OIL SPILL WASTE TREATMENT IN THE KYMENLAAKSO REGION AFTER A SHIP ACCIDENT

Mari Hupponen
Mika Horttanainen
Mika Luoranen
Lappeenranta University of Technology, Finland

ABSTRACT

The significance of the Gulf of Finland, which is part of the Baltic Sea, as an oil transport route has increased rapidly in recent years. Approximately 140 million tons of oil was transported through the Gulf of Finland in the year 2006. The amount of transport has doubled in a few years. At the same time, the accident risk has increased. The narrowness and the fragmented coastline make the Gulf of Finland extremely vulnerable in an oil spill situation.

There is as yet no comprehensive plan in Finland for how to treat oil spill waste after a large-scale accident. The aim of this study was to find out treatment methods and capacities in the Kymenlaakso region for the oily waste collected from the coastline after a large oil accident in the Gulf of Finland.

This study presents the principles of the treatment methods of oil spill waste and the limitations of the methods in handling the waste. The article also includes a background study of the treatment of wastes collected from the coastline from previous major oil accidents.

The possibilities of different companies to treat oily waste in the Kymenlaakso region were studied. Detailed information was collected by interviewing the companies' workers. 19 000 t of crushable oily equipment and organic matter mixed with normal solid fuels can be burned annually in the fluidized bed furnaces of regional power plants. 1 200 t of homogenized oily organic matter can be burned annually in the rotary kiln of a factory which produces expanded clay (LECA). The region's burning capacity will increase when the municipal solid waste incineration plant that was under construction during the study is ready and the oil spill waste can be burned on its grate. Oily soil can be treated with composting, washing, soil vapour extraction and stabilization with bitumen. Mobile treatment plants suitable for oily waste, such as thermal desorption plants, can also be transported to the region.

KEYWORDS

Oil accident; Oil spill; Oil spill waste; Oily waste treatment.

1 INTRODUCTION

The Gulf of Finland has managed to avoid large oil spills. The risk of oil spill has increased because the amount of oil transport and the other traffic has risen and the ship size has grown.

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In the Baltic Sea, fewer accidents have happened than on average in the world, compared to the amount of traffic [1]. A large oil spill can cause pollution of varying degrees to the whole shoreline of the Gulf of Finland [2]. The latest serious spill in the Gulf of Finland happened in 1987 when the tanker Antonio Gramsci grounded [3].

After an oil accident, the transport, segregation and treatment of the oil spill waste will be a huge challenge, in terms of the nature of the waste and often because of the large quantity. Inadequate plans make the management of large volumes of waste difficult and slow, and may lead to additional harm for the nature and people.

In this article we present the results of a study [4] concerning the different treatment methods of waste from a large oil accident and the treatment possibilities in the Kymenlaakso region (see *Figure 1*). The study was carried out in the project Oil Spill Waste Treatment (OSWAT).

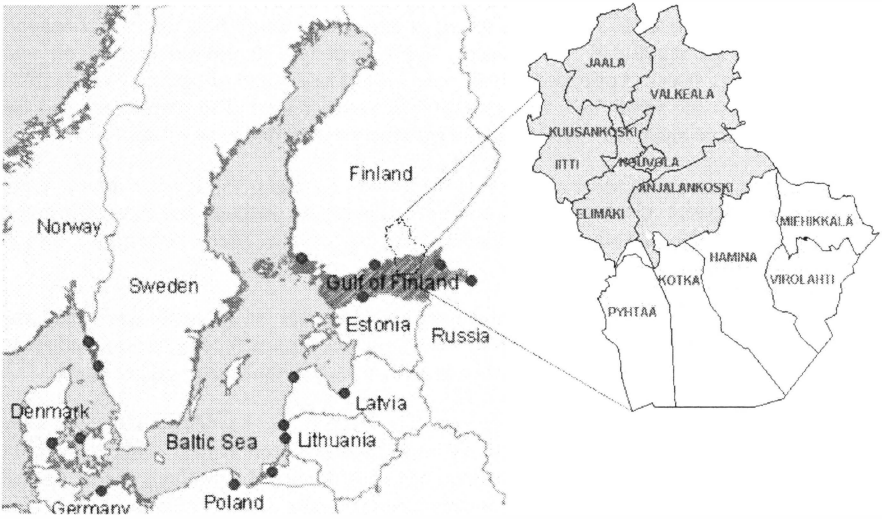

Figure 1. The Kymenlaakso region and the most important oil terminals in the Baltic Sea [5, 6].

