Experience with a new low-lime sludge-treatment process based on calcium oxide addition combined with electricity heating at NJA in Norway, the first sludge-treatmentplant of this type in Europe.

By Lasse Vråle – Assoc. professor at the Agricultural University of Norway 1432 Ås.

ABSTRACT:

Nord-Jarlsberg Avfallsselskap (NJA) in Vestfold in Norway has recently built a new type sludge-treatmentplant for Hygienization and Stabilisation. Sludge from five different treatment plants located in different communities are transported to a 40 m3 sludgehopper and converted into a useful biosolid product. The yearly sludge capacity for the plant is 6500 wet tons of sludge with an average of 22 % dry solids. The new process is based on the old calcium oxide CaO addition method ; "The Orsa method" from Sweden, but is modified by the American RDP system using additional heating from electricity and pasteurisation at 70 Cº degrees at minimum 30 minutes . This makes it possible to lower the amount of CaO addition from 50 % related to dry sludge solid and down to 30 % CaO and still obtaining a fully hygienized and stabilized biosolid product. The process has a lower cost of operation because it is cheaper to heat sludge with electricity than with lime CaO. The lower content of lime in the biosolid end-product even increases its value as a fertiliser, because the lime content will not be a limiting factor for biosolid addition to agricultural land. The loss of ammonia from the biosolid will also be reduced. The plant at NJA was started up in February 1998 and a set of different lime doses and temperatures was tested out in order to find the optimal operation point. Results from this examination, treatment operation and cost of the process are presented in the paper. So far, it looks to be a promising process due to low cost of operation, low processing time less than an hour, easy operation and a biosolid product that represents a valuable agricultural fertiliser.

Key Words

Sludge Treatment, Electrical heating, Lime treatment, Stabilisation, Pasteurisation, Hygienization, Soilconditioner.

Introduction

The sludge-treatment method using unslaked lime CaO was invented by Liljegren from Orsa in Sweden in the 60`s. The original " Orsa " method has been used at about 10 larger treatmentplants in Norway.

The advantages of the process is that it is easy to operate, low cost to build, short process time and gives a product with high pH value who is good for acid soils. The biosolid product from the "Orsa method" is easy to handle.

On the other hand, the traditional method has some disadvantages:

1. The lime dose of CaO needed to raise the pH to the necessary level in order to hygienize the Biosolids is rather high.
2. This results in a higher lime dose and thereby a higher operation cost than necessary.
3. The lime content in the biosolid will also be rather high and this can give a limitation to how much Biosolid that can be used pr 1000 m2 .
4. The loss of ammonia can be higher at high pH values in the Biosolids.

When the new sludge treatmentplant at Nord-Jarlsberg Avfallsselskap (NJA) should be built, we were looking for methods that could lower the lime dose without reducing the value of the biosolid. If a lower calcium content could be obtained, the value of the biosolid product would increase. However, care must be taken, because too low lime content will make the biosolid product more unstable.One way to lower the needed lime addition, is to increase the dry solids content in the sludge before it goes into the process. This project was tried out at the TAU treatment plant in Tønsberg .

At NJA the effort was to preheat the sludge and thereby lower the necessary lime content. Different methods for preheating the sludge like using gas from the nearby garbage disposal, and using heat exchange systems in pipes etc were discussed. We became aware of that the American RDP company already had had tried out different methods of preheating sludge in order to lower the lime dose in the " Orsa Sludge treatment Method ". After a closer look at the RDP process for producing Biosolids at NJA in Norway, it was decided to use their system. The Norwegian firm Poju R. Stephansen delivered and built the new plant at NJA. This was the first sludge treatmentplant of this type in Europe.

The type of sludge to be treated and the producers.

The new sludge treatment plant at NJA is located at Nordre Foss in Holmestrand county in Vestfold in southern part of Norway. The plant is owned by four different counties Holmestrand, Borre Horten, Våle and Hoff.

