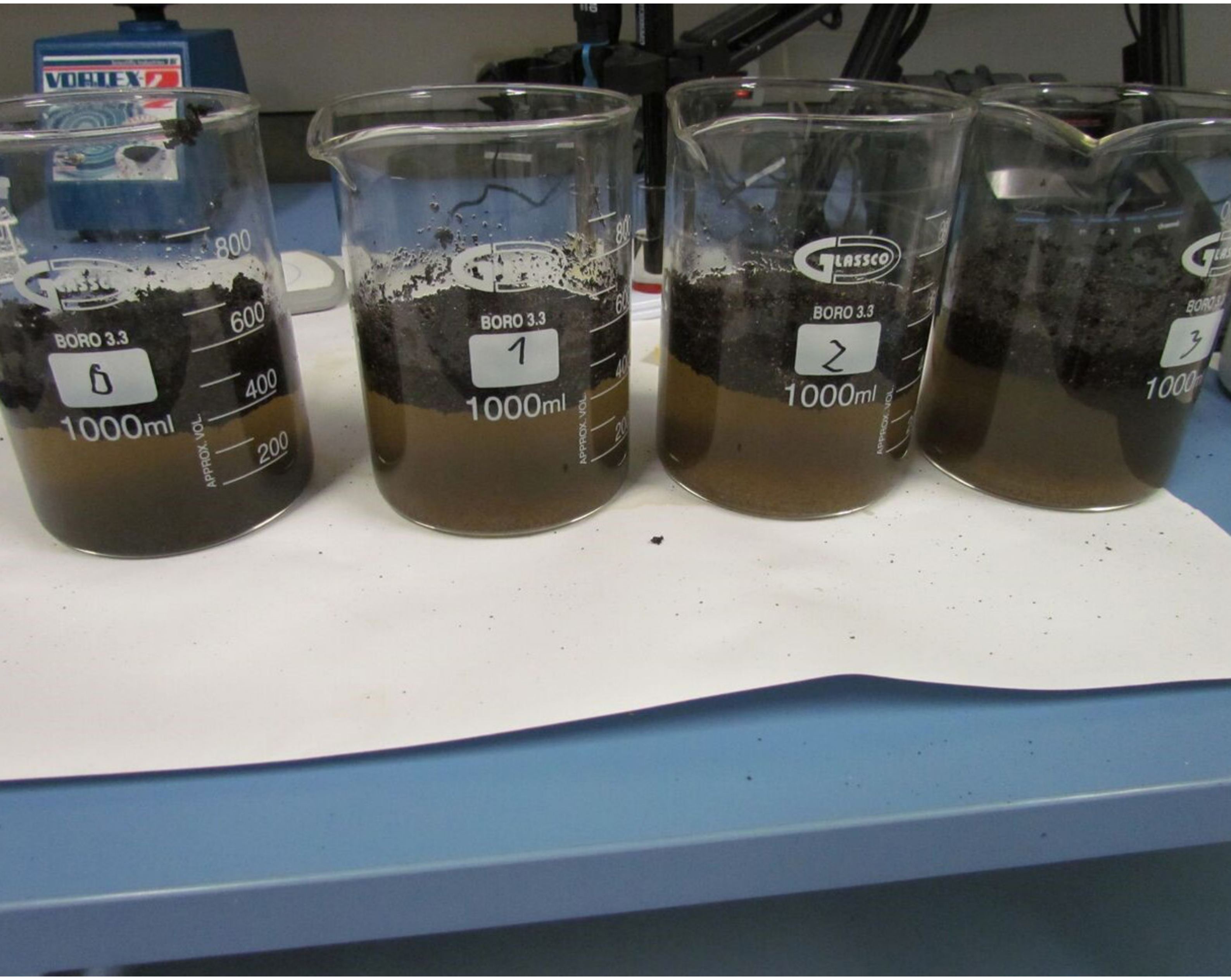
ARBETSRAPPORT 986-2018

Digestion and bleeding of oil from natural absorbents

– A COMPARATIVE STUDY BETWEEN DISSOIL AND ZUGOL

Nedbrytning av olja med hjälp av naturliga absorbenter



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Sammanfattning

I denna rapport har de oljenedbrytande egenskaperna hos DissOil, korkbaserad, och Zugol, bark-baserad jämförts för oljespill på grusväg, moränmark och humusrikt skogsvatten – samtliga testbäddar hämtade från ett avverkningsområde i Sverige.

Vanligt använda hydrauloljor, syntetiska och mineralbaserade, spreds över de fasta testbäddarna som därefter täcktes med DissOil respektive Zugol. Vatten är en katalysator för den mikrobiella nedbrytningen och tillsattes vid starten och sedan var sjunde dag.

Humusrikt skogsvatten blandades med oljorna och därefter med DissOil respektive Zugol. Absorbenterna silades sedan från överskottsvatten.

I DissOil-serien minskade vikten motsvarande de tillsatta oljorna inom 7 dagar från skogsvattnet och inom 14 dagar från grusväg och morän.

I Zugol-serien kunde inga viktminskningar observeras under de 28 dagar som försöket pågick.

Försöken utfördes vid 9 - 12° C, relativ fuktighet på 32 till 36 %.

Blödningstest genomfördes under tryck och trycklösa förhållanden med samma hydrauloljor och med vattenavstötande filterpapper. Trycklösa försök gjordes bara på Dag 7. Försök under tryck motsvarade en person på 90 kg som stod på DissOil respektive Zugol under 30 sekunder och 15 minuter på Dag 0 och 15 minuter på Dag 7.

I DissOil-serien var blödningen 0,05 till 0,09% från oljemättad DissOil under tryck och trycklöst. DissOil-materialet fastnade inte på filterpapperet.

