour nuisances. In 1976 quick-lime stabilisation come into operation. The lime-stabilisation reduced most of the obnoxious odours. The lime-stabilised sludge soon become popular with farmers in the acid precipitation struck region of western Sweden. Up to 1987 all sludge could be disposed of in agriculture during spring and in autumn. On an annual basis about 50 % of the sludge was disposed of in agriculture. Since 1988 disposal of sludge in agriculture has not be en possible due to acceptance problems in spite of a good and constantly improving sludge quality. Sludge disposal became soon very problematic and costs increased to over 30 MSEK or almost 50 % of the operational costs.

It soon became clear that the acceptance problem made it necessary to find a secure disposal route that was controlled by GRYAAB. The problem was solved by the acquisition of four immense underground rock caverns formerly used for strategic storage of oil. The total volume of the caverns is 2.8 million m3. It is interesting to note that after the rock cavern disposal was operational it became much simpler to negotiate reasonable agreements with potential non-agricultural users of sludge. Since the rock cavern disposal

was taken into operation in 1991 only about 10 % of the sludge has been put into the caverns. The main part has found non-agricultural uses within the city boundaries.

Sludge properties

In urban use of sludge some properties that has to be considered is leaching, odour and geo-technical behaviour.

Leaching of pollutants from sludge during field conditions is difficult to measure. In the Göteborg region one landfill is of particular interest. This landfill has received a top cover of limed sludge and composted sludge. In total 57,700 tons of limed sludge has been used on this landfill. The landfill catchment is drained by a small brook. Sampling and flow estimates in this brook have lead to the conclusion that the leaching of heavy metals and phosphorus is negligible. There is a considerable leaching of ammonia nitrogen. The first year after the completion of the landfill cover almost 1 % of the nitrogen in the sludge disposed of on the landfill was found in the brook. Seven years after the completion the nitrogen leaching was reduced by one order of magnitude. There has also been monitoring around other disposal sites. At these sites no quantification of leaching has been possible but the qualitative picture is the same; negligible increase in phosphorus and heavy metal concentrations and significant increases in ammonia nitrogen concentrations. The leaching of ammonia nitrogen may be a threat to ground-waters but in urban areas ground water interests are often limited.

Unstabilised sludge can cause serious odour problems. Sludge stabilised with quick-lime is much less odorous than raw sludge. However, when massive amounts of limed sludge are applied, odour problems can occur under certain weather conditions. The odour problems have disappeared within a few days or weeks. Anaerobically stabilised sludge is not odourless but no problems have been encountered in its use in the Göteborg region.

The possibilities to use sludge are in some cases limited by its geo-technical properties. Dewatered, anaerobically stabilised sludge cannot stand the pressure of vehicles and can normally only be applied in thin layers, where the subsoil takes the pressure. If the sludge is well dewatered, DS larger than about 32 %, it is possible to use the sludge for landscaping purposes with mound heights up to about 1.5 m. From a geo-technical point of view limed sludge is much better. It withstands the pressure of band vehicles, it can be used in thick layers and it has been used for embankments up to 6 meters height.

Examples of urban sludge use

Landfills
In the Göteborg region a number of landfills have received a top cover of sludge. In the 80-ies limed sludge was used. In most cases rather thick layers were used. The question whether the application of sludge was a top cover or actually plain landfilling was discussed several times with the environmental authorities. The surface of a landfill is uneven so in order to get a good coverage it is necessary with a 1 m layer. (There are examples of layers up to 5 m thick.) During operation some sludge is pressed down in the landfill, so in order to achieve a 1 m layer, more than 1 m3 per m2 is necessary. When limed sludge was used a 0.3-0.5 m layer of un-limed, composted sludge was placed on top of the limed sludge in order to facilitate the establishment of vegetation.

A layer of compressed limed sludge has in a laboratory test a very low permeability. It is therefore believed, but not shown, that a layer of limed sludge considerably reduces the infiltration and percolation of precipitation into the landfill.

Also anaerobically stabilised sludge has been used as a top cover on landfills. The geo-technical stability limits its use to layers of 0.2-0.3 m. Such a layer has proved to be enough to improve the visual appearance of the landfill as it has been possible to establish a green surface rapidly in the sludge top layer.

The implementation of the Landfill Directive is believed to result in that many landfills will have to be closed. This will create a demand for large amounts of material for the finishing off of landfill sites. It is hoped that sludge or a mixture of sludge with other materials could be processed into a material suitable for the finishing off of landfills. A research project for the evaluation of this possibility is now in the planning phase.

Soil substitute
In the Göteborg region 10-25 % of the annual sludge production has been composted in windrows together with bark. The composting operation is handled by a contractor, who has been successful in marketing the product as a soil substitute and as top-dressing for plantations, lawns and golf courses. Several industrial areas and derelict land areas has been "greened" in a very cost-efficient way.

In the Malmö region another contractor is producing a soil substitute from a mixture of sludge, sand and peat. Several cities in Sweden are now considering some kind of soil substitute production.

Golf courses
In the Göteborg region there are two examples of new golf courses built on derelict land with sludge. The first golf course was built with a mixture of soil and sludge. The second golf course was built entirely of sludge on derelict industrial land. This golf course was "landscaped" with mounds of up to about 1.5 m height. According to the designer of the course, it could be played much earlier than a conventionally built course.

Embankments
In the Göteborg region sludge has been used for embankments at rifle ranges, at golf course driving ranges and around storage buildings for explosives. Especially for the latter purpose, the sludge has been very appreciated, as it is absolutely free of stones and other hard objects.

Some general remarks

Urban use of sludge in the Göteborg region has been much more successful than in other Swedish urban regions. This is believed to be due to factors such as:

- a trustful and open co-operation with the local health authorities
- the use of an responsible and environmental conscious contractor
- contractor agreements with good incentives
- a number of successfully completed projects