

DEWATERING SLUDGE ORIGINATING IN WATER TREATMENT WORKS IN REED BED SYSTEMS – 5 YEARS OF EXPERIENCE

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Abstract

The most common methods of dewatering sludge are centrifugation which typically produces solids content of approximately 15% and filter pressing which can give solids content of 15 to 25%. In England there are over 200,000 tonnes/annum of water works sludge produced. Most of the dewatered sludge still goes to landfill at considerable expense. There are probably just 12 years of landfill capacity left in England. The Hanningfield Sludge Reed Bed System is a new system treating water works sludge. The system not only reduces the capital and operating cost, but also provides the site with an environmentally-friendly operational area. Trial beds have been monitored (2008 – 2012) to examine the dewatering processes of the iron sludge. Based on a total load of 1,275 tonnes ds /year and the test results a new system has been built with a process area of 42,500 m² and put into operation in October 2012. This system represents an alternative solution to traditional methods of water works sludge treatment and reduces the need for deposition via landfill in favour of an ecologically-friendly, cost effective and clean method of converting the sludge to a product that can viably be deposited on agricultural land.

Keywords

Ferric sludge, Load, Reed Bed System, Sludge dewatering, Sludge Treatment, Water works sludge.

Introduction

Treatment and disposal of coagulated settled sludge presents the greatest difficulty to the water industry in the UK today. It arises from the clarification and filtration processes at low solids concentrations using coagulants and polyacrylamide polyelectrolyte and is then thickened and dewatered. Dewatering characteristics are poor and the sludge is of limited beneficial use. It has been estimated that there are over 200,000 tons of water works sludge produced on a dry weight basis in England per year.

The most common methods of dewatering water works sludge are:

- Centrifugation which typically produces solids contents of approx. 15%
- Filter pressing which can give solid contents of 15 to 25% solids

The water works sludge is generated when potable water is produced from Surface Water, Reservoir Water or direct abstraction of river water. For the purification process coagulants are used to remove impurities, Aluminum based coagulants such as aluminum sulphate or polyaluminum chloride and Iron

based coagulants such as ferric sulphate or ferric chloride are the most common used chemical additions.

The nature of the resulting sludge can vary widely from one works to another but all tend to be:

- Sticky
- Difficult to handle
- Often have an unpleasant odour (dependent on their source.)

Some works are able to spray sludge which has not been dewatered onto neighbouring land at certain times of the year. Others pump it to a local waste water treatment plant which only transfers the problem of disposal to the waste water treatment plant. In general, however, most dewatered sludge still goes to landfill at considerable and increasing cost, but it has been reported that there are probably only 12 years of landfill capacity left in the UK.

Drinking Water Sludge at Hanningfield

The Water Treatment Works (WTW) at Hanningfield in Essex treats up to 240,000 litres of drinking water per day, supplying a major part of Essex with potable water. The site is managed by Essex and Suffolk Water as part of Northumbrian Water Limited (NWL). During the treatment process it also generates large quantities of ferric sulphate based sludge. Traditionally, this sludge has been discharged into one of two nearby lagoons which have acted as solids repositories, but these lagoons are now at the end of their lives. NWL needed to investigate the best method for future treatment of their sludge. Several proposals were considered whereupon, by further analysis, NWL narrowed their considerations down to two solutions which they deemed to be suitable, sustainable solutions. The first was the well proven, traditional, method of constructing a mechanical centrifuge system. The second was that of constructing a **Sludge Treatment in Reed Beds** system (STRB). Mechanical centrifuge systems are a well-known method of dewatering sludge from water and sewage treatment plants, where the sludge is commonly reduced to a dry solids content of approx. 15%. STRB are a new innovative treatment solution that provides long term storage and treatment of sludge.

NWL found that treatment by STRB would be the most sustainable solution. So they decided to establish a small scale trial system to see whether the method could be used on the ferric sludge at the Hanningfield WTW.

Sludge Treatment in Reed Bed systems

Sludge reed beds have been used for dewatering (draining and evapotranspiration) and mineralization of sludge in Denmark and other countries in Europe since 1986. Long-term sludge reduction takes place in reed-planted basins, partly due to dewatering (draining, evapotranspiration) and partly due to mineralization of the organic solids in the sludge. Sludge from wastewater treatment plants is pumped onto the basin surface. The dewatering phase results in the dry solids content of the sludge remaining on the basin surface as sludge residue, whereas the majority of its water content continues to flow vertically through the sludge residue. The water content is further reduced through evapotranspiration (Lienard 1995; Matamoros 2012; Nielsen 2003, 2005, 2008; Peruzzi 2011, 2012; Obarska-Pempkowiak 2003; Uggetti 2009).