1.1 Waste treatment after previous oil accidents

Oily waste collected from the coastline is always case-specific. The amount and quality of waste is influenced for example by the quality of the oil, oil spill prevention, type of shoreline and collection methods. Historical data shows that oil spills can produce more waste than the volume of oil originally spilt (see *Table 1*). The table also shows the treatment methods that were used in the oil accidents.

Table 1. Oil spill waste treatment methods in oil accidents.

Ship	Year	Oil quality	Oil to sea [t]	Oil spill waste from the coastline [t]	Treatment method
Antonio Gramsci	1979	crude oil	5 500	500-650 (from Åland)	• Incineration on the coastline • Incineration at the Kokkola Mill of Outokumpu Oy
Antonio Gramsci	1987	crude oil	570	38	• General principle was treatment at Ekokem hazardous waste treatment plant in Riihimäki
Exxon Valdez	1989	crude oil	40 000	25 000 (1st year)	• Natural biodegradation (in situ) • Chemical cleaning (in situ) • Incineration with small incinerators • Landfill disposal
Nakhodka	1997	heavy fuel oil	6 200	50 000	• Treatment mainly in incineration plants • Burial at beach margins • Industrial landfill disposal
Erika	1999	heavy fuel oil	20 000	270 000	• Building a suitable waste treatment facility for the oily waste • Incineration in a household refuse incineration plant • Recycling of scrap iron • Use of clay sediment as raw material in cement factories
Volgonef t 248	1999	heavy fuel oil	1 600	5 500	• Incineration • Landfill disposal
Prestige	2002	heavy fuel oil	63 000	115 000	• Treatment in a hazardous waste treatment plant • Incineration in different incineration plants • Oily seaweed treatment on the beach • Making of bricks

2 TREATMENT METHODS OF OIL SPILL WASTE

Oily waste is collected mechanically in areas that are heavily polluted and where the facilities for mechanical collection can be used. Mechanical collection is cheaper than collecting by hand. Manual collection has to be used often, because the coastline geography is too difficult for machines. [7] The army and voluntary groups like WWF (World Wide Fund for Nature) Finland oil brigades can help in manual collection. Oily waste is collected by hand in buckets protected with plastic bags. The plastic bags are carried to a bigger container, which is also protected with plastic bags. The containers are transported to an intermediate storage area [8].

The oil spill waste can be separated into different fractions to find the suitable treatment methods (see *Table 2*):

- Oil & seawater (not included in the study)
- Oil & soil (gravel, sand, clay etc.)

- Oil & organic debris (driftwood, reeds, shrubs, peat etc.)
- Oil & equipment (disposable overalls, plastic bags, oil mats etc.)
- Dead animals.

Table 2. Treatment methods that are technically possible for oil spill waste.

Treatment method	Oil & soil	Oil & organic debris	Oil & equipment	Dead animals
Stabilization with bitumen	+	+/-	-	-
Stabilization with cement	+/-	+/-	-	-
Washing	+	+/-	+/-	-
Bioremediation	+	+	-	-
Natural biodegradation	+	-	-	-
Incineration on the beach	-	+	-	-
Incineration in a fluidized bed furnace	+/-	+	+	+
Incineration in a grate furnace designed for municipal solid waste	+/-	+	+	+
Thermal desorption in a rotary kiln	+	+	+	+
Soil vapour extraction	+	+/-	-	-

\- → *The method is not suitable for the treatment of this specific waste.*
+/- → *There can be small amounts of the waste mixed with other suitable waste.*
\+ → *The method is suitable for the treatment of this specific waste.*

