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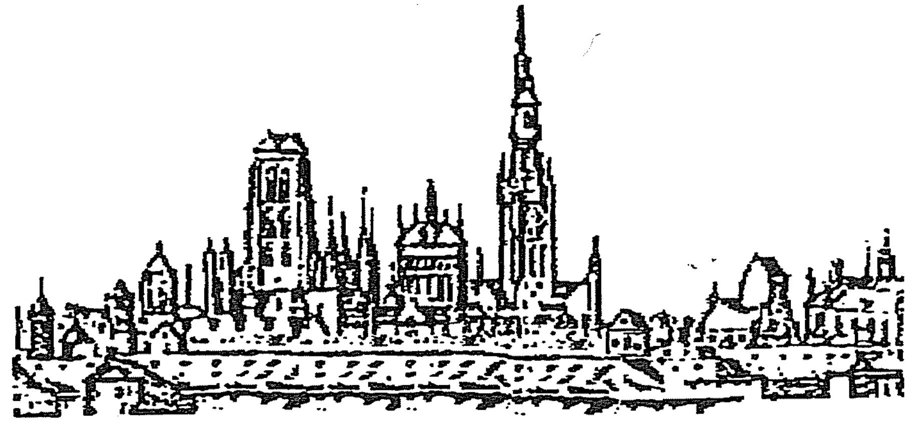

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ANALYSIS AND UTILISATION OF OILY WASTES

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OILY WASTE COMPOSTING

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Large scale composting of oily sludge mixed with horse manure and bark is a good method to reduce the contents of total hydrocarbons in a mixture of oily waste, horse manure and bark. The main mechanism of hydrocarbon reduction is biological transformation, although minor parts of the hydrocarbons volatilize or leak out with rain water. In 250 days a 80% reduction was measured. Larger scale oily waste composting need a careful handling of the compost by aeration, mixing and clumps crushing. The compost still remains a notable amount of hydrocarbons and shall not be used publicly. However it is acceptable to use the compost as a final cover at the landfill for establishing of plants and grass.

Kompostowanie na dużą skalę zaolejonych osadów wraz z nawozem końskim i korą okazało się dobrą metodą redukcji całkowitej zawartości węglowodorów w mieszaninie odpadów olejowych, nawozu końskiego i kory. Głównym mechanizmem zmniejszenia stężenia węglowodorów jest biologiczny rozkład, chociaż niewielka część węglowodorów odparowuje lub wycieka z wodą deszczową. Stwierdzono 80% redukcję stężenia po 250 dniach. Kompostowanie zaolejonych odpadów w większej skali wymaga starannej obróbki kompostu poprzez napowietrzanie, mieszanie i rozgniatanie brył. Kompost zawiera wciąż pewną ilość węglowodorów i nie powinien być używany powszechnie. Jednakże, można z powodzeniem wykorzystać kompost jako wierzchnie pokrycie wysypisk śmieci dla posadzenia roślin i trawy.

Keywords: composting, oily waste, oil, hazardous waste, biological degradation

1. INTRODUCTION

Today about 60% of the oily waste in Sweden is incinerated, but in spite of recycling and energy utilization of oily waste there will always be quantities of waste which have to be treated and get rid of. This kind of waste can occur by accidents as contaminated soil or be found as oily sludge in industrial or workshops water treatment plants or bottom sludge from storage tanks. The possibilities to take care of this kind of waste is, practically, limited to biological treatment and landfilling.

Oily sludge can be 20-80% oil products mixed with water in often stabile emulsions. There is also solid material, normally up to 40%. Sediments from storage tanks often have a important fraction of hydrocarbons with 30-35 carbon atoms. (Jack et al 1980)

Biological methods for oily waste treatment have been used since the first decades of the 20:th century as "landfarming". Even if this technology often have not been so well designed it will illustrate that mineral oil waste is possible will be biologically degraded. (Brown *et al*, 1987, Prantera *et al* 1991; Prado-Jatar *et al* 1993)

Composting as a way for biological treatment of hazardous waste is mentioned in the literature now and then, but seldom described or reported in detail. US army have done full scale tests of composting explosives (Williams *et al* 1990; Ziegenfuss *et al*, 1991) and there are also two reports in Swedish on creosote composting (Seman 1990 and Seman and Rydegren 1991). There are also some reports on oily waste composting (Webb 1990; Danielsen et al 1982) and in Swedish (Carlsson 1992; Eliasson 1992; Carlsson and Mattsson 1993; Bengtsson 1995). Carlsson and Eliasson have used the same kind of oily waste as used in this work.

