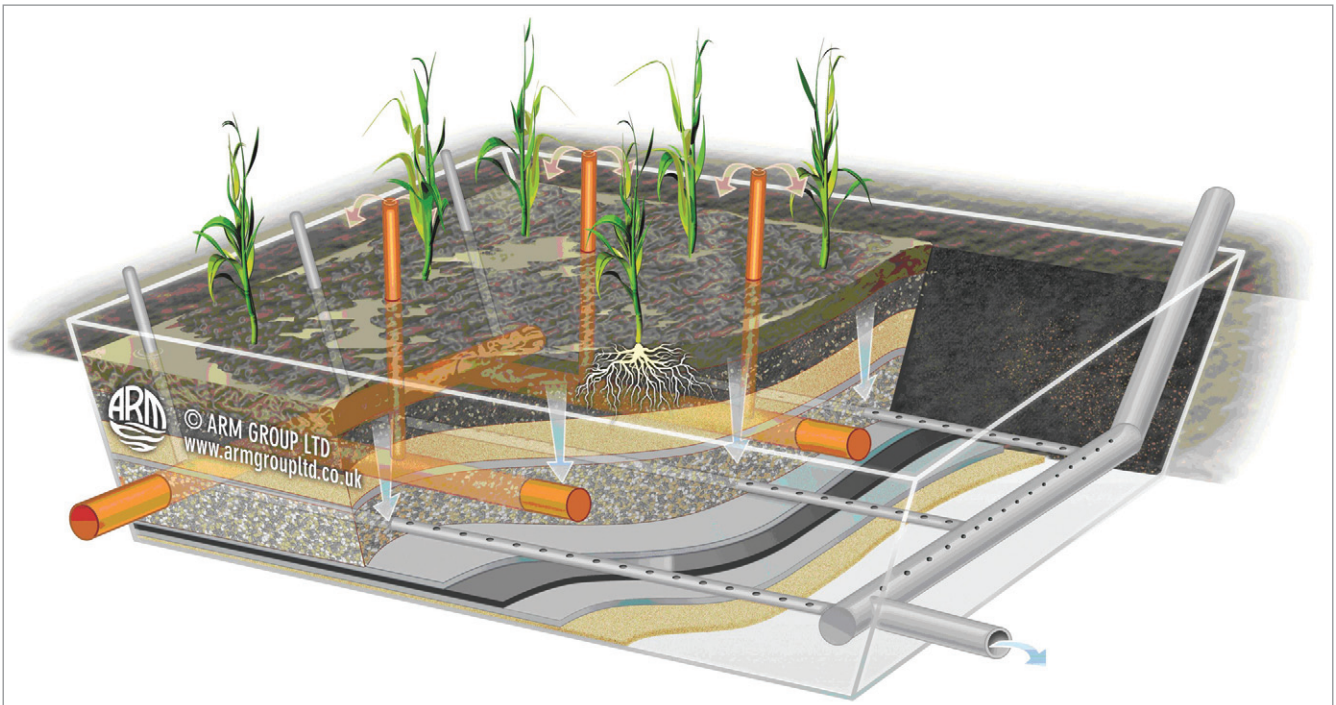
Sludge Treatment Reed Beds

Breaking new ground, a world first for a water treatment works

by Tori Sellers

All water providers in the UK have a legal requirement to meet the rigorous standards set out by the government and European Union to ensure drinking water is safe regardless of its origination. These standards ensure that levels of chemical, bacteriological and aesthetic qualities such as colour, taste and odour are all met. At present, raw water is sourced through a variety of watercourses including rivers and reservoirs drained from moorland, farmland and urban areas as well as groundwater from boreholes which draw water from underground rock aquifers. This water needs to be treated before it can be sent into the domestic drinking water system.



Sludge treatment reed bed - Courtesy of ARM Ltd

Background

The initial part of the treatment process involves the introduction of ferric sulphate or alum salts into pulsator clarifiers to remove silt and algae contained in the raw water. This generates a ferric or alum-based liquid sludge by-product which must be treated. This sludge contains 99.8% of valuable water which once separated, can be returned back to its original source for future use.

Currently many water companies use mechanical dewatering processes which produce approximately 25-30% dry solids content and the valuable water within that sludge is generally not returned to a watercourse to be reused. This technology system has high energy, operational and mechanical costs as well as polymer consumption.

Regulations enforced by the Environment Agency puts pressure on water companies to treat sludge effectively to re-coup as much water as possible. At present, sludge is spread to land or returned to a lagoon/reservoir. Now there is a need to achieve cleaner water through sustainable solutions which are cost-effective and have less impact on the environment.