I Zugol-serien var blödningen 0,89 till 1,38% från oljemättad Zugol under tryck och trycklöst. Zugol-materialet fastnade på filterpapperet men borstades bort före vägning.

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Abstract

In this study the oil digesting properties of DissOil, cork-based, and Zugol, bark-based, were compared using gravel from forest road, moraine and humus-rich water as matrices – all collected from a logging site in Sweden. Commonly used hydraulic oils, synthetic and mineral, were sprinkled over the solid matrices and then covered with DissOil and Zugol respectively. Water, being a catalyst for microbial activity, was added to each sample series, at start and every seven days. Humus-rich water was mixed with the oils. DissOil and Zugol respectively were mixed with the emulsion before being drained from surplus water. In the DissOil series oils were digested within 7 days for the liquid matrices and 14 days for the solid matrices. In the Zugol series no conclusive digestion could be observed during 4 weeks of monitoring. Tests were conducted at 9 to 12° C, relative humidity of 32 to 36 %. Bleeding tests were conducted under pressure and pressure-less conditions using the identical hydraulic oils on hydrophobic filter paper. Under pressure-less conditions the bleeding was measured only on Day 7. Pressure conditions were comparable to a 90 kg person standing on DissOil and Zugol respectively for 15 minutes and 30 seconds on Day 0 and 15 minutes on Day 7. In the DissOil series there was a bleeding of 0.05 to 0.09 % from oil-saturated DissOil under pressure and pressure-less conditions. DissOil granules did not adhere to the filter paper. In the Zugol series there was a bleeding of 0. 89 to 1.38 % from oil-saturated Zugol under pressure and pressure-less conditions. Zugol granules adhered to the filter paper but were brushed off before weighing.

Disclaimer

Study was conducted at Spikes & Cogs AB's laboratory, Uppsala, Sweden in January to March 2018 by:

- Spikes & Cogs AB, Johan de Faire
- Konstholmen AB, Tommy Blom
- Skogforsk, Lars Högbom (impartial member)
- BillerudKorsnäs, Per Nordahl (impartial member)

At least one of the impartial members was present at each evaluation event.

Contents

Introduction

Oil spillage is a common problem in forestry all through the logistic chain from harvester, forwarders and trucks at landing sites. Oil absorbents made of bark, minerals and plastic polymers are frequently used for the purpose. Recollection of such absorbents after oil spillage is very cumbersome in forestry environments as structures and textures of soil surfaces make it difficult to recollect everything using recommended tools, i.e. broom, rake and shovel.

Absorbents that cannot be recollected may leak absorbed oils contaminating soil and water as well as sticking to animals that tread on such absorbents. Finding a working material for quick oil absorption and destruction is of importance in order to reduce negative impacts on soil and water.

Therefore, a study was designed to compare a new product concept, called DissOil (under development) to an existing commercial absorbent, called Zugol. Purpose was to evaluate absorption capacity, bleeding under pressure and pressure-less conditions, stickiness and oil digestion properties.

Hypothesis 1: Due to larger surface DissOil has a better absorption capacity than Zugol, weight/weight.

Hypothesis 2: Due to high retention forces of DissOil absorbed oils will be retained even under pressure.

Hypothesis 3: Microbially inoculated DissOil will digest absorbed oils at average forest soil temperature, 9° to 12° C.

Zugol is a FSC certified and frequently used oil absorbent in forestry settings. Zugol is made of bark and claims to have oil-digesting properties by “microorganisms called Propagules” according to the company’s web site (www.zugol.se).

DissOil is based on Black Expanded Cork (BEC). Cork is an abundant natural resource and only rejects from other cork manufacturing is used for BEC/DissOil. The products are 100% organic, i.e. contain no added chemicals, and are carbon dioxide neutral. BEC is certified as oil absorbent on land and at sea with FSC (Chain of Custody), DEKRA (Germany), Cedre (France), USEPA (USA) and Baseefa (UK, ATEX proof). DissOil absorbs about 10 times its own weight, does not leak under pressure and floats on water when saturated. BEC/DissOil is water repellent and only oil is absorbed from emulsions.

Black Expanded Cork, is used as a natural organic carrier for the oil digesting agent, called FADE (Fast Acting Digesting Enzymes), as BEC has an enormous total area – about 4,500 $m^2\ g^{-1}$ – to which FADE strains may adhere in great numbers. FADE, a non-GMO culture, breaks down carbon chains of amongst other mineral, synthetic and vegetable oils into carbon dioxide and water. FADE is a naturally occurring co-existing blend of microbial strains extracted from soil and fermented on organic substrates only. Function of the blend in nature is to break down dead organic matters. Such organic matters comprise of carbon, which is preferred nutrient to the microbes for their proliferation and actions. The microbial agent as such is also used as a probiotic feed additive for farmed animals and dietary supplement for humans.

BEC also contains free carbon that facilitates the establishment of FADE strains once activated. Water is the catalyst for activation and added to BEC-FADE the biological/ biochemical actions start. Once established the microbial strains excrete a cascade of enzymes, i.e. active proteins, that can break down macromolecules of proteins, carbohydrates and lipids, into smaller fragments releasing carbon to the microbes. The more available carbon, the quicker the multiplication of microbes, the more breaking-down actions. When the carbon source is depleted the microbes are deactivated. Mineral, synthetic and vegetables oils are such easy-accessible carbon chains for the FADE strains to thrive on, i.e. breaking down into smaller and harmless fragments, carbon dioxide and water while consuming free carbon.