The literature indicates that composting can be a useable method for biological treatment of oily waste. Under the right circumstances it will be possible to degrade as much as 70-80% of the hydrocarbons measured as TEX[1] in five months. There is no significant decrease of the degradation due to high amount of heavy metals or to a possible synergetic toxic effect of heavy metals and free hydrocarbons.

2. AIM OF THE STUDY

The aim of the study was to answer questions like: Is this possible to compost oily waste in large scale in the cold and windy climate of Sweden? Even if it is possible to compost sewage sludge and household waste, is it possible to compost oily waste in open windrows outdoors during winter time? Can this be done with simple "low-tech" technology, like open piles turned by a front end loading tractor?

3. EXPERIMENTAL

3.1 General

Oily waste like bottom sludge from storage tanks, residues from oil separators, contaminated soil etc have been disposed in ponds at Torsviken Hazardous Waste Landfill. In the ponds the heavy particles are separated as sediments. Water and free oil were withdrawn for further treatment and the oily sediments digged out and disposed in the landfill. These oily sediments was used in the composting tests.

Horse manure mixed with wood chips was taken from stables in the neighborhood. Pine and spruce bark was bought from a sawmill. The bark particles were in size 2-5 cm x 10-20 cm

One compost pile (3x1,5x13 m) and two compost beds (each 2x0,5x12 m) were established at the landfill surface, where the landfill was covered with a mix of clay and gravel of at least 1 meters depth. The compost pile was underlined with sand, gravel and PVC tarpaulin. In this bed a perforated pipe was used as a drainage. The pipe was also possible to use for gas sampling.

Bark, manure and oily sludge were laid out in layers (1:1:1 by volume) about 20 cm high each and were then mixed with the same excavator used for digging out the sludge. The beds were mixed with a Spading mixer.

The three composts were established December 21-22. The first 140 days the composts were covered with a roof in order to protect them from expected snow and heavy rainfall. Neither the pile nor the beds were aerated by forced aeration. Once a month the pile was redigged and the beds were mixed. During this process the aeration took place. The last three months the pile was redigged with a special tool, which also crushed oily clayey clumps in the compost.

After about 150 days 1 m^3 of manure was added to bed 1 in order to study the effect of a extra source of energy in terms of biological activity.

Outdoor max and min temperature and ground temperature as well as the local precipitation was measured every day. (max min Hg thermometer and a garden precipitation meter)

Compost temperatures were measured with a thermo element and instrument (Petronic, $\pm$ 0,1°C). The temperature was measured at a depth of 40 cm at every 1,5 m of pile and beds respectively - 8 measuring points. Normally the temperature was measured every day. After one week the number of measuring points were increased to 16. When at a check it was clear that the temperature was lower at the west side of the composts we started to measure temperature at the east side as well.

When no raise of temperature was recorded after three weeks we began to measure temperature in a pile of pure manure in order to have a reference temperature from a normally easily composted materia. This pile was 3x4x1 meter. After redigging it was 2x3x1,5 meters.

[1] TEX is Total Extractable Hydrocarbons, the method is described under "Experimental".

3.2 Sampling

The solid phase, the compost, was sampled after redigging the compost pile in order to get as homogeneous samples as possible. At every meter a one liter of compost was taken from a depth of 40 cm on the east side of the pile. The samples were mixed to a general sample of about 10 liters size. In order to crush the bigger clumps the general sample was milled in a common household compost mill.

Samples from the bed composts were taken the same way. The first samples were mixed to a common sample for the two composts. After more manure was added to bed 2, the two beds were sampled separately.

The liquid phase, the leachate was sampled as "random" samples. A one liters container was filled in the flow of leachate water and directly transported to the laboratory for the following analyzes: pH value, conductivity, hydrocarbons and heavy metals.

The gas phase was sampled threw the pipe under the pile. A small fan sucked air threw the compost via the pipe. The flow of air was measured by filling up a 200 liters balloon. The air flow was sampled by using a Tenax absorbent tube and a calibrated gas sampling pump.

The CO_2 content in the compost was measured with Dräger pump and tube in a specially designed 40 cm sond. After the sond was put into the compost 200 ml gas was pumped out and after that the registration tube was attached.

3.3 Analysis

A sample of compost was mixed with water to slurry - compost/water ratio of 0,21-0,32. After settling **pH-value** was measured with a portable HANNA-instruments pHe_p+. Once a pH indicator paper was used. **Conductivity** was measured in the settled slurry with a portable HANNA-instruments, Dist 4 ATC.

