EFFECTS OF WATER WORKS SLUDGE ON SEWAGE TREATMENT AND SLUDGE HANDLING

A. Harri and J. Bosander

Syvab, Himmerfjärdsverket, S-147 92 Grödinge, Sweden
(E-mail: anita.harri@syvab.se, jan.bosander@syvab.se)

Abstract
This paper presents an experiment concerning the discharge of water treatment residuals (WT-residuals) from Norsborg water treatment works (NWTW) in Stockholm, Sweden, to Himmerfjärden sewage works (HSW) in Grödinge, Sweden. The aim of the project was to investigate the potential of discharge as a method for treating aluminium-rich water treatment sludge from NWTW, and especially to study its impact on the sewage and sludge treatment processes of HSW.

The main effects observed at HSW during the period of discharge were an impaired thickening of primary sludge, causing an increased hydraulic load on digesters and centrifuges, and a deteriorated dewatering of digested sludge. As a positive effect, indications of improved phosphorus removal over the primary sedimentation were observed.

Due to the limited volume of the sludge treatment system at HSW, a future discharge of WT-residuals would require measures to be taken to increase the capacity of this part of the plant. Providing that such measures are taken and show planned effect, discharge to HSW is considered a possible method for treating residuals from NWTW.

Keywords
Aluminium-rich water works sludge, sewage treatment, sludge handling, Sweden, water treatment residuals

INTRODUCTION

At the water treatment works of the Stockholm water Co; Lovö and Norsborg, 1800 tonnes of water treatment residuals (WT-residuals) in the form of aluminium-rich sludge is produced every year. These residuals consist to 50% of humus and to 50% of aluminium hydroxide. Since chemical precipitation was introduced at the water treatment works; 1933 and 1953, the residuals have been returned to Lake Mälaren, the source of water supply. The accumulated volume has now got so large, that it actually constitutes a physical problem.

The Stockholm Water Co wishes to avoid the release of WT-residuals to Lake Mälaren to the greatest extent possible. One of several alternative methods investigated is discharge to sewer systems.

This paper describes an experiment with discharge of WT-residuals from Norsborg water treatment works (NWTW) in Stockholm, Sweden, to Himmerfjärden sewage works (HSW) in Grödinge, Sweden.

The aim of the project was to investigate the potential of discharge as a method for treating these residuals, and especially to study their impact on the sewage and sludge treatment processes of HSW. Further, the impact on the sewer system was to be studied, although the latter is not described in this paper.

METHODS

The experiment was conducted in two parts; in the autumn of 1999, and in the autumn/winter of 2000/2001, resulting in two separate reports (Öman, 2000 and Harri, 2001). In the first part of the experiment, HSW received 50% of the residuals formed at NWTW. Thereafter, the discharge was stopped for half a year. During the second period of the experiment, July 2000 – February 2001, 100% of the residuals produced at NWTW was, when technically possible, discharged.

This paper refers only to the second period of the experiment, although similar effects were observed during both periods. To clearer show trends and effects, though, both periods have been included in diagrams shown in the paper. Also included, to show the recovery of HSW after finishing of the discharge, is the period Mars – April 2001.

To evaluate the effects of the WT-residuals on HSW, the experiment period was compared to a reference period, chosen from the time before discharge first took place. For the evaluation of the effects on the primary sedimentation and the bio step, a reference period with similar inlet flow as the one of the experiment was searched. This was complicated by the extremely rainy winter of 2000. The best choice showed to be July 1998 - February 1999. For the evaluation of the effects on the sludge treatment, inlet flow is of less importance. As more data were available from 1999 an on, January – June 1999 was chosen as reference.

DATA OF THE PLANTS

The NWTW water production is 216 000 m^3/d (yearly average, 2000) and the amount of WT-residuals formed approximately 3 t DS/d. As chemical coagulant, aluminium sulphate (ALG; containing 9,1% Al) is used, with a normal dose of 27 g ALG/m^3.

HSW receives wastewater from 252 000 people, excluding industry, and the inlet flow is 110 000 m^3/d (yearly average, 2000). The plant is operated with pre-precipitation with iron(II) sulphate, activated sludge, post-denitrification, and sand filter. Just before the sand filter, poly aluminium chloride is added in an amount equivalent to 1 g Al/m^3. Primary and excess sludge are pumped separately to gravity thickeners and further to the digesters. At the start of this project, primary and excess sludge were digested together in one step. Since November 2000, digester operation in series has been applied, with primary sludge in the first, and digested primary sludge together with excess sludge in the second step. Digested sludge is dewatered in centrifuges, and used for construction of golf courses, or dried and put on landfill.