2.1 Stabilization with bitumen and cement

Stabilization reduces the environmental risk of waste but it does not eliminate the risk [9]. Stabilization is a fast treatment method, but it can take up to five months to test the suitable mixtures for the stabilization process [10, 11]. After the test, the waste is homogenized and the matter goes forward to the mixing process where binders and additives are added into the waste. After this the waste is ready for disposal. In stabilization with cement the oily soil is mixed with cement, water and additives so that the waste takes a form of mass that hardens and prevents the oil from leaching [10]. The applicability of inorganic binders for non-volatile oily waste is poor. In stabilization with organic bitumen the oily soil is mixed with bitumen that encapsulates the oil [10]. Bitumen suits well for heavy oils and poorly for other non-volatile oils. The suitability has to be estimated case-specifically. [11] The treatment method is suitable for mechanically collected oily soils when the oil content is below the hazardous waste boundary value (the indicative boundary value is 10 000 mg/kg) [12].

2.2 Washing

The washing process can be used on site or off site to treat soil polluted by oil. In the process the oily soil is mixed with water and the mixture is passed through for example sieves, mixing blades and water sprays. The fine matter (clay, silt) is separated from the coarser soil (sand, gravel) during the process. The contaminated water generated in the washing process is treated with a water treatment device. [11] A smaller volume of soil (fine particles) that contains the main part of the oil can be further treated or disposed. The clean coarser soil can usually be used practically. [13] The treatment method is suitable for mechanically collected oily soils when the oil content is max. 20 000-50 000 mg/kg, the outdoor temperature is over 0°C, and the concentration of fine matters is below 20-30% [14].

2.3 Bioremediation

Bioremediation uses micro-organisms to degrade the organic contaminant in waste. Bioremediation methods include for example windrow composting, bioreactor composting and land farming. Light oils are easily biodegradable, but the developed gases need to be treated. Thus the treatment has to happen in a closed space. Medium heavy oils suit well for composting. Heavy oils are poorly or weakly biodegradable, and need to be treated in optimal conditions. [11]

Windrow composting is the most commonly used composting technique in Finland [10]. The oily soil is mixed for example with wood chips and laid out in windrows in the open air. The windrows are aerated mechanically or/and by turning the windrows. [15] The treatment method is suitable for mechanically collected oily soils when the oil content is max. 20 000 mg/kg. Then the handling time is approximately 1-3 years in Finland's climate. [16] It was concluded in the study that the maximum oil content is 20 000 mg/kg because of the long handling time and for economical reasons.

Bioreactor composting is more effective in decreasing the detrimental organic elements than windrow composting. The composting takes place in a closed space. Thus, the process conditions (temperature, oxygen content, and humidity) and emissions are easier to control than in other biological processes. That is why the oil content can be even 10%. Composting with a bioreactor is approximately six times faster than with windrow composting. [10] The treatment method is suitable for mechanically collected oily soils.Land farming is quite a simple method, but the results are not as good as with windrow and bioreactor composting. There is no control of the biodegrading circumstances and the handling time is long. The detrimental elements remain in the ground. [10] The oily waste is laid out in windrows in the open air and mixed with the top layer of the ground. The ground is turned and nutrient is added to the area. The turnings continue far into autumn. [17] Earlier, oil refineries have especially used land farming in Finland. The use of this method is not recommended anymore [18].

2.4 Natural biodegradation

Natural biodegradation can be used in situ to clean up polluted soil with natural processes. The process requires careful follow-up. The cleaning should be quick enough, so most of the oil has to be collected from the coastline. Finland's cold climate slows down natural biodegradation. Environmental pollution and oil spreading from the coastline are not allowed during the treatment. [10] The oily topsoil of the coastline can be turned around so that the oil does not wash away from the coastline and the oil does not smut animals so easily. The treatment does not fit to coastlines that are in recreational use. Biodegradation can be made more effective by manuring and liming the coastline. [7]

2.5 Incineration on the beach

Small amounts of oily driftwood and waterside vegetation can be burned on the beach if the environmental impacts of transport are great compared to open air incineration. This treatment method requires a permission from the authorities. Simple furnaces should be used if possible, because they have better burning circumstances than bonfires [7].