Heavy metals were done after Swedish Standard SS 02 81 50 in a flame ionization spectrophotometer (Perkin Elmer) after extraction in HNO_3 during 3 hours heating. The absorption was converted via calibration curves (TK, 1988). The detection limit was put as 0,1 mg/l.

To understand the degradation of hydrocarbons **TEX** was measured in solid phase samples after Swedish Standard SS 02 81 45. The extraction was done in 1,1,2-trichloro-1,2,2-trifluoroethan (TTE). The two liquid phases were separated and the TTE was taped. The residual liquid phase was analyzed in a IR spectrophotometer. The absorbance was converted to "grams of hydrocarbons" via a calibration curve.

The GC analyzes were carried out in a 50 m OV17 column coated with 1 μm methyl-phenyl-silica. The sample was thermically desorbed directly from the Tenax absorbent.

4. RESULTS

There was no or only low activity in the composts the first two months. The temperature in the windrow followed the temperature in a control pile with manure mixed with wood chips. After a second redigging of the windrow day 60 the temperature fall down to +2 °C. After another 20 days the outdoor temperature had raised and the activity developed "the normal way" in the windrows. See figure 1. The record of CO_2 confirms the low activity during the first 160 days and the later increase, see table 1.

The bed composts, however did not show any real activity during the winter and even during the spring and summer the temperature in the beds were very close to the ground temperature. The low activity was confirmed by the CO_2 content, see table. However, this did not mean that there was no microbiological activity in the beds - on the contrary, the decrease of hydrocarbons recorded as TEX was 76.% in bed one and 59.% in bed two after 253 days. The difference depends on a additional amount of manure to bed 1 after 160 days. See figure 2. The remaining amount of hydrocarbons was 22500 mg/kg DS and 37600 mg/kg DS respectively.

Table 1. Carbon dioxide records in windrow, beds and manure

	Windrow	Bed 1	Bed 2	Manure/straw
Day 8	0,7%	-	-	1%
Day 156	0,8%	-	-	2%
Day 199	7,0%	2,5%	0%	6%
Day 219	4,3%	1,0%	0,5%	-

The decrease of hydrocarbons in the windrow was 77%, and the remainings were recorded to 17500 mg TEX/kg DS. In a mixture of bark and manure a initial level of TEX was recorded to 3100 mg TEX/kg DS.

There was no loss of importance regarding hydrocarbons (recorded as TEX) via the leachate water. Less than 0,1% of the decrease of TEX can be explained by leachate. See table 2. Neither the loss of TEX to the gas phase was of great importance. Less, probably much less, than 3% seems to evaporate referring to the record of hydrocarbons in gas sucked threw the windrow.

Table 2. Leachate water quality

	Water flow l/h	pH value	conductivity µs/cm	TEX mg/l	Cd mg/l	Cu mg/l	Ni mg/l	Pb mg/l	Zn mg/l
Day 45-46	0,0	-	-	-	-	-	-	-	-
Day 47	0,4	-	-	-	-	-	-	-	-
Day 48-50	0,1	-	-	-	-	-	-	-	-
Day 55	0,1	7,7	1300	-	-	-	-	-	-
Day 59	0,1	7,9	700	14,4	$< 0,1$	$< 0,1$	$< 0,1$	$< 0,1$	0,13
Day 61	0,4	7,8	1200	-	$< 0,1$	0,12	0,10	$< 0,1$	0,18
Day 73	-	8,2	1600	12,0	$< 0,1$	0,11	$< 0,1$	$< 0,1$	0,14
Day 164	0,4	8,5	480	6,1	-	-	-	-	-
Day 165	0,4	8,5	4600	2,0	-	-	-	-	-

5 DISCUSSION

5.1 A few remarks on sampling and sample preparation

Sampling is difficult in such a inhomogeneous mixture as oily waste compost. There is a need of a great number of samples, which aught to be analyzed separately to give information about the distribution of the amount of oil in the compost and how representative each individual sample is. If, of any reason, a general sample is formed the preparation of the sample must be done with much care. The are always risks of losses of oil threw evaporation, thermal degradation in the shredder etc.

After milling, the general samples were still inhomogeneous, and great care is therefor needed at reduction of the sample size to an amount suitable for the laboratory analysis. If that, of any reason is impossible, a number of parallel samples could be analyzed and the results could than be interpreted by help of statistics.