The two plants are connected by a pipe and tunnel system, and the distance for the WT-residuals to be transported is 30 km.

RESULTS AND DISCUSSION

Amount of WT-residuals discharged

During the period of July 2000 – February 2001, 634 ton DS of WT-residuals were discharged to HSW, corresponding to an average value of 2,6 ton DS/d and constituting 10% of the total suspended solids load on HSW.

Effects on the primary sedimentation

No significant effects of the WT-residuals could be seen on the removal of suspended solids or COD in the primary sedimentation.

The reduction of phosphorus was higher during the experiment than during the reference. To what extent this was due to the ability of the aluminium-rich WT-residuals to remove phosphorus is difficult to estimate, as the iron(II) sulphate dose was not constant during the experiment. When comparing two periods with similar inlet flow and iron(II) sulphate dose; September 1998 and September 2000, the removal of phosphorus increased from 47 to 57%, as WT-residuals were added. Parts of this improvement might, though, be caused by iron remaining in the system since the summer of 2000, when a higher dose than normal was applied.

Effects on the activated sludge step

Both the loss on ignition and the amount of volatile suspended solids were approximately equal during the experiment and the reference period. This was expected, as aluminium analysis on sewage and primary, excess and dewatered sludge performed during the first experiment period; in 1999, have shown the main part of the WT-residuals to be removed in the primary sedimentation (Öman, 2000).

The average sludge index was higher during the experiment (115) than during the reference period (92). According to common known theories, an addition of aluminium would rather lower the index than make it higher. In fact, poly aluminium cloride has earlier been dosed at HSW to improve the sludge quality. The increased sludge index observed during the experiment was explained by a lower sludge age and suspended solids concentration, applied to prevent escaping sludge during the extremely rainy winter of 2000/2001.

No impact on the nitrification was observed during the experiment.

Effects on the thickening

An impaired thickening of primary sludge was observed during the experiment (Figure 1). The DS percentage in primary sludge from the thickener decreased from an average value of 4,2% during the reference period to only 3% during the experiment, most likely to a large extent due to the aluminium-rich WT-residuals. Other possible contributing factors are the varying dose of iron(II) sulphate and the shorter retention time in the thickener, caused by the larger hydraulic load.

The DS in thickened excess sludge was not affected by the discharge of WT-residuals.

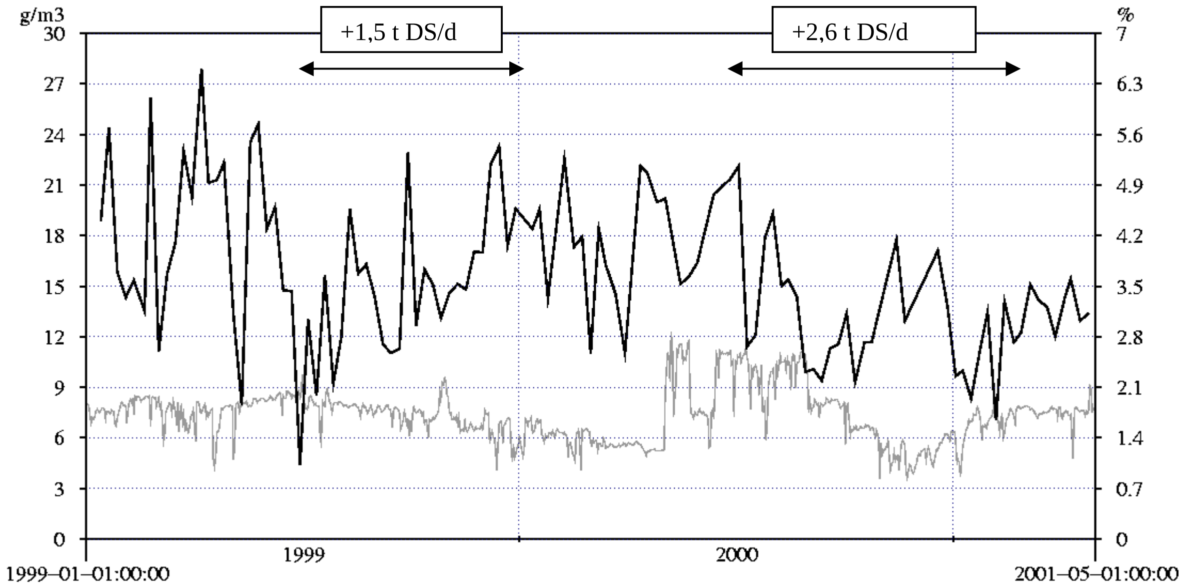

Figure 1. DS in primary sludge from thickener (black) and iron(II) sulphate dose (grey)

Effects on the digestion

Due to the poor thickening, the volume of sludge to handle increased, causing a larger hydraulic load on the digesters and a shortened retention time. As a result, the alkalinity, the degree of digestion and the gas production decreased in the autumn of 2000 (Figure 2). To run the digesters in parallel at such a high hydraulic load turned out to be impossible. After digester operation in series was applied in November 2000, the gas production increased, and the alkalinity started to rise slowly. The degree of digestion remained low, probably partly because of a continuously rising withdrawal of excess sludge. With the digesters operated in series, the larger hydraulic load was manageable, although the margins were still small.