In addition to dewatering, the organic solids in the sludge are mineralized, thereby minimizing the sludge volume. Oxygen diffusion via filter aeration and through the cracked sludge surface and oxygen diffusion

from the roots into the sludge residue enable aerobic micro-organisms to exist close to the roots and in the sludge residue. The overall reduction of the sludge volume occurs without the use of chemicals. The process involves only a very low level of energy consumption for pumping the sludge. The sizing and design of reed bed systems depends on the sludge production (Tonnes of Dry Solids per annum), sludge type, quality and regional climate. The treatment period is approximately 8 - 12 years and the operation of the system may be divided into a number of phases related to different periods in the lifetime of a system. Each phase consists of commissioning, full operation, emptying and re-establishment of the system.

STRBs represent a method of sludge reduction and treatment that is cost effective and environmentally friendly in comparison with the traditional, mechanical methods. The sludge is pumped onto a basin which has a filtration and drainage system and is planted with reeds. The sludge is reduced as the effluent runs down through the root matt of the reeds and through the filtration layers where it is collected by the drainage system. The sludge is accumulated and treated for a period of up to 10 years, where after it generally reaches dry solids content 20- 40 % depending on the sludge quality and is most often suitable for deposition on agricultural land as fertilizer, thus alleviating the need for disposal at land-fills.

The treatment and reduction of sludge in an STRB occurs without the use of chemicals. Pumping the sludge onto the basins is the only energy consumption needed. STRB are a very energy efficient, low maintenance and cost effective process. STRBs have been used successfully for the treatment of sewage sludge for the last 25 years, but have never before been tested for water works sludges.

Test system

In order to confirm whether an STRB system could be used for the water works sludge at Hanningfield, a small scale system was established in March 2008, ran through 2012 and is continuing to run in order to provide ongoing results and information . Six existing 20 m² tanks were used as basins (Nielsen 2011). The tests were designed to determine:

- The suitability of an STRB for use on the ferric water works sludge at Hanningfield
- The dimensions and number of beds needed for a full scale system that could treat the full production capacity of the water works
- The quality of the effluent
- The quality of the sludge residue and its suitability for deposition on agricultural land

Table 1: Sludge residue quality in the basins (29.07.2009)

Parameter	Unit	Basin 1	Basin 2	Basin 3	Basin 4	Basin 6
Dry solid	%	39 (21)	40 (18)	44 (28)	42 (4)	31 (6)
Loss on ignition	% af DS	24	25	26	25	28
Total nitrogen	mg/kg DS	4,800	7,200	7,900	8,600	7,600
Total phosphorus	mg/kg DS	11,000	10,000	9,700	9,600	8,100
Aluminium	mg/kg DS	1,700	1,400	1,400	1,300	2,200
Calcium	mg/kg DS	47,000	47,000	46,000	43,000	50,000
Iron	mg/kg DS	370,000	390,000	390,000	370,000	370,000

FeS ₂ (pyrite)	mg/kg DS	610	830	920	180	140
Grease + Oil	mg/kg DS	<60	81	140	110	160

* The numbers in the brackets are amount of days since last load

The tests produced very favourable results showing that an STRB system was, in fact suitable for treating the sludge type (the dry solid content of the raw sludge was on average of 0.17%) Test results showed:

- Good reed growth in the trial beds
- Favourable pH level, approx. 7, in the raw sludge allowing for good growing conditions
- Good settlement properties in the raw sludge, favourable to the system's proper functioning criteria
- Excellent filtration properties
- Good dewatering properties resulting in dry solids contents of over 40 % in the sludge residue

The amount of Nitrogen and Phosphorus in the sludge residue appears to be sufficient to support reed growth (Table 1). Based on a total load of 1,275 tonnes ds/year and the test results a new system has been built with a process area of 42,500 m² and put into service in October 2012 (Figure 1).



Figure 1: Hanningfield Sludge Treatment System (August 2012)

The advantages of STRBs over conventional methods

The test data collected between March 2008 and November 2012 at the small scale plant at Hanningfield confirmed that STRBs are a suitable and sustainable method for treating the ferric Water Works sludge produced at this site. Based on the test results NWL and its consultants unanimously agreed to progress

with constructing a full scale plant in the knowledge that the project would contribute to such strategic achievements as:

Saving water: The tests produced residues with dry solids contents of over 40 %, thus contributing more water to reuse.

Operational costs and stability: STRBs require only minimal energy, operational and maintenance costs. Cyclic emptying ensures the re-usability of the reed beds.

Capacity: The STRBs can receive all the raw sludge, regardless of flow rate or density so that emergencies and reliance on third parties is avoided

Handling: A STRBs sludge residue has much higher dry solids content than that of a mechanical system making handling and disposal of the final product much easier and more stakeholder friendly.