The purpose of the plant is to hygienize and stabilise dewatered sludge from five different sewage treatment plants located in each of the four counties:

1. Holmestrand treatment plant, 12.000 PE (personal equivalent). Chemical precipitation using Pax 21.
2. Falkensten treatmentplant, 25.000 PE. Chemical precipitation plant using Pax 21.
3. Åsgaardstrand treatmentplant, 6.000 PE. Chemical precipitation using Pax 21.
4. Våle Treatment plant, 1050 PE. Chemical precipitation.
5. Vike Treatmentplant, 1500 PE and some smaller plants.

The dewatered chemical sludge from these plants is trucked to the plant in containers with a volume of 7 to 8 m3 . After half a year larger containers up to 15 m3 has been used in order to reduce the transportation cost.

How the new plant are working and dimensions.

The plant is designed for a capacity of 6500 wet tons a year. The average dry solids content in the sludge was expected to be 23 %. The plant can take care of 1.500 dry tons pr year and is designed to operate 7 hour a day 5 days a week. The maximum capacity pr hour is: 0,82 dry tons pr hour and 3,6 wet tons / h .

When the sludge arrives at the plant, it is tipped into a large sludge hopper with a volume of 40 m3. Conveyors brings the sludge from the hopper to the Thermoblender. In the Thermoblender the sludge is heated with special equipment based on electrical energy and from the slaking process from the lime added. The unslaked lime CaO reacts rapidly with the water in the dewatered sludge and produces slaked or hydrated lime Ca(OH)2 and a large amount of heat is released and the temperature increases.

$CaO + H2O = Ca(OH)2 + Heat$ (15.58 kcal/mole)

The lime is stored in a 50 m3 silo and the CaO is screwed into the Thermoblender in the desired rate. The temperature is raised to 70 Cº at the outlet end of the Thermoblender where processed sludge goes into the Pasteurisation Vessel where all particles are processed through 70ºC and at a minimum time of 30 minutes. This new treatment process ensures pasteurisation in a two-step patented process which meets the requirements for stabilisation grade A as described in the EPA Guide 503. (4). These guidelines require Pathogen reduction, and reduced vector attraction to meet grade A standards as outlined fore a range of processes. The requirement to reach this standard is that the Biosolids shall maintain a temperature at 70ºC for 30 minutes and by adding sufficient lime to raise the pH above 12,0 for two hours and then 11,5 or higher for an additional 22 hours, to prevent pathogen regrowth. From the Pasteurisation Vessel the finished Biosolids product, which now has obtained the highest standard grade A, drops down into a concrete bunker below the processing main floor. Total processing time from the untreated sludge leaves the hopper until the finished Biosolids fall into the bunker, takes approximately 45 minutes.

The final product is transported outside with a wheel loader to a larger nearby outdoor site where the Biosolid product is laid in ranks waiting for the final heavy metals analysis before it is going out to the farmers. The heavy metal limits are presented in Norwegian regulations (3). The last part of the paper shows some figures and pictures of the RDP plant at NJA.

Odour Control

The process is fully enclosed and the ammonia rich air is collected and cleaned in a scrubber. The indoor air is protected from ammonia losses because the air from all places were odour can occur like the sludgehopper, the Thermoblender, the Pasteurisation Vessel and the biosolid bunker is pulled to a scrubber. Here almost 100 % of the ammonia is taken care of as an ammonia sulphate product.

In the traditional Orsa method it is more difficult to control ammonia loss because it is a more open process and is important to reduce this loss as much as much as possible. We want as much nitrogen to stay in the Biosolid product as possible an ammonia to the air may cause odour problems.

Experience from the start-up and operation of the plant.

The plant was ready for operation and started in February 1998.
beginning. When a lime with particle size was increased to 3-15mm and an inlet port for the lime was moved upstream in the cooler inlet end of the Thermoblender, the problems disappeared. The biosolid product however, seemed too to be of first quality from day one.

Almost from the first day, the RDP process seemed to work as expected. There were some problems with too wet sludge arriving the plant the first weeks. There were also some problems adjusting the amount of air going into the lime screw. Too much air transported lime dust into the scrubber giving a too high pH in this system. Do to this, the scrubber did not work properly the first 2 month. There was also a problem in the beginning to collect the ammonia rich air in the processing room. After some adjustments and changes, this problem was also solved.