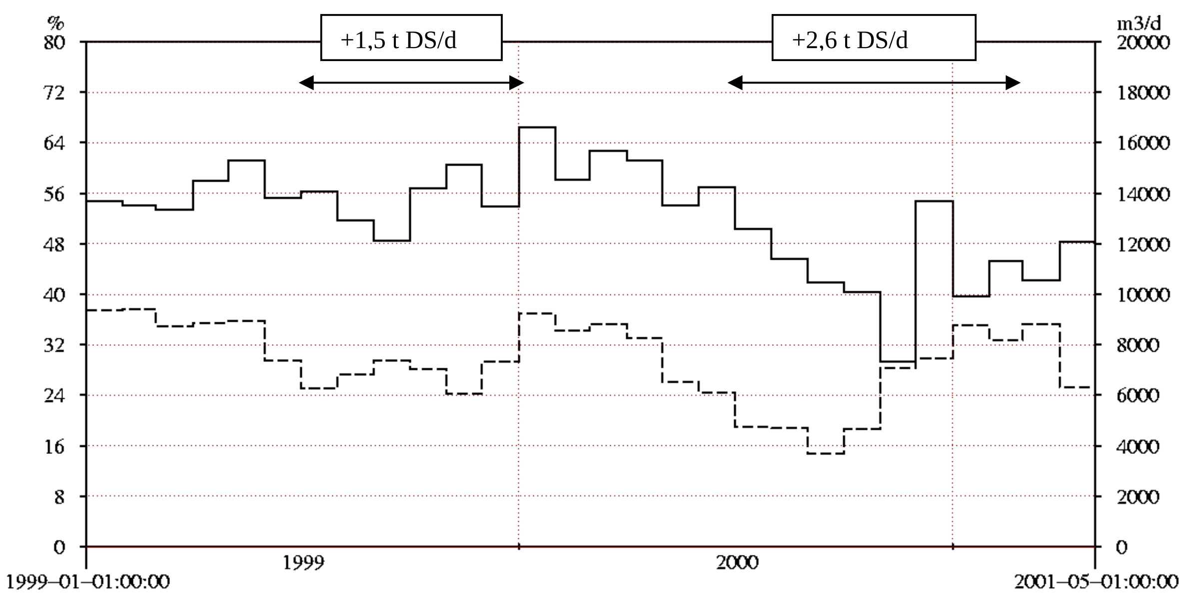

Figure 2. Gas production (dotted line) and degree of digestion (continuous line)

Effects on the dewatering

Cation analysis performed at three occasions; before and during the second experiment period, have shown that an addition of WT-residuals corresponding to 3 ton DS/d would lower the dewatering capacity and increase the polymer dose required with 70-80% at HSW (Bengtsson, Bjurling, 2000). During the second experiment period, the average DS-percentage in dewatered sludge at HSW was 23%, and the polymer dose 5,7 kg polymer/ton DS. Corresponding figures for the reference period are 28% and 3,2 kg polymer/ton DS. (Figure 3)