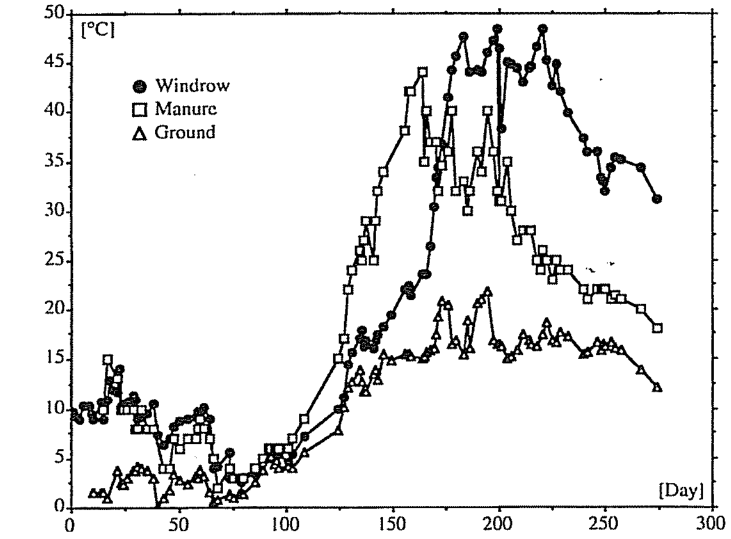

Figure 1 Temperature in windrow and manure/straw mix

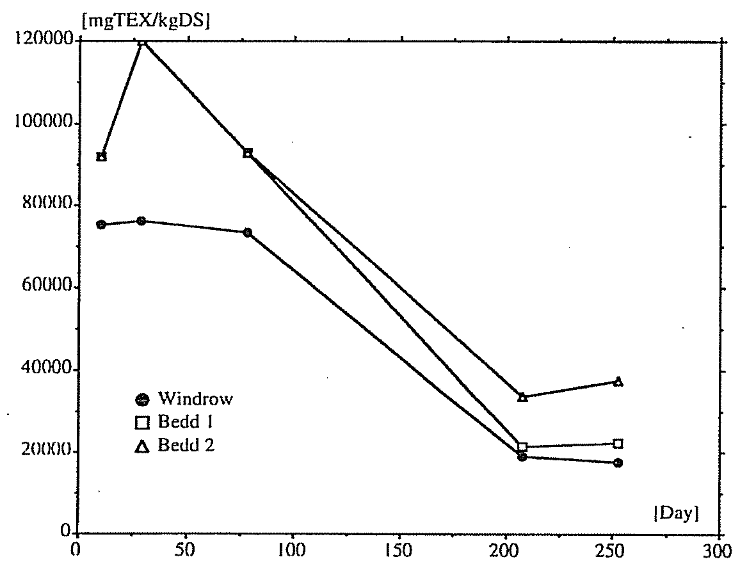

Figure 2 Hydrocarbons as TEX in windrow and two bed composts

5.2 Comments to the composting techniques

There i a possibility to reach higher temperatures if needed. According to Eliasson (1992) in Fröling (1996) tests done in large scale in the Stenungsund composting plant indicates a possibility of 70-80% reduction of TEX in eleven weeks. The beds and windrow used in this test, however, were small and badly located close to the sea, open for storms and wind. A better location in shelter under roof helps to speed up the process.

No essential reduction of hydrocarbons where measured during winter, nor any temperature increase in the compost beds. The temperature in the surroundings and the compost need to reach about 10 °C for the biological process to start. For use in Sweden and in similar climate winter temperature and wind limits the usability of this method. However, in higher windrows in the right location the composting can be carried out during the winter.

Good mixing and aeration makes the degradation go faster if the turning does not mean that the compost will be cold. However, if the compost have a low activity or no at all during the winter, the reduction rate of hydrocarbons will increase in the spring, when the temperature raise. Data shows that at least 10 °C is a need for a controlled process.

There was a normal loss of nitrogen observed in the windrow and bed one, but in bed two there was no significant change of the nitrogen content. The record of phosphorus in the composts shows a remarkable decrease in the windrow (> 90%) and a reduction of about 60% in the beds. This phosphorus reduction can not be explained by a loss to water or gas phase, but much more as a result of analyses techniques. During the composting process phosphorus will be harder bound to the solid phase and is therefor no longer detectable with standard methods.

Composting is a good method for stabilizing and reducing the hydrocarbon content of oily wastes. The compost still contain a notable amount of hydrocarbons, why the compost should not anywhere but on the landfill The compost can be used as a upper cover at the landfill, where plants and grass can be established.

Composting is good for minor amounts of oily wastes and small scale treatment, but could also be implemented in middle scale systems. In bigger systems, however, the need of land for the composts can put the limits for implementation

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