

# Kemicond process at the Käppala wastewater treatment plant, Lidingö, Sweden

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## ABSTRACT

Käppala Association has the responsibility to receive and treat wastewater from 11 municipalities situated just north of Stockholm in Sweden. Running a tunnel system, 60 km long, and treatment plant meet this responsibility. The plant is situated on the island Lidingö, just northeast of Stockholm. The load 2003 corresponds to about 520,000 p.e. The treatment comprises mechanical, biological, chemical and filtration. The biological process is activated sludge. The sludge, mixed primary and excess sludge, is digested and then dewatered on belt filter presses. The dry solid content is comparably low, around 20 %. The total amount is 40 000 tons or 8 000 tons of dry solids, DS.

## INTRODUCTION

The Association has investigated various methods to improve the dewatering process. Originally the first choice was to replace the belt filterpresses with centrifuges and by that achieve a dry solid content of about 30 %. There are however suggestions within the European Union and in Sweden to impose new regulations, which call for the sludge to be hygienic before it could be used, for instance, on farm land. This requires another step in the sludge handling process to fulfil this proposal. The most common method is heat treatment, > 70 °C for at least 30 minutes. We investigated how this could be implemented at the Käppala plant. The investment cost estimate is around 2 million €. Even with efficient heat recovery there will be losses, which can be estimated to around 3.5

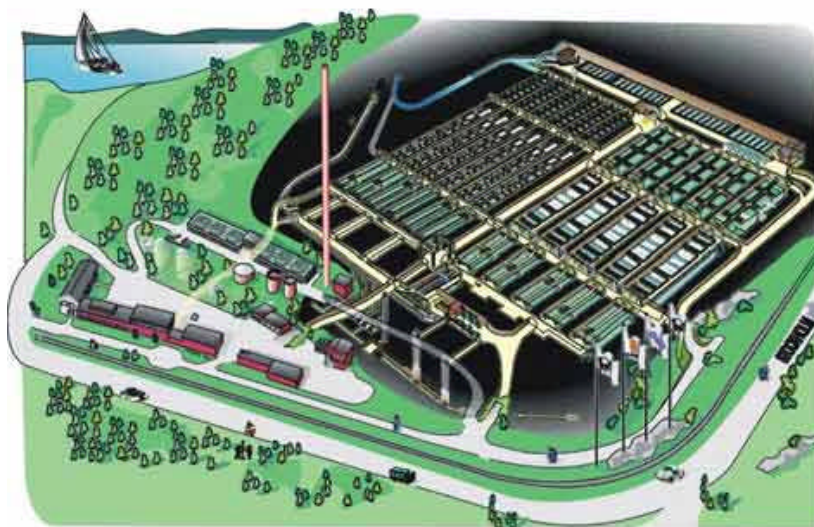
GWh per year, corresponding to 15 % of the heat generated from the digester gas produced at the plant.

Another concept of treating the sludge before dewatering, chemical conditioning, was proposed by Kemira in early 2003, the KEMICOND process.

## KÄPPALA SEWAGE TREATMENT PLANT

At Käppala sewage treatment plant sewage from approximately 500 000 people equivalents is treated mechanically, biologically and chemically. The plant is situated in rock, see figure below. The discharge limits are 8 mg/l or BOD<sub>7</sub>, 10 mg/l for total nitrogen and 0.3 mg/l for phosphorous. The biological step, activated sludge, is built for predenitrification and biological phosphorous removal, UCT-process. The final treatment step is filtration through 2 media filters, sand and expanded clay.

In the chemical treatment, to remove phosphorous, we use iron(II)sulphate. The dose, about 10 – 12 g Fe/m<sup>3</sup>, is divided in two parts. One is added to the return sludge in the biological step, 8 – 10 g/m<sup>3</sup>, and second one, 2 – 4 g/m<sup>3</sup>, is added to the sand filters.



## ACTUAL SLUDGE SITUATION OF KÄPPALA PLANT

The sludge, mixed primary and excess sludge, is digested in two digesters (volume: 9.000 m<sup>3</sup> each) and then dewatered on four belt filter presses. The

excess sludge includes chemical sludge. The dry solid content is comparably low, around 20 %. The total amount is 40 000 tons or 8 000 tons of dry solids, DS per year.

It is likely that a requirement for recovering phosphorous and other nutrients from sludge as well as a demand for hygienisation will come in the future in Sweden.

Today sludge from the Käppala plant is used mainly for soil production where the soil is used on construction sites, golf courses and for covering old landfills. Part of the sludge is used on farmland, 2003 about 15 000 tons. Sludge handling costs the Association about 1.2 million € each year. The cost is mainly dependent on sludge volume not on the DS content.