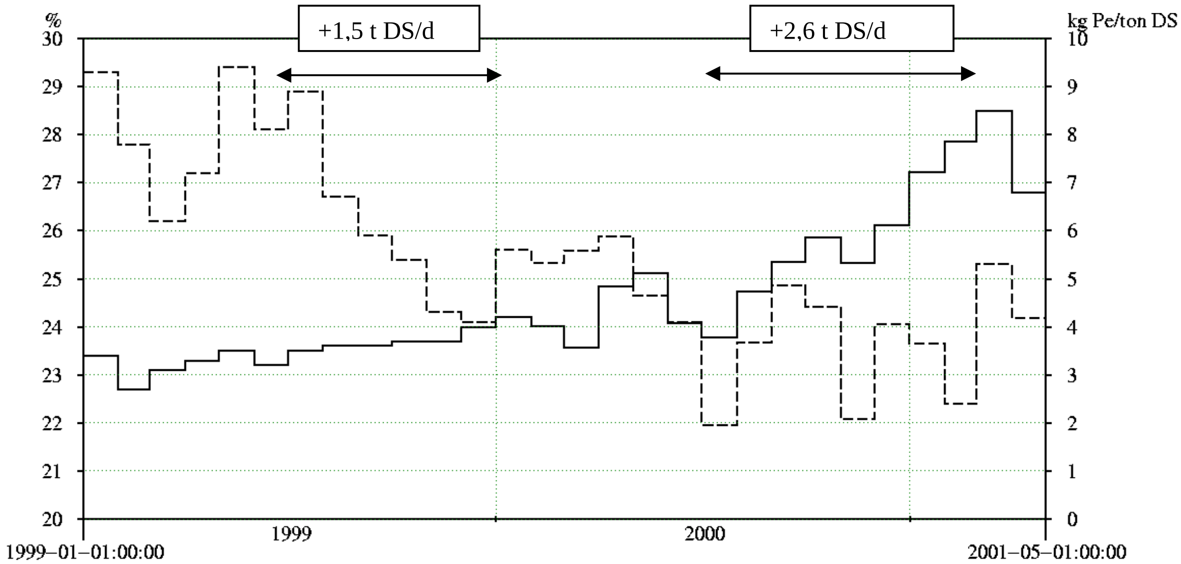

Figure 3. DS in dewatered sludge (dotted line) and polymer dose (continuous line)

Striking is that the dewatering did not recover entirely as the first experiment period was brought to its end and no WT-residuals were added for half a year. Apparently, several factors were contributing to the impaired sludge quality at HSW. One of these is the increased production of excess sludge. The low DS-value in May 2000 was probably caused by a disturbed operation of the plant due to construction work.

Heavy metals and aluminium in sludge

The concentrations of both chromium and zinc in dewatered sludge from HSW have been high during the latest couple of years, and a lot of effort has been put into tracing possible sources.

The WT-residuals from NWTW contain on average 31 mg Zn/kg DS and 27 mg Cr/kg DS, according to analyses performed at five different occasions (Blomberg, 1997). As the concentrations in the HSW sludge are several times higher (Figure 4), a positive result of the discharge of WT-residuals is a dilution of zinc and chromium in the HSW sludge.

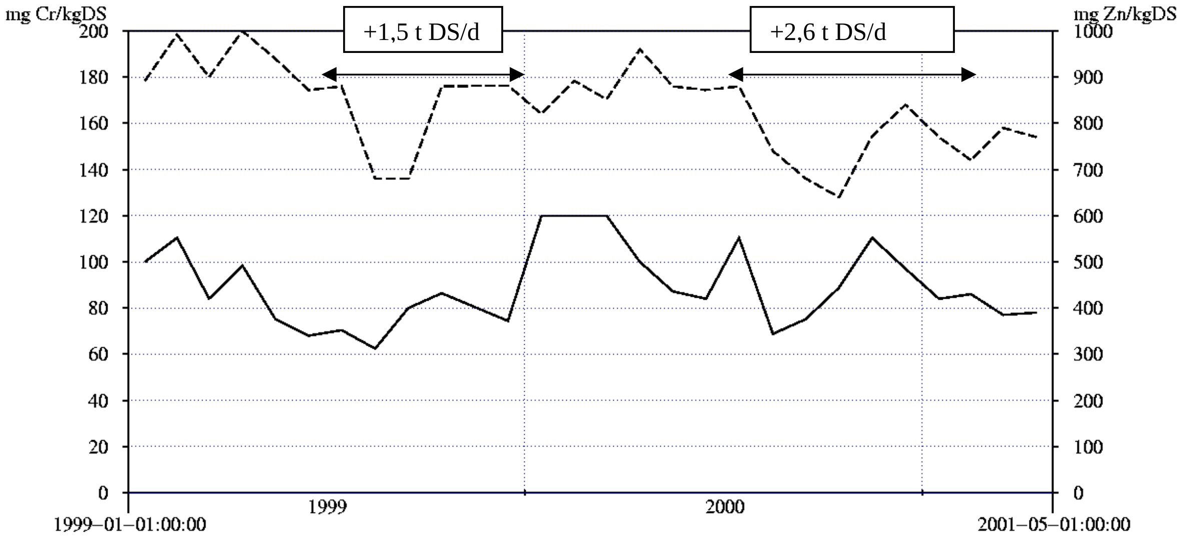

Figure 4. Concentrations of chromium (continuous line) and zinc (dotted line)

The concentration of aluminium in WT-residuals from NWTW is 147 g/kg DS, according to analyses performed at three occasions (Blomberg, 1997). The concentration of aluminium in sludge from HSW, of course, increased during the experiment, and was stable just over a month after starting and finishing of the discharge (Figure 5).