Absorbed oils are broken down and the microbial strains also migrate to the soil breaking down oil residues that have penetrated into deeper soil layers – “follow the easy food”. When there is nothing left to digest, the strains are deactivated. What remains is cork, which is a natural organic material that does not constitute a burden to the recipient.

Reason for using weight measurement for establishing oil digestion capacities instead of certified analytical methods, e.g. oil index, was that oil-saturated DissOil also absorbed solvents, e.g. hexane, used for extracting absorbed matters, i.e. oil contents could not be collected for measurement. Attempts were made using centrifugation, 5,000 g for 4 minutes, to collect the liquid phase of DissOil-hexane but the liquid was re-absorbed before it could be collected. These tests were conducted at ALcontrol, Linköping, Sweden.

Material and Methods

Table 1. Overview of used materials in the different studies.

	Description	Used in study no
Matrices	Gravel from forest road Österbybruk, Uppland, Sweden	1, 4, 6
	Moraine from top layer of soil Österbybruk, Uppland, Sweden	1, 4, 6
	Humus-rich water collected from an active logging site at Österbybruk, Uppland, Sweden	1, 5, 7
BEC	Black Expanded Cork: Oil absorbent without oil digesting properties	4, 5, 6, 7
Water	Tap water from grid	1, 4, 6
DissOil	Oil digesting absorbent made of BEC and inoculated with FADE, supplied by Spikes & Cogs, Stockholm, Sweden	2, 3, 4, 5
Zugol	Oil digesting absorbent made of bark from conifers, from Zugol AB, Falun, Sweden	2, 3, 4, 8, 9
Hydraulic oil, synthetic	Lukoil Geyser Bio M 46, Lot#: 41672	3, 4, 5, 8, 9
Hydraulic oil, mineral	Lukoil Geyser LT 46, Lot#: 44475	6, 7, 8, 9
Drying cupboard	Heraeus Instrument, GreenLine	1, 2
Balance	Kern PFB, 1200 g, d. 0.01 g	1, 2, 3, 4, 5, 6, 7, 8, 9
	Radwag XA 82/220/2X, 82 g, d. 0.01 mg	8, 9
Pressure device	Cylinder with flat circle-end, 40 cm^2, and weight, 7.14 kg	8, 9
Miscellaneous	Teflon coated plates	1, 2, 3, 4, 5, 6, 7, 8, 9
	Munktell Glass fibre MGA, diameter 90 mm, water retention 1.6 µl/filter disk	8, 9
	Utensils used were made of glass, porcelain and plastic.	Throughout

STUDY DESIGN

Gravel from surface of a forest road, moraine from top layer of soil and humus-rich water from a stream were collected from an active logging site at Österbybruk, Uppland, Sweden.

Study 1 – Moisture contents of solid matrices

100 g of each matrix were dried at 80° C and weights were noted every day until stable for one day.

Study 2 – Moisture contents of DissOil and Zugol

25 g of each absorbent were dried at 60° C and weights were noted every three days until stable for three days.

Study 3 – Absorption capacity

10 g of synthetic hydraulic oil were put on teflon plates and 5 g of DissOil and 10 g of Zugol were spread over the oil. After 30 minutes the surplus of absorbents was blown away and the weight of saturated matrices was noted. Fivefold samples were prepared as Zugol has a wide particle distribution, i.e. from dust to 1 x 2.5 cm flakes, compared to DissOil, 0.1 to 0.5 mm granules.

Study 4 to 7 – Digestion of oil

Solid matrices were formed into beds, diameter 9 cm and thickness 2 cm on teflon plates.

DissOil: Four samples of each matrix were prepared per type of hydraulic oil, i.e. synthetic and mineral. One 0-sample with BEC as absorbent, i.e. no digesting property, and three samples with DissOil as absorbent. Weight of gravel from road was in average 150 g and from moraine 110 g.

Zugol: Three samples of each matrix were prepared per type of hydraulic oil, i.e. synthetic and mineral. Zugol without digesting property was not available and therefore, no 0-sample could be prepared. Only three samples with Zugol as absorbent were prepared. Weight of gravel from road was in average 150 g and from moraine 110 g.

Ten g of each oil type was added to the matrices and left for 5 minutes before DissOil and Zugol respectively was spread over the beds. 10 g of DissOil and 20 g of Zugol were added as Zugol has about half the absorption capacity of DissOil. See graphs Studies 4 to 7.

Ten g of tap water, was added to each sample before weighing 0-weights on Day 0.

Samples were left at 8 to 12° C, relative humidity 32 to 36 %, for seven days. On Day 7, Day 14, Day 21 and Day 28 the samples were weighed before 10 g of tap water was added to each sample.

Liquid matrix, i.e. humus-rich water: 10 g of each oil type was mixed with 1 litre of the water under stirring. 10 g of DissOil was added and stirred for 30 seconds and 20 g of Zugol was added under stirring for 30 seconds. The samples were left for 15 minutes before drained from water using a sieve until drop-free, about 15 minutes. See graphs Studies 4 to 7. Samples were left at 8 to 12° C, relative humidity 32 to 36%, for seven days on teflon plates. On Day 7, Day 14, Day 21 and Day 28 the samples were weighed before 10 g of tap water was added to each sample.

Study 8 and 9 – Bleeding of oil

BEC: 10 g of each oil type were put on teflon plates and 10 g of BEC were spread over the oil and left to absorb the oil for 15 minutes. Three samples of synthetic hydraulic oil were prepared.

Zugol: 5 g of each oil type was put on teflon plates and 10 g of Zugol was spread over the oil and left to absorb the oil for 15 minutes. Three samples of synthetic hydraulic oil were prepared. Half the weight of oil was used for Zugol samples as the product has half the absorption capacity of DissOil, w/w. This as the test series included bleeding under pressure and to be able to collect comparable data, the identical surface/volume of absorbents was required to be able to apply identical pressure per cm2 of absorbent.