Today the sludge is loaded in containers directly from the belt presses through eccentric screw pumps. The containers are automatically conveyed after they are filled. In the container building there can be 6 containers at the same time. The containers are lifted one by one on to a lorry. Each working day there are three to four transports. During weekends the sludge is kept in two silos, 2600m<sup>3</sup> each. The container system is fit for one kind of containers only and we are therefore constrained to one contractor. The contractor owns the containers. Furthermore the container handling is time consuming.

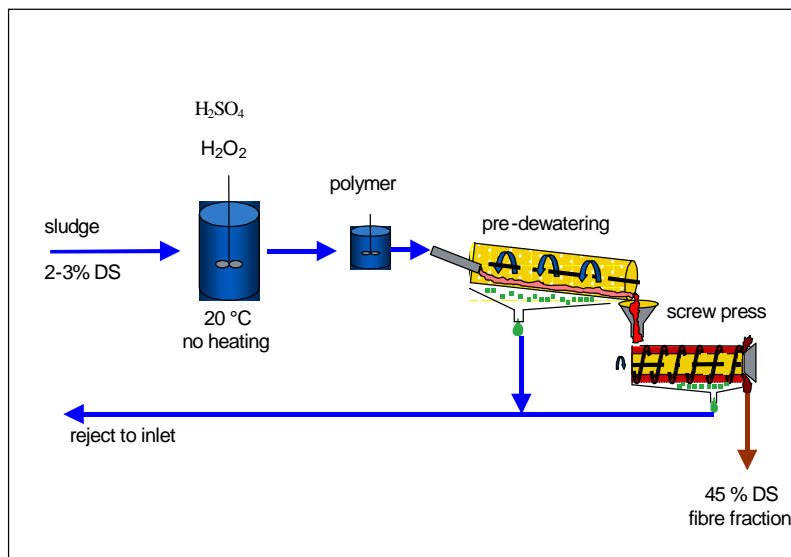
## INVESTIGATIONS TO IMPROVE SLUDGE DEWATERING

Taking the future requirements and the high cost situation of the low dry solid concentration in consideration, the Association looked for new solutions to improve the dewatering process. The concept we investigated involved replacing the belt presses with centrifuges and the container system with silos. With a silo system when out loading the sludge, any container can be used and we are no longer constrained to only one contractor. The cost for exchanging the presses and building silos was estimated to approximately 6.5 million € in 2003. Planning this project had gone to nearly completion when we were approached by Kemira. Through Kemira's work on a process for chemical extraction of phosphorous from digested sludge, the KREPRO process, they discovered that chemically treated sludge had much better dewatering properties than untreated sludge. Kemira had already done some tests with this new process called Kemicond and in February 2003 they showed us the effect in small scale, jar test, which was astounding, sludge property really changed and the sludge's ability to hold water was dramatically decreased. Several jar tests were made with practically the same results and full-scale tests were planned. These were started in spring 2003. The results from those tests are described later.

## DESCRIPTION OF KEMICOND PROCESS

As described above we use ferrous iron sulphate for precipitation of phosphorous. The main dosage is to the biological step where we have aerated zones. Most precipitated phosphorous is converted to ferric phosphate in the aerated zones. However this is again converted to ferrous phosphate in the digesters. The ferrous phosphate precipitate is very voluminous and jelly-like. It holds water very strongly. The id e of the Kemicond process is to convert the ferrous precipitate into a ferric precipitate. The ferric precipitate has a completely different property; it contains small compact particles, which doesn't hold water.

The Kemicond process is shown in the figure below.



The digested sludge is first treated with sulphuric acid down to a pH between 3 and 4. The temperature is not changed,  $20\text{ }^\circ\text{C}$ . Hereby the ferrous phosphate precipitate is dissolved. Then hydrogen peroxide is added and the iron is oxidised to the ferric stage. Ferric phosphate precipitates at the current pH-level, 3 – 4. The contact time for those two steps is altogether 40 minutes up to an hour. pH is then adjusted to about 5 and polymer is added. The first dewatering step is a roller drum where about 80 % of the water is drained. The final dewatering is done in screw presses. The ferric precipitate function as filter aid

in the screw press whereby high dry solids concentrations can be achieved, some test runs showed ds concentrations of more than 50 %.

## TEST RESULTS AND EFFECTS ON SLUDGE QUALITY

Kemira has run several nearly full scale tests at the Käppala plant during 2003 and 2004. The result as far as the dry solid concentration is concerned varied between 30 up to 55 %. In the pilot plant it was hard to control the process regarding dosage of chemical with sludge quality variations. In a full scale with proper control systems the difficulties will be overcome. We estimate to achieve a dry solid concentration of at least 40 %. The sludge will of course have a lower pH value after treatment, about 5. For most sludge application this will not be a drawback but for, for instance use on farmland, pH perhaps must be raised. How this will be done, at Käppala site or at some other location where the sludge will be treated further, we will discuss with our contractor.