OPEX reduction: there is no requirement to remove sludge from the system until the first basin requires emptying after a period of approx. 12 years.

Another important advantage for NWL at the time was that the STRB solution was seen as a proactive, innovative, “Green” solution that fits with their company mission and objectives.

An Environmental Impact Assessment made at the time concluded that the construction of an STRB at Hanningfield would have a very minimal impact and longer term benefits.

Environmental advantages and CO₂

STRBs have a number of environmental advantages over mechanical dewatering processes which were also important criteria when choosing this alternative for the Hanningfield sludge, including:

Sustainability: They require minimum operational and energy resources. Periodic emptying of the beds allow for re-usability into the foreseeable future.

Carbon management: Recent studies indicate that the operational CO₂ emissions for an STRB are less than 25 % of the emissions for a centrifuge system where the end product is dried and pelleted and spread onto agricultural land; The feasibility study leading to the choice of an STRB for the Hanningfield sludge also showed that STRBs have a lower carbon whole life than a mechanical system.

STRBs provide a much friendlier, odour free and safer working environment than traditional systems. The filtered water will feed the adjacent wildlife habitat of the Great Prestons Lagoon and finally end up in the reservoir.

Operational Costs

A comparison of capital and operational costs undertaken in the considerations up to the choice of an STRB system for the Hanningfield sludge found that the overall capital costs for the two alternatives were roughly equal but that the STRB system requires far less operational and maintenance than a mechanical system and is, as such, the best value on a whole life cost basis.

Conclusion

After careful consideration, comparison and planning, the world’s first STRB system for the treatment of water works sludge has been commissioned at the Hanningfield Water Treatment Works near Chelmsford in Essex which, as a byproduct of the production of 240,000 litres of drinking water per day,

produces up to 2,000-3,000 litres of ferric sludge per day. In the past, this sludge has been piped to nearby lagoons as landfill, but now that these lagoons are nearing full capacity and the Hanningfield WTW needed to address the sludge management issue. This must be a common issue for water treatment works in the UK. After 5 years of consideration and testing, NWL has determined that an STRB system for treating the sludge is the most viable solution available, providing lower operational costs, better environmental advantages and CO₂ emissions as well as the possibility for an end product than can be disposed of in a sustainable, even beneficial manner. The construction of this STRB system began in June 2011 and was completed autumn 2012. The system was put into service in October 2012.

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References

- Liénard, A., Duchène Ph., Gorini, D. (1995) A study of activated sludge dewatering in experimental reed-planted or unplanted sludge drying beds. *Water Science & Technology* **32(3)**, 251-261.
- Matamoros V., Loc Xuan Nguyen, Carlos A. Arias, Steen Nielsen, Maria Mølmer Laugen, Hans Brix. (2012) Musk fragrances, DEHP and heavy metals in a 20 years old sludge treatment reed bed system. *Water Research*, 46(12), 3889-3896.
- Nielsen, S. (2003) "Sludge Drying Reed Beds". *Water Science and Technology*. Vol. 48 No 5 pp. 101 – 109.
- Nielsen, S. (2005) Mineralization of hazardous organic compounds in a sludge reed bed and sludge storage. *Water Science & Technology* **51(9)**, 109-117.
- Nielsen, S. (2008) Sludge treatment and drying reed bed systems 20 years of experience. In: *Proceedings of the European Conference on Sludge Management*, Liège, Belgium.
- Nielsen, S., Cooper, D.J. (2011) Dewatering sludge originating in water treatment works in reed bed systems. *Water Science and Technology* 64.2, 361-366.
- Peruzzi, E., Nielsen, S., Macci, C., Doni, S., Iannelli, R., Aiello, M., Masciandaro, G. (2012). Effectiveness of reed bed systems for sludge stabilization treatment: Danish and Italian examples
- Peruzzi E., Masciandaro G., Macci C., Doni S., Ravelo S. G. M., Peruzzi P. and Ceccanti B. (2011) Heavy metal fractionation and organic matter stabilisation in sewage sludge treatment wetlands. *Ecological Engineering*, **37(5)**, 771–778.
- Obarska-Pempkowiak, H., Tuszyńska, A., Sobocinski, Z. (2003) Polish experience with sewage sludge dewatering in reed systems. *Water Science & Technology* **48(5)**, 111-117.
- Uggetti, E., Llorens, E., Pedescoll, A., Ferrer, I., Castellnou, R., García, J. (2009) Sludge dewatering and stabilization in drying reed beds: characterization of three full-scale systems in Catalonia, Spain. *Bioresource Technology* **100**, 3882-3890.