2.6 Incineration in a fluidized bed furnace

Crushable equipment and organic debris can be combusted in existing power plants equipped with a fluidized bed furnace. The oily waste has to be mixed with normal solid fuels in a

proper way. Pretreatment of the oily waste has to be done, so that the waste does not harm the conveying and supply system of the plant. Small amounts of soil are not harmful, but bigger stones have to be sieved off. There is no limit for the share of oil in the waste material. [19] These plants rarely have experience of the treatment of oily waste. Thus, testing is needed.

2.7 Incineration in the grate of a municipal solid waste incineration plant

Most of the waste incineration plants burning municipal solid waste (MSW) use grate firing technology. The plants can incinerate variable types of waste. The technology does not usually require preliminary treatment of the waste. [20] The waste load is emptied in a bunker. The plant can have a separate silo for the sludge. From the bunker the waste is transferred with a clamp bucket to a feed hopper, from which the waste is fed to the grate. [21] The treatment method is suitable for equipment, organic debris and dead animals. Small amounts of soil are not harmful. The waste can be collected in plastic bags. The calorific intensity of the waste has to be below 16-17 MJ/kg, so that the grate will not get damaged. [22]

2.8 Thermal desorption in a rotary kiln

Thermal desorption can be used on site or off site. The process is carried out in two steps; first volatile compounds are vaporised from the soil by heating and after that the evaporated contaminants are combusted or separated from the gas flow with different flue gas treatment methods. Thermal desorption can be executed in different temperatures (from 90°C to over 1000°C), depending on the purpose of use and structure of the kiln. In low temperatures the physical qualities of the soil stay almost unchanged and the organic debris is undamaged. [11] High temperatures suit hazardous wastes and badly polluted soil. In high temperatures the organic debris burns and the soil melts partly. [13, 23] Low temperatures suit especially oily waste containing a lot of soil. When the volume of the oily debris and equipment grows, high temperatures are favoured. The choice of the method is always case-specific. [21] Thermal desorption is a fast method (the delay time in the rotary kiln is approximately 20 - 60 min.). High moisture content increases the energy requirement and makes the treatment longer. [11] There is no limit to the share of oil in the waste [22, 24, 25, 26].

Mobile thermal desorption plants have been designed for treating polluted soils, but also other waste with a size below 5-10 cm can be treated simultaneously. If the waste is collected in plastic bags, the bags have to be broken before the combustion. [25, 26] In the hazardous waste treatment plant in Riihimäki the waste can be treated without breaking the plastic bags, but the size of the waste should be approximately below 10 cm. [22] A factory which produces expanded clay is suitable for oily organic debris that is crushed below the size 8 mm [24].

2.9 Soil vapour extraction

In soil vapour extraction the waste is loaded in an airproof hall onto a suction pipework [27]. Volatile compounds are taken away from the waste along the pipes and with the help of negative pressure. The sucked air is treated for example with an active carbon filter or catalytic combustion. [10] Soil vapour extraction can be used as a treatment method and as a preliminary treatment method when the rest of the contents are treated with other treatment methods. When the cleaning has passed a certain level, continuing of the treatment is not worthwhile. The method suits especially easily vaporizable compounds, such as soil polluted with petrol. [11] There is no limit for the share of oil in the soil but the oil content influences

the handling time, which is months, and usually soil with high oil content has to be treated further [12].

2.10 Waste drying

Oily waste can be dried to improve its properties for the above-mentioned treatment processes. Usually waste drying is carried out in basins where the water runs off because of gravity and evaporation. [28] If the oily waste is incinerated, lime can be added to it when necessary [29].