Pressure-less: After 15 minutes a tared filter paper was put under the absorbent and left at 8 to 12° C, relative humidity 32 to 36%, for seven days wrapped up in airtight plastic bags. On Day 7 the filter paper weight was noted.

Under pressure: After 15 minutes a tared filter paper was put on top of the absorbent and a pressure of 0.18 kg/cm2 (7.14 kg on 40 cm2) for 30 seconds was applied and weight of the filter paper was noted. The same filter paper was put on top of the bed and the identical pressure was applied for 15 minutes. The weight of the filter paper was noted and then wrapped in airtight plastic bags. On Day 7 the same filter paper was put on top of the bed and the identical pressure was applied for 15 minutes. The weight of the filter paper was noted. See graphs Studies 8 and 9.

Results

Study 1. Moisture contents of solid matrices

Mean value of moisture content from three samples of Gravel was 14.24 % (dried at 80°C), Table 2. Mean value of moisture content from three samples of Moraine was 22.03 % (dried at 80°C), Table 2.

Table 2. Moisture contents of solid matrices, dried at 80° C.

	Moisture content Day 1, %	Moisture content Day 2, %	Moisture content Day 3, %	Moisture content Mean value Day 3, %
Gravel 1	6.37	14.29	14,30	
Gravel 2	5.58	14.32	14.24	
Gravel 3	6.04	14.18	14.18	14.24
Moarine 1	11.74	22,39	22.38	
Moraine 2	11.16	22,23	22.26	
Moraine 3	14.06	21,45	21.45	22.03

Study 2. Moisture content of DissOil and Zugol

Mean value of moisture content from three samples of DissOil was 0.20% (dried at 60°C), Table 3. Mean value of moisture content from three samples of Zugol was 3.90% (dried at 60°C), Table 3.

Table 3. Moisture content of DissOil and Zugol, dried at 60° C.

	Moisture content Day 1, %	Moisture content Day 6, %	Moisture content Day 9, %	Moisture content Mean value Day 9, %
DissOil 1	0.12	0.24	0.28	
DissOil 2	0.12	0.08	0.12	
DissOil 3	0.28	0.16	0.20	0.20
Zugol 1	3.19	4.31	4.35	
Zugol 2	1.56	2.28	2.28	
Zugol 3	4.70	5.01	5.05	3.90

Study 3. Absorption capacity

Mean value of absorption capacity from five samples of DissOil was 5.97 times its own weight, Table 4. Mean value of moisture content from five samples of Zugol was 2.90 times its own weight, Table 4.

Table 4. Absorption capacity of DissOil and Zugol.

	Oil, g	Absorbent, g	Absorption factor, g oil/g absorbent	Absorption factor Mean value
DissOil 1	10.07	1.62	6.22	
DissOil 2	10.01	2.20	4.55	
DissOil 3	10.09	1.46	6.91	
DissOil 4	10.07	1.55	6.50	
DissOil 5	10.02	1.76	5.69	5.97
Zugol 1	10.02	4.08	2.46	
Zugol 2	10.06	3.99	2.52	
Zugol 3	10.07	4.03	2.50	
Zugol 4	10.03	2.93	3.42	
Zugol 5	10.04	2.78	3.61	2.90

Study 4a
– Digestion of synthetic hydraulic oil using BEC/DissOil on solid matrices

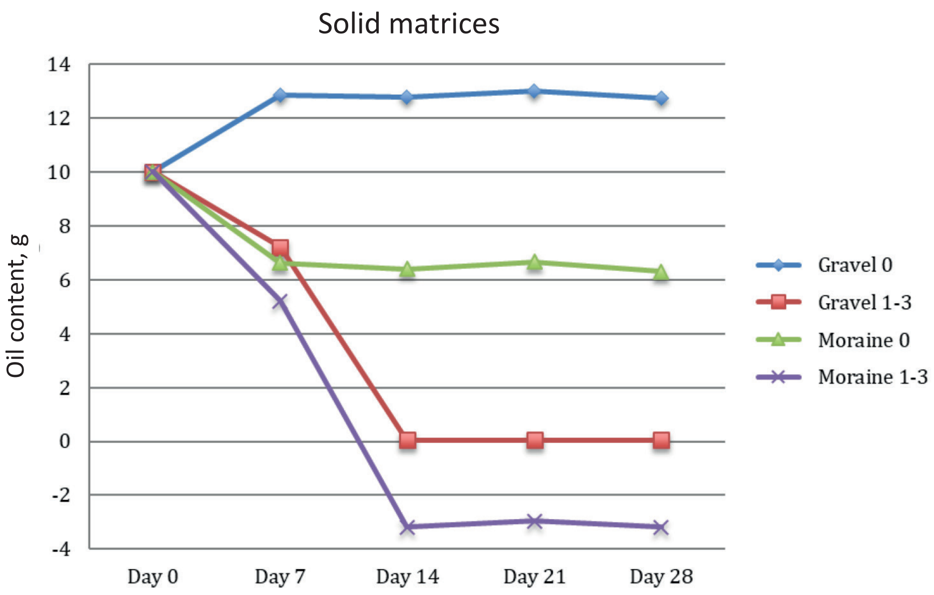

Figure 1. Mean values of oil (synthetic hydraulic oil) weights on Day 0 to 28 in the different matrices using DissOil. Data available in Table 5.