Digested sludge has an apparent smell, not as bad as raw sludge. But after the Kemicond process you hardly can feel any odour at all. This is a bonus effect of the treatment. Another bonus effect is hygienisation. We have investigated the content of some bacteria before and after treatment. In all cases we achieve the same effect as thermal treatment or better, see table below.

Bacteria	Unit	Digested sludge	Kemicond sludge	Thermal treated sludge <sup>1</sup>
Coliforms 37 °C	cfu/ml	63 000	< 10	< 10
Thermo tolerant Coliforms	cfu/ml	8 800	< 10	< 10
Escherichia coli	cfu/ml	7 100	< 10	< 10
Chlostridium perfringens	cfu/ml	112 000	55 000	198 000
Salmonella enteritidis	cfu/ml	Positive	Negative	Negative
Salmonella Virchow	cfu/ml	Positive	Negative	Negative

Another effect of the treatment is that nickel and zinc to some extent are dissolved. The concentration of those two metals decreased with 50 % in treated sludge. At equilibrium we estimate the reduction will be 25 %. The difference will be found in treated water: We don't regard this as an environmental improvement since we move the metals from one media to another. As far as

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<sup>1</sup> 70 °C, 1 h

other constituents in the sludge are concerned we have found little or no differences compared to untreated, digested, sludge.

## CHEMICAL CONSUMPTION

Chemicals will be used in the Kemicond process. This is the main drawback of this concept as we see it. The consumptions are shown in the table below

Chemical	Amount per ton	Amount per annum
Sulphuric acid	150 – 300 kg	1100 – 2200 tons
Hydrogen peroxide	25 – 60 kg	180 – 450 tons
Sodium hydroxide	7 – 40 kg	50 – 300 tons
Polymer <sup>2</sup>	4 – 7 kg	30 – 50 tons

One of the most important issues when introducing a process like Kemicond is to reduce transports from the Käppala plant. Transports of sludge will therefore be compared to transports of chemicals. An overall estimate shows that with present system Käppala handles about 1400 transports per annum out of which sludge transports is about 1250. With Kemicond there will be a total of 800 transports per annum out of which sludge is about 600.

## ENVIRONMENT IMPLICATIONS

The most important effect of the Kemicond process is decreased transports, from about 1400 a year to about 800. This means a decreased discharge of carbon dioxide among other positive effects from reduced traffic. The impact on the treatment process at Käppala plants is very insignificant. The pH and alkalinity is lower in reject water but the effect on alkalinity in incoming wastewater is small. No detrimental effects on nitrification have been detected with up to 10 % of reject water mixed with incoming wastewater. As an average the reject water corresponds to about 0.5 % of incoming water, peak values are round 2 %.

Zinc and nickel are dissolved to some extent and this will be transported into the outgoing treated water. We calculate an increased discharge of nickel from 350 kg/year to 380 kg/year and for zinc from 4600 kg/year to 4700 kg/year. This is a marginal increase.

Energy consumption will also increase compared to the situation today, from 700 MWh/year to 1500 MWh/year. But one should keep in mind that the alternative to the Kemicond process, centrifuges is more energy demanding compared to belt filter presses.

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<sup>2</sup> The polymer consumption will at the same range as today

During the chemical treatment gases are produced, about 1 m<sup>3</sup> per ton ds treated. This means about 1000 m<sup>3</sup> per day. The concentration of hydrogen sulphide is significant, 10 % (vol). This must be treated in some way. At the Käppala plant we have several treatment facilities for air. We have a wet chemical scrubber which treats the most odorous ventilations flows from the plant, about 50 000 m<sup>3</sup>/h. We are looking into pre-treating the gas stream to recover sulphur. After pre-treatment the gas will be led to the scrubber.