3 TREATMENT POSSIBILITIES IN THE KYMENLAAKSO REGION

Oil spill waste treatment possibilities in companies in the Kymenlaakso region were studied to find out the capacities, pretreatment demands and transportation needs for different fractions of the waste in case of a large oil accident. Detailed information was collected by interviewing companies' workers in spring 2007 (see *Table 3*). The focus of the study was to find out whether the treatment of oily waste is technically possible. Therefore, during the interviews attention was not paid to the plants' environmental licenses and possible restrictions concerning the treatment of oily waste.

Table 3. Oil spill waste treatment possibilities in the Kymenlaakso region.

Company	Treatment method	Oil & soil	Oil & org. debris	Oil & equipment	Dead animals	Estimation of capacity [t/a]
Incineration plant of Kotka Energy Ltd in Kotka (under construction)	Incineration in grate	+/-	+/-	+	+	2 500
Power plant of Kotka Energy Ltd in Kotka	Incineration in fluidized bed	+/-	+	+	-	3 000
Power plant of Kymin Voima Oy in Kuusankoski	Incineration in fluidized bed	+/-	+	-	-	0-300
LECA factory of Maxit Oy Ab in Kuusankoski	Incineration in rotary kiln	-	+	-	-	1 200
Stora Enso Publication Paper, Anjala Mill in Anjalankoski	Incineration in fluidized bed	+/-	+	+	-	4 000
Stora Enso Publication Paper, Summa Mill in Hamina	Incineration in fluidized bed	+/-	+	+	+	9 000
Power plant of Vamy Oy in Myllykoski, Anjalankoski	Incineration in fluidized bed	+/-	+/-	+	-	Thousands of tonnes
Ekokem-Palvelu Oy in Anjalankoski (old plant & new plant under construction)	Soil vapour extraction	+	+/-	-	-	License for 5 000 + 8 000*
	Stabilization with bitumen	+	+/-	-	-	License for 20 000** + 17 000
	Composting (new plant)	+	+	+/-	-	License for 8 000*
	Washing	+	+/-	+/-	-	License for 8 000
Kymenlaakson Jäte Oy in Anjalankoski	Windrow composting	+	+/-	-	-	Receives 4 000 t
Salvor Oy in Kotka (under construction)	Soil vapour extraction	+	+/-	+/-	-	License for 50 000***
	Washing	+	+	+/-	-	

\- → *The company does not receive the waste.*
+/- → *The company can receive small amounts of the waste mixed with other suitable waste.*
\+ → *The company receives the waste.*
* → *Includes the composting and soil vapour extraction at the new plant.*
** → *Includes the stabilization and disposal at the old plant.*
*** → *Included all treatment methods of Salvor Oy (Kotka).*

4 CONCLUSIONS

The handling of oil spill waste is possible in the Kymenlaakso region, but there are limitations in the quality and amount of the waste. The waste can be treated also outside the region, for example at the rotary kilns of the hazardous waste treatment plant of Ekokem Oy in Riihimäki. Mobile treatment plants that suit oily waste, such as thermal desorption plants, can also be transported to the region.

Main conclusions:

- Thermal methods for the treatment of polluted soil are suitable for most of the waste materials collected from the coastline. There are a couple of mobile facilities in Finland, but they have to be transferred to the Kymenlaakso region in the case of an accident.
- Existing power plants using fluidized bed combustion technology are willing to treat oil accident waste and their capacity is large, but they do not have experience in treating this kind of waste.
- Stabilization does not clean the waste. Thus, other methods should be primarily favoured.
- Windrow composting and washing suit low oil contents. The content can be very high in the oil accident waste. At the end of the coastline cleaning the content can be lower and the methods can suit it well.
- Soil vapour extraction is not a suitable method if compounds have already evaporated at the sea.
- Incineration of dead animals in a fluidized bed is technically possible, but according to the research it is not a recommended method.

The results can be applied especially in the Kymenlaakso region: by municipalities, the Rescue Department of Kymenlaakso, environmental authorities and the refuse disposal plants of the region. Information about the treatment methods and the limitations concerning the methods can be utilized at national level.