The biggest problem in the beginning was that the fine graded lime had a tendency to stick to the blades in the Thermoblender. Different outlet ports was tried out in the beginning. The RDP Company had all the time recommended a more coarse unslaked lime CaO with particles with larger diameter than used in the lime in the

Investigation of how the process temperature and lime dose effect the Biosolids quality.

After the guarantied capacity was tested out and accepted, it was important too find out how different lime doses and temperatures effects the Biosolids product.

In Norway there are other rules and regulations for stabilised and hygienized Biosolids to be used on farmland. In USA, the unrestricted use of Biosolids defined as the highest quality Grade A is regulated by the USA EPA Rule 503 (4). This rules seems to be more complicated than the Norwegian rules.

Hygienized sludge in Norway is defined as :

1. Fecal coliform : < 2500 per gram dry solids.
2. Salmonella : Shall not be found.
3. Parasite eggs : Shall not be found

If the analysis of samples after treatment meets this requirements (3) then the process and the biosolid product is accepted. The maximum load of Biosolids that can be added to the Norwegian farmland during a 10 years period is 2 tons (in some cases 3 ton) dry solids per 1000 m2. Based on this is, it was important to see how far down we could reduce the dose of lime and if possible the temperature and still have a hygienized sludge after the Norwegian definition.

The RDP company and the Norwegian company Poju R. Stephansen who delivered and installed the system had guarantied that the normal lime dose in the Orsa method could be reduced from 500 kg CaO (50 %) per dry tons solids into the system and down to 300 kg CaO (30 %) pr ton dry solid in the RDP system, a saving of 25 %. The lime dose was therefore reduced even further down too 25 % CaO and lower in controlled steps 5 % CaO at the time. The electrical heating system would try too keep the temperature at a higher level. Also temperatures were tried to be decreased in controlled steps. Samples of the Biosolid product was taken out and analysed.

The results are shown in the table 1 below. The results are sorted after decreasing lime dose.

Table 1 Biosolid content of fecal coliform and Salmonella related to decreasing lime dose and temperature at the RDP system at NJA in Vestfold Norway April and may 1998 (2).

Date	Lime dose kg Cao Wet sludge in %	Ca/drysolid out % Theo-retical	Aver. Temp in Past. Vessel C°	pH	Fecal Coli-form Bact. Per g	Salmonella
15.4-2	8.8	18.3	74.2	12.3	0	Not Found
15.4-3	8.7		73.8	12.4	0	Not Found
21.4-7	7.7	14.5	70.5	11.8	0	Not Found
21.4-6	7.5		72.3	11.8	0	Not Found
22.4-10	6.8		76.8	11.9	0	Not Found
22.4.9	6.6		75.2	11.9	0	Not Found
16.4-4	5.6		71.5	11.8	0	Not Found
27.4-11	4.8		66.2	11.8	0	Not Found
28.4-12	4.1	14.4	65.5	11.3	0	Not Found
5.5-14	3.4	10.3	58.3	11.1	0	Not Found
29.4-13	2.4	9.9	59.2	11.2	0	Not Found

The table shows that no fecal coliform or Salmonella was found even when the lime dose was reduced to 2,4 % CaO related to kg wet sludge going into the treatment system and temperature was as low as 59,2 Cº.

The average dry solids in the incoming sludge was 23,7 %.

Results from full-scale regular operation and lime and energy consumption.

After the investigation presented above, it was decided to operate the temperature at 70 Cº for standard production in spite of the good pathogen removal that was obtained at lower temperatures. The lime dose will normally be set to 5 % CaO to the kg wet sludge going into the plant. This lime dose corresponds to about 22 % CaO to dry solids into the system. This is lower than 30 % guarantied. The stability in the Biosolids product however will be closely watched in the month ahead. So far, we have obtained results for three separate months June, July and August 1998. In June there were still some small problems with to fine grained lime and during June it was changes to 3 to 15 mm. After this the specific energy consumption has been reduced because stops in the Thermoblender increased energy consumption per ton.

Table 2 Average Treatment-parameters per month in the RDP method in the new plantat NJA in Vestfold Norway 1998.