Study 4b
– Digestion of synthetic hydraulic oil using BEC/DissOil on liquid matrix

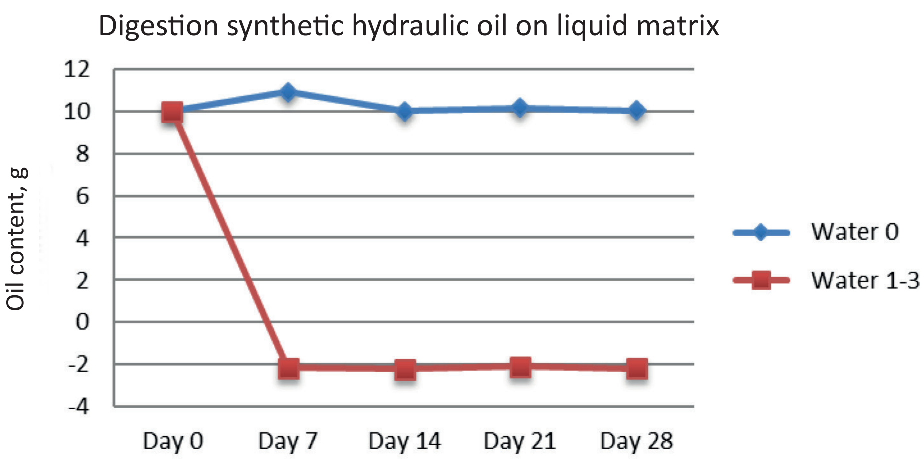

Figure 2. Mean values of oil weights on Day 0 to 28, using DissOil. Data available in Appendix 1, Table 1.

Table 5. Study 4a and 4b. Digestion of synthetic hydraulic oil using BEC and DissOil on three matrices.

	Dry weight of beds[1], g	Day 0[2], g Tot. weight/ Oil weight	Day 7, g Tot. weight/ Oil weight[1]	Day 14, g Tot. weight/ Oil weight[1]	Day 21, g Tot. weight/ Oil weight[1]	Day 28, g Tot. weight/ Oil weight[1]
Gravel 0[3]	154.86	174.86/**10.00**	167.70/**12.84**	167.72/**12.86**	167.85/**12.99**	167.58/**12.72**
Gravel 1	153.77	173.77/**10.00**	160.97/**7.20**	156.00/**2.23**	156.16/**2.39**	155.97/**2.21**
Gravel 2	154.96	174.96/**10.00**	167.78/**12.82**	154.51/**-0.45**	154.67/**-0.29**	154.54/**-0.42**
Gravel 3	154.77	174.77/**10.00**	164.34/**9.57**	153.12/**-1.65**	153.30/**-1.47**	153.12/**-1.65**
Moraine 0[3]	108.95	128.95/**10.00**	115.57/**6.62**	115.61/**6.66**	116.12/**7.17**	115.26/**6.31**
Moraine 1	111.44	131.44/**10.00**	115.80/**4.36**	104.58/**-6.86**	104.76/**-6.68**	104.49/**-6.95**
Moraine 2	110.14	130.14/**10.00**	116.35/**6.21**	109.75/**-0.39**	109.99/**-0.15**	109.73/**-0.41**
Moraine 3	107.81	127.81/**10.00**	112.86/**5.05**	105.52/**-2.29**	105.77/**-2.04**	105.63/**-2.18**
Water 0[3]	20.00	40.34/**10.00**	30.93/**10.93**	30.00/**10.00**	30.16/**10.16**	30.04/**10.04**
Water 1	20.00	42.38/**10.00**	17.84/**-1.16**	17.79/**-1.21**	17.89/**-1.11**	17.80/**-1.20**
Water 2	20.00	41.61/**10.00**	18.96/**-1.04**	18.99/**-1.01**	19.12/**-0.88**	19.08/**-0.92**
Water 3	20.00	42.12/**10.00**	19.09/**-0.91**	19.08/**-0.92**	19.19/**-0.81**	19.13/**-0.87**

[1] Teflon plate + matrix less water content
[2] Solid matrices: Matrix + 10 g BEC/DissOil + 10 g oil
Liquid matrix: 10 g BEC/DissOil + 10 g oil + absorbed water
[3] BEC with no oil digesting property was used for all 0-samples
Oil weight[1]: Including remaining water moisture

Study 5a – Digestion of mineral oil on using BEC/DissOil on solid matrices

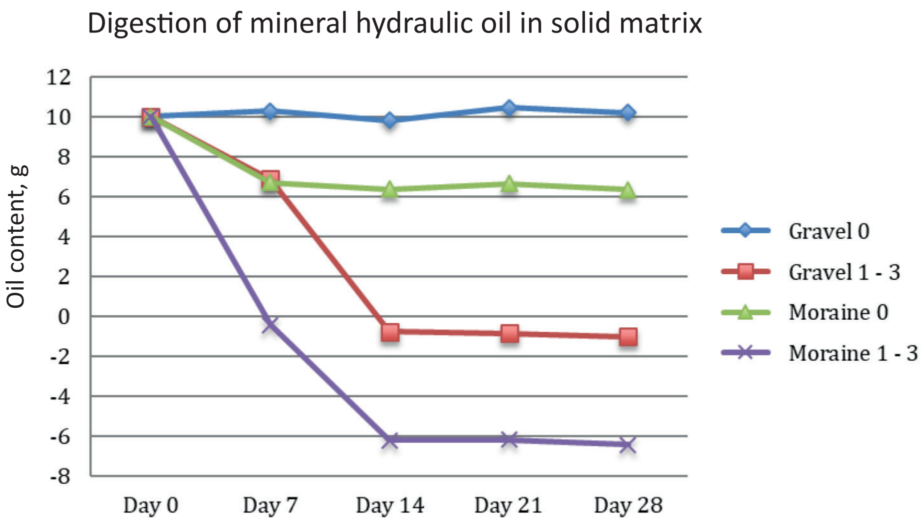

Figure 3. Mean values of oil (mineral oil) weights on Day 0 to 28. Using DissOil. Data available in Table 6.