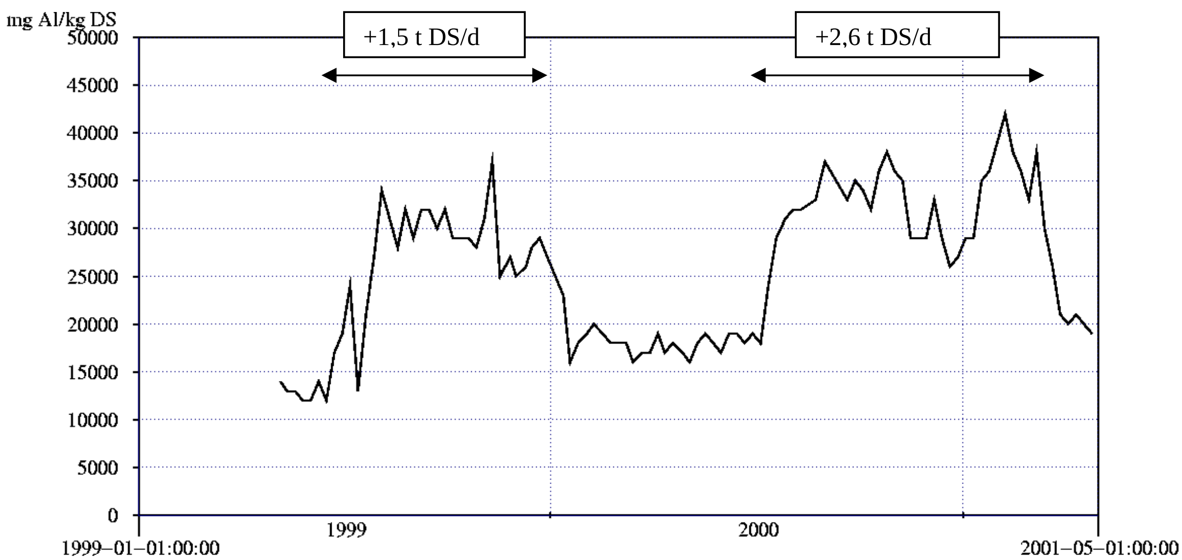

Figure 5. Aluminium concentration in dewatered sludge

CONCLUSIONS

As mentioned in the introduction, the aim of this project was to investigate the potential of discharge to HSW as a method for treating the aluminium-rich WT-residuals of NWTW, and especially to study their impact on the sewage and sludge treatment processes of HSW.

As far as the sewage treatment is concerned, no drawbacks connected to the WT-residuals were observed. As a positive effect, indications on an improved reduction of phosphorus in the primary sedimentation were seen.

A negative impact was seen on the operation of the sludge treatment system of HSW, mainly in the form of a deteriorated thickening, an increased hydraulic load on digesters and centrifuges, and an impaired dewatering of digested sludge.

A satisfactory solution to the problem with increased hydraulic load was found in the changeover to operation in series, although the capacity was still small. As the number of people connected to HSW is expected to increase, this might involve future problems.

To enable a future long-term discharge, measures to increase the capacity of the sludge treatment system of HSW are required. Examples on such measures, except from the already performed change of digester operation, are flotation of excess sludge and thermophilic digestion. The latter two are at the time of writing being tested at the plant.

Providing that measures to improve the sludge treatment system are taken, and that these have expected effect, discharge to HSW is considered a possible method for treating the NWTW residuals.

ACKNOWLEDGEMENTS

The authors wishes to express their appreciation to involved staff at Stockholm Vatten, especially J. Blomberg and J. Öman.

REFERENCES

Bengtsson J., Bjurling K. (2000). *Vattenverksslammets inverkan på avvattningsbarheten av rötat slam*, AB CDM (Chemical dyestuffs minerals), Västra Frölunda, Sweden.

Blomberg J. (2000). *Metallinnehåll i vattenverksslam,* R Nr 25; Oct 1997, Stockholm Vatten AB, Stockholm, Sweden.

Harri A. (2001). *Överledning av vattenverksslam från Norsborgs vattenverk till Himmerfjärdsverket. Försöksperiod 2*, SYVAB, Grödinge, Sweden.

Öman J. (1998). *Överledning av vattenverksslam till reningsverk,* R Nr 24; Aug 1998, Stockholm Vatten AB, Stockholm, Sweden.

Öman J. (2000). *Överledning av vattenverksslam från Norsborgs vattenverk till Himmerfjärdsverket*, R Nr 16; Apr 2000, Stockholm Vatten AB, Stockholm, Sweden.