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REFERENCES

[1] Finnish Environment Institute, 2007. Alusonnettomuusriski ja ennakkoturvallisuus. [In Finland's environmental administration www-pages]. Updated March 9, 2007 [retrieved June 7, 2007]. From: http://www.ymparisto.fi/default.asp?node=2900&lan=fi (*in Finnish*)

[2] Jolma K., 2004. Ympäristövahinkojen torjunta tänään - Meriympäristövahinkojen torjunnan tulevaisuuden haasteita. [www-document]. Finnish Environment Institute. Presented September 7, 2004 and April 27, 2004 [retrieved June 7, 2007]. 11 p. From: http://www.wwf.fi/wwf/www/uploads/pdf/Jolma130904.pdf (*in Finnish*)

[3] Hänninen, K., 2002. Suomenlahden meriliikenteen riskitekijät. Esiselvitys. [www-document]. Finnish Funding Agency for Technology and Innovation. Research report BVAL34-021198. Published June 11, 2002 [retrieved June 7, 2007]. 106 p. From: http://www.lvm.fi/www/sivut/dokumentit/liikenne/merenkulku/meririski.pdf (*in Finnish*)

[4] Hupponen, M., 2007. Oil spill waste treatment in the Kymenlaakso region after a ship accident. [In Oil Spill Waste Treatment project www-pages]. Lappeenranta University of Technology. Published May 25, 2007 [retrieved June 4, 2007]. 176 p. + app. 6 p. From: http://www2.et.lut.fi/oswat/news.html (*in Finnish*)

[5] Finnish Environment Institute, 2007. Special features of the Gulf of Finland. [In Finland's environmental administration www-pages]. Updated March 13, 2007 [retrieved June 4, 2007]. From: http://www.ymparisto.fi/default.asp?contentid=226279&lan=EN

[6] Kymenlaakso region, 2007. Kunnat. [In Kymenlaakso region www-pages]. Updated April 6, 2007 [retrieved June 4, 2007]. From: http://www.kymenlaakso.fi/internet.htm?kunnat (*in Finnish*)

[7] Jolma K., 2002. Rantavyöhykkeen öljyntorjuntaopas. Finnish Environment Institute. 35 p. (*in Finnish*)

[8] Lehmuskoski, A., 2006. Öljyntorjuntaopas – Ohjeita öljyyntyneiden rantojen puhdistamiseksi. [www-document]. Report of WWF Finland number 19. Updated 2006 [retrieved June 13, 2007]. 2. edition. 16 p. From: http://www.wwf.fi/wwf/www/uploads/pdf/oljyntorjuntaopas_suomi_2painos.pdf (*in Finnish*)

[9] Sarkkila, J., Mroueh, U., Leino-Forsman, H., 2004. Contaminated soil remediation and quality assurance. [www-document]. Environment Guide 110. Finnish Environment Institute. Published March, 2004 [retrieved June 13, 2007]. 118 p. + app. 13 p. From: http://www.ymparisto.fi/download.asp?contentid=13915&lan=fi (*in Finnish*)

[10] Penttinen, R., 2001. Maaperän ja pohjaveden kunnostus – Yleisimpien menetelmien esittely. [www-document]. The Finnish Environment 227. Finnish Environment Institute. Published August 2001 [retrieved June 11, 2007]. 51 p. From: http://www.ymparisto.fi/download.asp?contentid=12461&lan=fi (*in Finnish*)

[11] Mroueh, U., Vahanne, P., Eskola, P., Pasanen, A., Wahlström, M., Mäkelä, E., Laaksonen, R., 2004. Quality management of contaminated soil remediation project. [www-document]. VTT Research Notes 2245. Published 2004 [retrieved June 11, 2007]. 317 p. + app. 44 p. From: http://www.vtt.fi/inf/pdf/tiedotteet/2004/T2245.pdf (*in Finnish*)

[12] Uimarihuhta, H., 2007. Project engineer, Ekokem-Palvelu Oy, Anjalankoski. Interview by telephone March 14, 2007.