Study 5b – Digestion of mineral oil using BEC/DissOil on liquid matrix

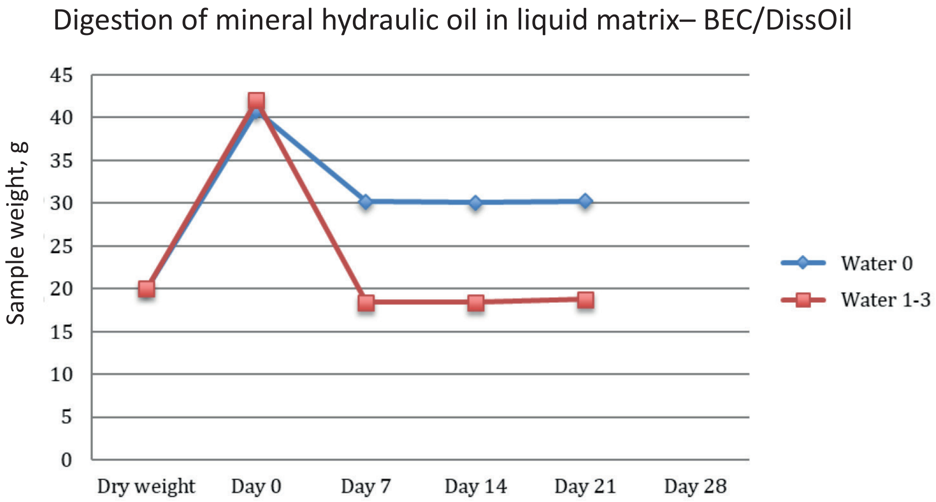

Figure 4. Graphic presentation of Table 5 – Mineral oil on liquid matrix using DissOil. Data available in Table 6.

Table 6. Study 5a and 5b. Digestion of mineral hydraulic oil using BEC and DissOil on three matrices.

	Dry weight of beds[1], g	Day 0[2], g Tot. weight/ Oil weight	Day 7, g Tot. weight/ Oil weight[1]	Day 14, g Tot. weight/ Oil weight[1]	Day 21, g Tot. weight/ Oil weight[1]	Day 28, g Tot. weight/ Oil weight[1]
Gravel 0[3]	155.68	175.68/**10.00**	165.96/**10.28**	165.49/**9.81**	166.12/**10.44**	165.88/**10.20**
Gravel 1	153.95	173.95/**10.00**	164.01/**10.06**	156.29/**2.34**	156.08/**2.13**	155.89/**1.94**
Gravel 2	154.62	174.62/**10.00**	165.32/**10.07**	157.93/3.**31**	158.03/**3.41**	157.90/**3.28**
Gravel 3	155.28	175.28/**10.00**	155.12/**-0.16**	147.33/**-7.95**	147.20/**-8.08**	147.03/**-8.25**
Moraine 0[3]	104.99	124.99/**10.00**	111.68/**6.69**	111.36/**6.37**	111.64/**6.65**	111.33/**6.34**
Moraine 1	109.45	129.85/**10.00**	111.78/**2.33**	105.91/**-3.54**	106.15/**-3.30**	106.00/**-3.45**
Moraine 2	110.18	130.18/**10.00**	101.76/**-8.42**	95.81/**-14.37**	95.40/**-14.78**	95.06/**-15.12**
Moraine 3	108.90	128.90/**10.00**	113.66/**4.76**	108.14/**-0.76**	108.40/**-0.50**	108.20/**-0.70**
Water 0[3]	20.00	40.75/**10.00**	30.19/**10.19**	30.07/**10.07**	30.23/**10.23**	30.12/**10.12**
Water 1	20.00	42.01/**10.00**	17.92/**-2.08**	17.93/**-2.07**	18.02/**-0.98**	17.95/**-2.05**
Water 2	20.00	41.90/**10.00**	18.97/**-1.13**	19.08/**-0.92**	19.21/**-0.79**	19.13/**-0.87**
Water 3	20.00	42.05/**10.00**	18.29/**-1.71**	18.21/**-1.78**	18.34/**-1.66**	18.28/**-1.72**

[1] Teflon plate + matrix less water content
[2] Solid matrices: Matrix + 10 g BEC/DissOil + 10 g oil
Liquid matrix: 10 g BEC/DissOil + 10 g oil + absorbed water
[3] BEC with no oil digesting property was used for all 0-samples
Oil weight[1]: Including remaining water moisture

Study 6. Digestion of synthetic hydraulic oil using Zugol on three matrices

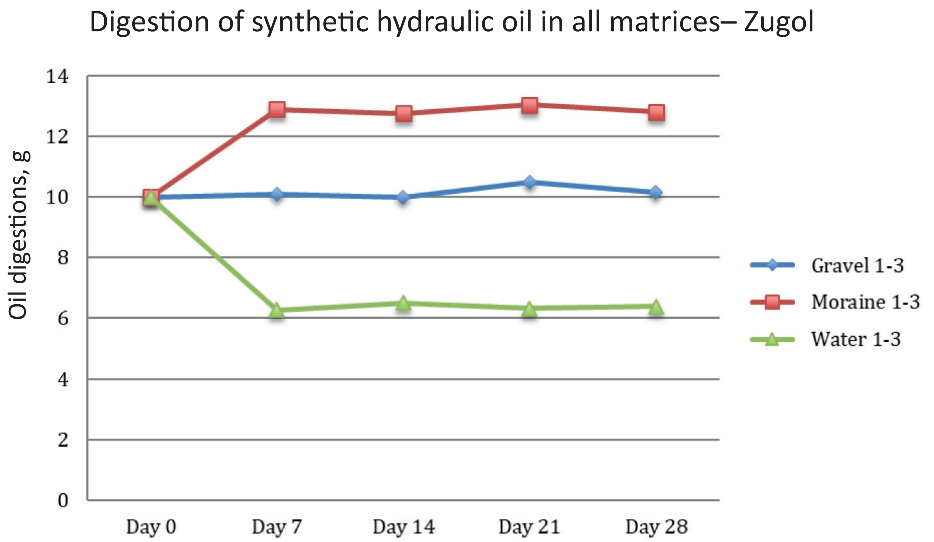

Figure 5. Mean values of oil (synthetic hydraulic oil) weights on Day 0 to 28, using Zugol. Data available in Appendix 1, Table 1.