Following trials with Essex & Suffolk Water at its Hanningfield Water Treatment Works, sludge treatment reed bed systems (STRBs) can provide this long-term solution.

Sludge treatment reed beds

Since 1988 sludge treatment reed bed systems (STRBs) have been used for the dewatering of sludge from sewage plants across Europe. In 2008, ARM Limited partnered with Danish firm Orbicon to bring STRBs to the UK to treat sewage wastewater, but after working with water companies on other reed bed systems, it was evident that there was no existing low energy, sustainable solution to treating ferric or alum-based sludges.

An STRB is a vertical flow filter bed which receives raw sludge and separates the solids from the clear water content. Although they had not been designed to treat ferric or alum-based sludge, extensive trials were successful and provide an efficient alternative to other mechanical processes.

Traditional methods of dewatering involves centrifuges and belt presses resulting in high energy and maintenance costs, whereas the STRB system reduces both and provides a long-term sludge treatment solution. Unlike the mechanical dewatering processes, there is no need to use polyelectrolyte to thicken the sludge as the reed beds prefer a thin consistency liquid sludge.

Dewatering

Dewatering occurs on several levels; draining, evaporation and evapotranspiration. It does this by retaining the sludge residue

on the surface whilst allowing the clear water to pass vertically through the filter via a drainage system at the base of the bed. This leaves a dry solid content of up to 60% and a better quality of reject water with 99% returning to stream or reservoir. Comparatively centrifuges only leave dry solid content of about 25%.

The treatment system varies but contains individual lined reed beds which are typically 2-2.5m deep. The ferric or alum-based sludge is then pumped in sequence to each basin to a pre-determined fixed solids loading. Typically, the sludge loadings amount to a maximum of 30-60 DS/m^2/year dependent on the characteristics of the sludge.

Benefits

The reed bed system will retain sludge residue up to a depth of 1m, which builds up over approximately 10 years before it needs to be excavated. Following excavation, the system can receive raw sludge almost immediately as the filter media and reed roots are retained in situ.

Whilst the use of STRBs in the removal of water from sludge for drinking water is a relatively new concept, the benefits are huge.

- STRBs use no chemicals to treat sludge, reducing potential health and safety issues in the working environment and a reduction in chemical residue in the treated wastewater.
- The only appreciable power consumption is by the use of transfer pumps between the treatment plant and STRB.
- Reduced CO_2 emissions and a better quality of sludge also increase the possibility of recycling the resulting residue with greater environmental options for removal.
- A STRB system will more than halve the costs of transport in the long-term with no transport costs for the first 10 years or until the dry solid content needs to be removed from the reed bed.

Perhaps the greatest benefit of using STRBs for water companies is sustainability. This coupled with reduced transport costs makes it an extremely cost-effective and attractive on OPEX expenditure.

STRBs in action

Hanningfield Water Treatment Works (WTW)

In 2008, Essex & Suffolk Water, embarked on finding a solution to its existing sludge treatment system at Hanningfield WTW, which was coming to the end of its serviceable life.

Since operations began at Hanningfield in the 1950s, sludge had been discharged into Great Prestons lagoon to the north of the reservoir through an underground pipe. When this became full in 1989, the flow was re-directed to Whitelilies lagoon.

The lagoons act as a repository for solids whilst allowing the clear water to overflow back into the main reservoir for reuse. As Whitelillies was nearing the end of its serviceable life, an alternative sustainable solution was required to enable Hanningfield to continue producing cleaner drinking water.

Hanningfield WTW treats up to 240Ml/day of drinking water for a large part of Essex and east London. The initial part of the treatment process involves the introduction of ferric sulphate into the pulsator clarifiers to remove silt and algae contained in the raw reservoir water. This generates up to 3Ml/day of a ferric-based liquid sludge by-product which must be treated. This sludge contains 99.8% of valuable water which once separated, can be returned back to the reservoir for future use.

E&SW commissioned ARM Limited and its Danish partner Orbicon in March 2008 to design and build a system to treat ferric sludge. If successful, a full-scale STRB system would be implemented in preference to an automated mechanical centrifuge system.

The trials

In order to make a reasonable estimate of the efficiency of STRBs under these particular circumstances, the Hanningfield test system was built with 6 (No.) basins, each 20m^3 with a design comparable to a full-scale plant. The purpose of the test was to clarify:

- Whether the sludge from Hanningfield was suitable for further treatment in a STRB.
- The dimensions required (capacity, operations, loads, area, number of basins) for a full-scale plant.
- Quality of reject water.