Parameter	Unit	June 98	July 98	Aug.98
Sludge in	% D.S.	23,4	22,7	21,9
Biosolid out	% D.S.			33,2
Treated Sludge in	Tons wet in	227	231	266
Lime added	Tons CaO	12,21	12,71	12,87
Total energy consumption	kwh	18307	16433	17690
Total energy in operation time	kwh	8434	7857	7832
Percent energy in process time	%	46	48	44
Average Pastau. Temp.	C°	69,3	71,5	69
Lime dose CaO/Wet Sludge in	kg %	4,66	5,62	4,87
Lime dose CaO/Dry solid in	%	21,4	25,2	19,5
Calcium Ca add/Dry solid out	%	12,5	14,3	11,7
Specific energy consumption	kwh/kg dry S in	0,161	0,088	0,066

As can be seen the % dry solid content increases from around 22% to approximate 33%. The average lime dose added has variations between 4,66 % to 5,62 % of the wet sludge treated at the plant. This represents from 11,7 % Ca to 14,3 % Ca to dry solid out. This is based on theoretical calculations and the true results are a little less because the CaO is not 100 % pure. Another important discovery is that the total energy consumption is much higher than the energy going to the heating of the sludge. The energy consumption in the processing time is only around from 44 to 46 % of total energy consumption. Some of the reason for this is that the ventilation system runs all the time. This is unnecessary and will be changed. The specific energy consumption in the bottom line of table 2 is based on the total used energy in the operation time when the process is producing Biosolids. The energy used by the ventilation system during night and weekends when the production is shut down are not included.

Operation cost for lime and energy for the RDP system at NJA.

The table 3 below shows the variable costs of lime and heating energy.

Table 3 Average Cost in NOK per month in the new plant at NJA in Vestfold Norway 1998

Parameter	Unit	June 98	July 98	aug.98
Lime added	Tons CaO	12,21	12,71	12,87
Lime cost	1140 NOK/ton	13.919	14.489	14.672
Total energy in operation time	kwh	8434	7857	7832
Energy cost	0,47 NOK/kwh	3964	3693	3681
Treated Sludge in	Tons wet in	227	231	266
Total energi consumption	kwh	18307	16433	17690
Energy cost per ton	NOK/wet ton in	17,5	16	13,8
Lime cost per wet ton in	NOK/wet ton in	61,3	62,7	55,2
Sum lime and energy	NOK/wet ton in	78,8	78,7	69

As seen in table 3 the variable cost of lime and heating energy when only the energy in the processing time is used, has a variation from 69,0 to 78,8 Norwegian crones (NOK) pr wet ton in (22%). The energy cost is around 16 NOK per wet ton.

If the plant had used the traditional Orsa method at 55 º C without preheating, the lime dose required would have been about 580 kg CaO pr dry ton sludge in into the system. This amount of lime based on august 98, consumes 33,7 tons of lime costing 38.000 NOK . This represents 145 NOK / wet ton in.

The RDP system however is operated at 70 º C, but compared to 55 º C in this case still saves 145 – 69 = 76 NOK in operation cost for lime and energy per wet ton sludge coming into the plant. In spite of this, the saving is 52 %. The operation cost in labour maintenance is probably about the same for the two processes. If the RDP process is operated at 70 º C and without electrical heating, the lime dose must be close to 80 %. The cost will then be very high and the saving with electrical heating will be much higher than 52 %.

Conclusions

The following conclusions can be drawn from the full-scale operation of the new RDP Company Sludge/lime Stabilisation process used at NJA in Norway :

1. The process is easy to operate, takes only 45 minutes to become a popular Soilconditioner to the farmers and produces a Stabilised and Hygienized biosolid product class Grade A as defined by EPA USA (4).
2. The process has for a short period been tested out for an even lower lime dose and temperature than the normally recommended lime dose of 30 % CaO and 70 Cº. The lowest lime dose used in the test was 16 % CaO and a temperature of 59 Cº without finding any fecal coli or Salmonella.
3. The cost of operation for lime and electrical energy demonstrates that it is much cheaper to heat the incoming sludge with electric energy rather than with lime alone. Savings in relation to Orsa operated at 55 º C will be around 52 % can be obtained for the sum of lime and electricity cost. The lime content can be reduced to a more balanced lime to dry solid ratio in the Biosolid product.

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