Study 7. Digestion of mineral hydraulic oil using Zugol on three matrices

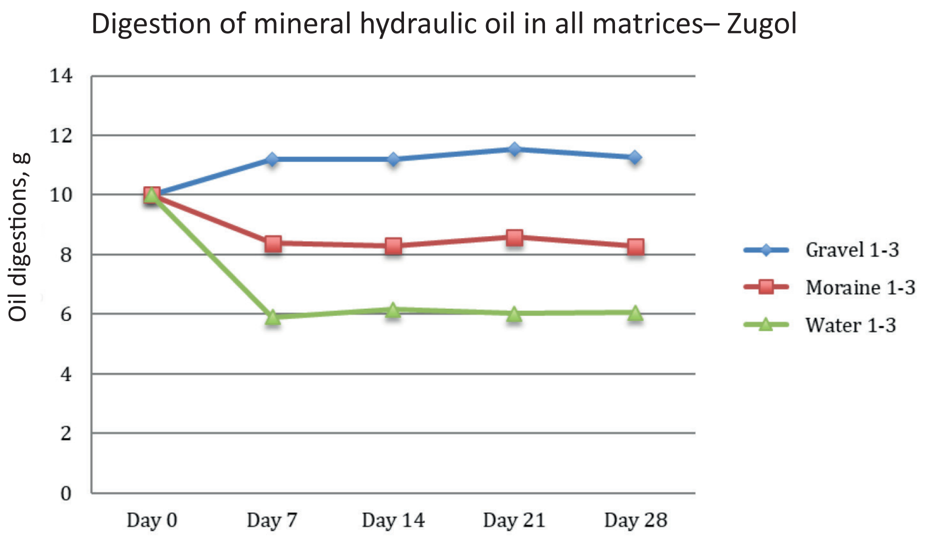

Figure 6. Mean values of oil (synthetic hydraulic oil) weights on Day 0 to 28, using Zugol. Data available in Table 8.

Table 7. Study 6. Digestion of synthetic hydraulic oil using Zugol on three matrices.

	Dry weight of beds[1], g	Day 0[2], g Tot. weight/ Oil weight	Day 7, g Tot. weight/ Oil weight[1]	Day 14, g Tot. weight/ Oil weight[1]	Day 21, g Tot. weight/ Oil weight[1]	Day 28, g Tot. weight/ Oil weight[1]
Gravel 1	155.28	185.28/**10.00**	164.38/**9.10**	164.37/**9.11**	164.69/**9.41**	164.49/**9.21**
Gravel 2	154.42	184.42/**10.00**	164.74/**10.32**	164.62/**10.20**	164.95/**10.53**	164.73/**10.33**
Gravel 3	155.65	185.65/**10.00**	166.49/**10.84**	166.53/**10.88**	166.86/11.**21**	166.63/**10.98**
Moraine 1	109.28	139.28/**10.00**	121.56/**12.28**	121.37/**12.09**	121.67/**12.39**	121.42/**12.14**
Moraine 2	108.70	138.70/**10.00**	121.97/**13.27**	121.72/**13.02**	121.97/**13.27**	121.74/**13.04**
Moraine 3	109.01	139.01/**10.00**	122.13/**13.12**	122.18/**13.17**	122.49/**13.48**	122.25/**13.24**
Water 1	30.00	69.17/**10.00**	36.92/**6.92**	37.18/**7.18**	37.00/**7.00**	37.08/**7.08**
Water 2	30.00	68.12/**10.00**	36.24/**6.24**	36.50/**6.50**	36.30/**6.30**	36.36/**6.36**
Water 3	30.00	67.89/**10.00**	35.62/**5.62**	35.84/**5.84**	35.67/**5.67**	35.71/**5.71**

[1] Teflon plate + matrix less water content
[2] Solid matrices: Matrix + 20 g Zugol + 10 g oil
Liquid matrix: 20 Zugol + 10 g oil + absorbed water
Oil weight[1]: Including remaining water moisture

Table 8. Study 7. Digestion of mineral hydraulic oil using Zugol on three matrices.