[13] Kantola, T., 2007. Project manager, Ekokem-Palvelu Oy, Riihimäki. Interview by telephone April 5, 2007.

[14] Hurme, O., 2007. Eastern Finland's area manager, Salvor Oy. Interview by telephone March 26, 2007.

[15] Forsbacka, A., 1996. Öljy-yhdisteiden biologinen hajoaminen ja saastuneen maan biosaneeraus. City of Helsinki, Environment Centre's publications 2/96. 50 p. (*in Finnish*)

[16] Aho, E., 2007. Waste management foreman, Kymenlaakson Jäte Oy. Interview by telephone March 5, 2007.

[17] Pasanen, J., 1991. Öljyisen maan ja jätteen mikrobiologinen puhdistus. Publication of Water and Environment Administration – series A 76. National Board of Waters and the Environment. 76 p. (*in Finnish*)

[18] Southwest Finland Regional Environment Centre, 2001. Fortum Oil and Gas Oyj:n Naantalin öljynjalostamolle jätelupa. [In Finland's environmental administration www-pages]. Published January 2, 2001 [retrieved June 12, 2007]. From: http://www.ymparisto.fi/default.asp?contentid=18079&lan=fi (*in Finnish*)

[19] Reponen, P., 2007. Environmental manager, Stora Enso Publication Paper, Anjala Mill in Anjalankoski. Interview by telephone February 26, 2007.

[20] Vesanto, P., 2006. The use of best available techniques (BAT) reference document for waste incineration in Finland, Waste incineration BREF 2006. [www-document]. The Finnish Environment 27/2006. Finnish Environment Institute. Published August, 2006 [retrieved June 13, 2007]. 101 p. From: http://www.ymparisto.fi/download.asp?contentid=54918&lan=FI (*in Finnish*)

[21] Häme Regional Environment Centre, 2006. Decision on the granting of an Environmental license. [www-document]. HAM-2004-Y-443-111, YSO/59/2006. Given April 20, 2006 [retrieved June 13, 2007]. 67 p. From: http://www.ymparisto.fi/download.asp?contentid=49833&lan=fi (*in Finnish*)

[22] Onikki, P., 2007. Project manager, Ekokem Oy Ab, Riihimäki. Interview by telephone April 10, 2007.

[23] Ekokem-Palvelu Oy, 2006. Thermal treatment. [www-document]. Published July, 2006 [retrieved June 13, 2007]. 2 p. From: http://www.ekokem.fi/main/Download.asp?ItemId=11435 (*in Finnish*)

[24] Mukkula, J., 2007. Factory manager, LECA factory of Maxit Oy Ab in Kuusankoski. Interview by telephone April 23, 2007.

[25] Uotila, J., 2007. Technical manager, Savaterra Oy. Interview by telephone February 27, 2007 and e-mail message September 14, 2007.

[26] Naumanen, P., 2007. Plant manager, Niska & Nyyssönen Oy. E-mail message August 13, 2007 and September 11, 2007.

[27] Salvor Oy, 2006. Salvor Oy:n käsittelykeskus pilaantuneille maille ja teollisuuden jätteille - Kotka, Heinsuo – Ympäristövaikutusten (YVA) arviointiselostus. [www-document]. Published 2006 [retrieved June 14, 2007]. 109 p. + app. 12 p. From: http://www.salvor.fi/pdf/Salvor_Heinsuo.pdf (*in Finnish*)

[28] Vahanne, P., Rytkönen, J., 2005. Riskien hallinta ruoppaus- ja läjityshankkeissa. [www-document]. VTT. Sedimenttiasioiden koulutuspäivä February 17, 2005, Finnish Environment Institute [retrieved November 30, 2006]. 16 p. From: http://www.ymparisto.fi/download.asp?contentid=31238&lan=FI (*in Finnish*)

[29] Kilpinen, E., 2006. Sales manager, Nordkalk Oyj Abp, Lohja. Helsinki Fair Centre, Trade fair for professional in the environmental field. Short conversation October 10, 2006.