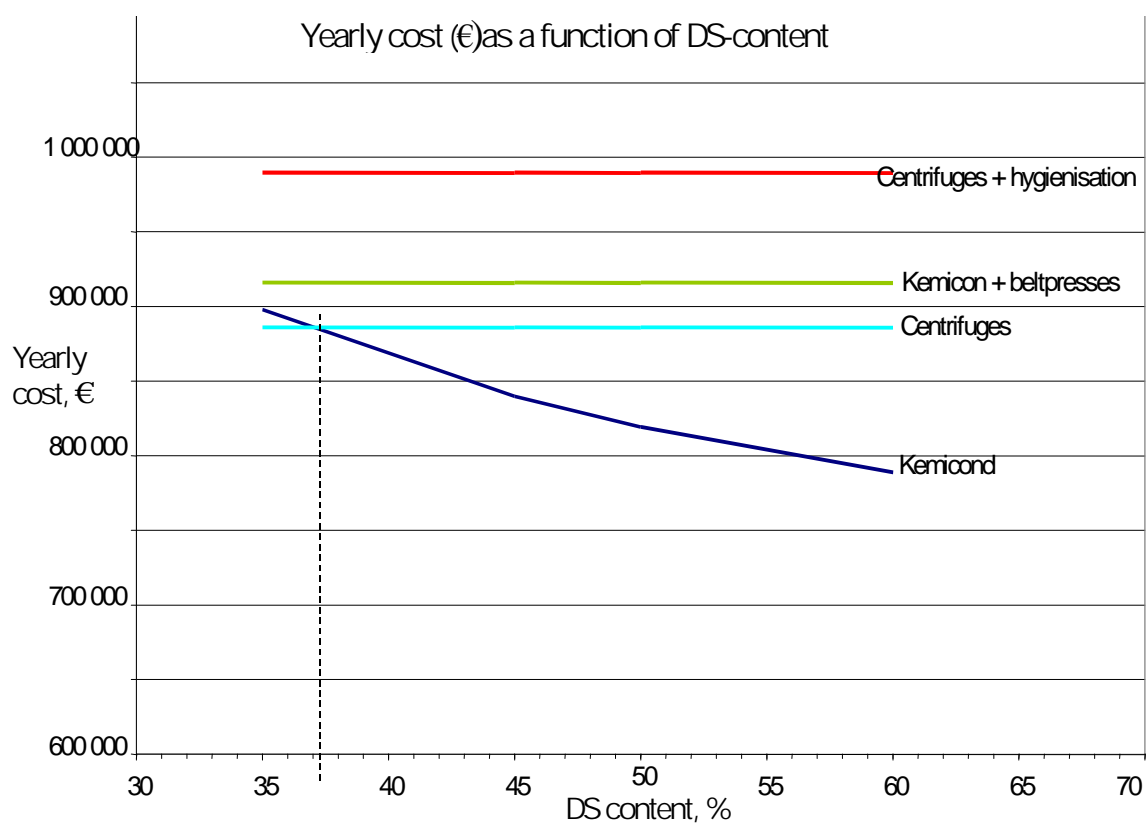
## ECONOMICS

Käppala has calculated and analysed the yearly costs of Kemicond as well as an alternative with a fully built traditional centrifuges. When looking up on these two alternatives we have including the silos (which is the same costs for both) and the cost for hygienisation (i.e. only additional for the alternative with Centrifuges), which end up that the estimated investment cost is for Kemicond 6,1 million € and for centrifuges 8,2 million €. A summary plus the yearly cost analysis is shown in table below.

	Alt 1 – Kemicond	Alt 2 – Centrifuges + hygienisation
Investment, M€ <sup>1)</sup>	6,1	8,2
Capital cost, M€/year	0,5	0,7
Operations, MSEK/year		
Process	0,6	0,6
Contractor cost (for transport and recycling to land)	0,6	0,9
Yearly cost, MSEK	1,7	2,2

<sup>1</sup> Total investment cost incl. Design

One of the main inputs to the calculation is the dry solid concentration. We have estimated an average concentration from the dewatering process of 45 % for Kemicond and 30 % for centrifuges. The yearly cost is very demanded on the outcome concentration from the processes. The sensitivity of this variation is shown for the two alternatives and for Kemicond process applied together with the existing belt filter presses.



## CONCLUSIONS AND DECISIONS OF NEXT STEP

In the present situation, with digested sludge and a dewatering belt press devices at the end of its lifetime, having comparably low dry solid concentration which leads to expensive handling costs, Käppala concludes that Kemicond together with proper dewatering devices will be the next step.

From the test result and our analysis we are confident on the following conclusions.

1. It is the cheapest alternative among those we have studied
2. We will receive a better environment with less odour emissions
3. It shows promising results from the hygienisation point of view with better effect on the investigated bacteria than thermal treatment

As far as we know today we are not hesitating to take the next step which will be a full-scale test with Kemicond plus one set of roller drum and a screw press. We will during these test period focus on process operating development, on the influence from the reject water to the water process and try to clarify whether Kemicond as a method will be accepted as a hygienisation method. Another interesting issue is how the market will accept and develop the biosolids as a fertilizer and/or as soil material.

These coming steps will start in operation next year and will continue approximately for a two years period.

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