	Dry weight of beds[1], g	Day 0[2], g Tot. weight/ Oil weight	Day 7, g Tot. weight/ Oil weight[1]	Day 14, g Tot. weight/ Oil weight[1]	Day 21, g Tot. weight/ Oil weight[1]	Day 28, g Tot. weight/ Oil weight[1]
Gravel 1	156.69	186.59/**10.00**	166.84/**10.15**	166.84/**10.15**	167.15/**10.46**	166.89/**10.20**
Gravel 2	155.48	185.48/**10.00**	168.66/**13.18**	168.59/**13.11**	168.91/**13.43**	168.63/**13.15**
Gravel 3	156.55	186.55/**10.00**	166.78/**10.23**	166.91/**10.36**	167.22/**10.67**	167.02/**10.47**
Moraine 1	109.32	141.15/**10.00**	118.35/**9.03**	118.21/**8.89**	118.50/**9.18**	118.21/**8.89**
Moraine 2	104.79	141.33/**10.00**	112.83/**8.04**	112.64/**7.85**	112.94/**8.15**	112.60/**7.81**
Moraine 3	109.27	141.51/**10.00**	117.34/**8.07**	117.39/**8.12**	117.71/**8.44**	117.42/**8.15**
Water 1	30.00	63.80/**10.00**	34.07/**4.07**	34.34/**4.34**	34.21/**4.21**	34.28/**4.28**
Water 2	30.00	66.82/**10.00**	36.34/**6.34**	36.56/**6.56**	36.38/**6.38**	36.42/**6.42**
Water 3	30.00	67.75/**10.00**	37.30/**7.30**	37.56/**7.56**	37.43/**7.43**	37.46/**7.46**

[1] Teflon plate + matrix less water content
[2] Solid matrices: Matrix + 20 g Zugol + 10 g oil;
Liquid matrix: 20 g Zugol + 10 g oil + absorbed water
Oil weight[1]: Including remaining water moisture

Study 8.
Bleeding of synthetic hydraulic oil from BEC and Zugol, pressure-less

In the DissOil series there was a bleeding of 0.08 % from oil-saturated DissOil under pressure-less conditions after seven days. Under pressure the bleeding on Day 0 was 0.05 % after 30 seconds and 0.09 % after 15 minutes and 0.09 % on Day 7 after 15 minutes under pressure. DissOil granules did not adhere to the filter paper (Table 9 and 10).

In the Zugol series there was a bleeding of 1.21 % from oil-saturated Zugol under pressure-less conditions after seven days. Under pressure the bleeding on Day 0 was 1.17 % after 30 seconds and 1.38 % after 15 minutes and 0.89 % on Day 7 after 15 minutes under pressure. Zugol granules adhered to the filter paper but were brushed off before weighing (Table 9 and 10).

Table 9. Study 8. Bleeding of synthetic hydraulic oil from BEC and Zugol, pressure-less.

	Oil, g	Absorbent, g	Tare filter paper, mg	Weight filter paper Day 7, mg
BEC 1	10.07	5.04	504	509
BEC 2	10.22	5.13	489	497
BEC 3	10.13	4.99	501	511
Zugol 1	10.08	9.98	491	568
Zugol 2	10.02	10.06	496	572
Zugol 3	10.07	10.05	473	596
Zugol 4	5.12	10.01	490	522
Zugol 5	5.03	10.00	482	517
Zugol 6	4.99	10.02	486	518

Study 9.
Bleeding of mineral hydraulic oil from BEC and Zugol, under pressure

Table 10. Study 9. Bleeding of synthetic hydraulic oil from BEC and Zugol, under pressure.

	Oil, g	Absorbent, g	Tare filter paper, mg	Weight filter paper Day 0 30 sec, mg	Weight filter paper Day 0 15 min, mg	Weight filter paper Day 7 15 min, mg
BEC 1	10.24	5.00	502	505	512	510
BEC 2	10.13	4.99	501	511	511	511
BEC 3	9.99	5.08	494	496	502	500
Zugol 1	10.22	10.03	482	612	812	810
Zugol 2	10.19	10.06	491	610	648	648
Zugol 3	10.12	10.05	473	678	683	681
Zugol 4	5.15	10.00	492	556	567	570
Zugol 5	5.00	10.01	491	548	557	556
Zugol 6	5.31	10.04	491	551	564	568

Discussion

Hypotheses were confirmed:

1. DissOil has twice the absorption capacity compared to Zugol, weight absorbent : weight oil;
2. There is no to extremely little bleeding of oils from DissOil under pressure and pressure-less conditions;
3. DissOil is able to digest all absorbed oil at low temperature.

Possible oil residuals of DissOil could not be analytically confirmed at termination of digestion tests due to lack of certified methods for the purpose, as described above. Subjectively, no traces of remaining oil could be detected by touch, smell or oil-on-water after keeping DissOil under water for 2 hours.

Studies 4 and 5 show weight reductions below the weight of added oil. Likely reason for this is that organic contents of the matrices have been enzymatically digested into water and oxygen and evaporated.

DissOil was found purposeful and useful as an effective absorbent and digester of oils solid and liquid matrices and without bleeding or stickiness when oil-saturated.

Zugol did not show any conclusive digestion properties of absorbed oils on solid or liquid matrices. Bleeding and stickiness were observed.

DissOil that cannot be recollected after an oil spill, constitute no to very little negative environmental risk to flora and fauna as oil residues be broken down into non-hazardous residues without bleeding. Oil-saturated DissOil at sea/water will not stick to seabirds, fish or plants and thus reducing suffering, death as well as costs for oil recovery and remediation.

According to Swedish Standard SS155434, section 4.3.4.1, biodegradable oils shall be digested up to 70% in 28 days at 25°C. Lukoil Geyser Bio M 46, approved by RISE/SP as biodegradable, did not show any significant oil reduction in this experimental setting on solid matrices, i.e. 0-samples, at 9 to 12°C, which is assessed to be a more relevant temperature span in real-life situations than 25°C.

Literature

BEC/CorkSorb: http://www.spillkontroll.se Zugol: https://www.zugol.se

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https://www.researchgate.net/profile/O_Otitoju_Olawale/publication/27794350_Crude_Oils_Spills_in_the_Environment_Effects_and_Some_Innovative_CleanUp_Biotechnologies/links/00b7d53aaa9fb37c93000000.pdf

Collecting matrix from forest road.

Collecting moraine matrix.

Collecting matrix from humus-rich water.