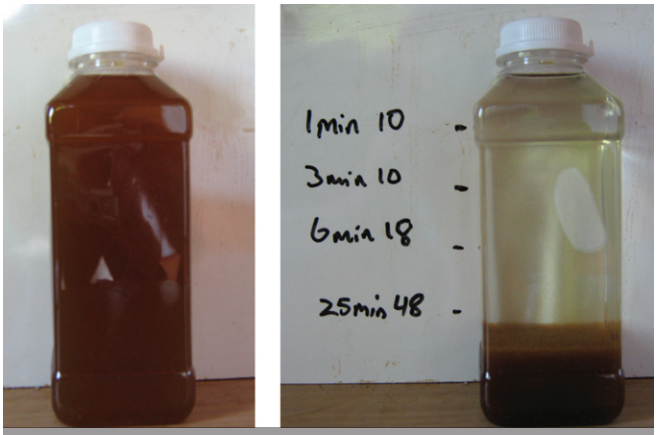
Unlike mechanical systems where polymers are added to thicken the sludge, STRBs require a thin layer of sludge which can be loaded onto the surface of the trial reed bed.

As the sludge dewaters, the sludge residue remains on the surface whilst the water permeates through the filter media. The surface sludge cracks up in the dewatering process.

Aerial view of Hanningfield WTW - Courtesy of CA Blackwell

Trial reed bed at Hanningfield - Courtesy of ARM Ltd

Cracked sludge following dewatering process - Courtesy of ARM Ltd



Sludge sample and sedimentation period - Courtesy of ARM Ltd

Clear reject water - Courtesy of ARM Ltd

Throughout the trial, loading to each bed was varied and monitored visually against a set criteria including reed health, residue depth as well as samples taken to determine raw sludge input, filtrate output and the sludge residue left on the surface.

This determined the area and number of reed beds required to take the full load of sludge from the works. The trials were successfully developed and monitored by Essex & Suffolk Water, ARM and Orbicon.

As expected, the reed growth on the trial beds was very good during the summer with reasonable spreading. The pH levels of the sludge (around pH7) were within the parameters needed for good reed growth to sustain the system.

Samples of the filtrate water also showed efficiency of the filtration throughout the beds with a normal flow turbity of less than one nephelometric turbity unit.

Trials were initially undertaken to determine if ferric sludge was treatable in reed bed systems and following two years of successful trials where dry solids content of the sludge reached up to 60% and 99% of the valuable water held in the sludge returned to the reservoir, the decision to move ahead with a full-scale system was taken.

Full-scale STRB system

In June 2011, construction began on building a STRB system consisting of 16 (No.) basins, covering a total of 4.5ha. All of the beds were completed in October 2012 and are fully operational.

As the reeds grow, raw sludge will be distributed over the surface of one reed bed for a pre-determined period of time. This bed will then be rested for approximately two months as the other beds are utilised. The resting period enables the sludge on the reed bed to dry out and crack to achieve maximum dry solid content which will eventually be recycled. The STRBs are managed by a SCADA system which links to Essex & Suffolk Water's software to load the beds to ensure optimal efficiency.

Initial research has shown that the build-up of sludge residue to achieve a full bed takes approximately 10 years. In 2009 this was re-calculated to around 13 years with the most recent data indicating that due to the consistency of the sludge and capacity of the reed beds, the removal process would not need to begin for 20 years.

Once the reed beds reach capacity, one bed will be emptied in any one year and once emptied the bed will be able to receive raw sludge almost immediately with the reed beds regenerating themselves without intervention. Tests from the trials showed that the residue would be suitable for reuse as an agricultural soil improver – eliminating costs for landfill and other disposal options.

Essex & Suffolk Water has also estimated the reed beds will save approximately 70 tonnes of CO_2 emissions a year.

Conclusion

There has been a considerable amount of research undertaken to prove that reed beds work at Hanningfield and effectively treat ferric sludge and the results have been outstanding.

- ***A flexible system***: It has low energy consumption and operational costs, and it eliminates the need for costly chemicals at this stage in the process.
- ***Sustainable***: It is a cost-effective long term solution to producing high quality drinking water at a water treatment works.

The Editor & Publishers would like to thank Tori Sellers, Director with ARM Ltd, for providing the above article for publication.

Waterworks sludge treatment

- No requirement for sludge removal from site for at least ten years
- No chemical dosing required
- Achieves sludge dry solids content of over 40%
- Applies to either alum or ferric sludges
- Low energy and OPEX costs
- Returns 99% of filtrate to water course
- Proven technology
- Flexible operation
- Fully SCADA controlled
- Environmentally friendly operation

natural wastewater treatment

ARM Ltd. Rydal House, Colton Rd
Rugeley, Staffordshire. WS15 3HF

t. +44 (0)1889 583811
www.armgroupltd.co.uk