CANINE SCENT DETECTION IN USE OF LOCATING CONTAMINATED SITES IN FINNISH DEFENCE FORCES

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INTRODUCTION

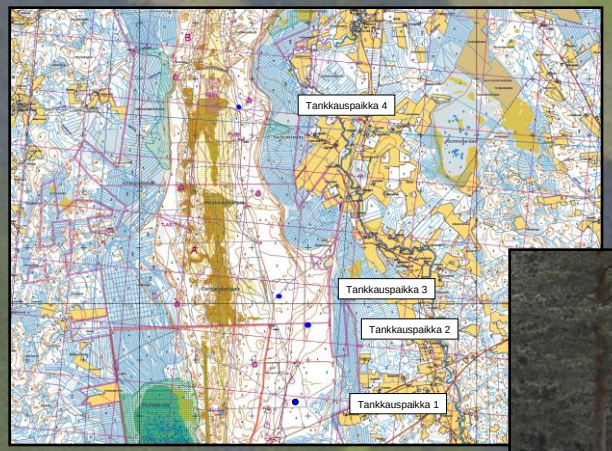
- Military exercise regions are wide and they are often located on groundwater areas.
- Equipment using oil compounds are widely used which makes it challenging for environmental monitoring, soil and groundwater protection.
- The Environmental Protection Act obligates the operator to be aware of the environmental impacts the training is causing or may cause.
- The threshold value for hydrocarbon fractions (<C10 - C40) in Finland is 300 mg/kg.
- The Governments Decree (214/2007) clarifies that contamination and remediation assessment has to be done, if one or more substance concentrations exceed the threshold value.
- Artillery Brigade uses the ISO 14001 certificated Environmental System since 2009

INTRODUCTION

- In this field study a GPS-dog (Gasoline and Pollution Search Dog) was used for assistance of environmental monitoring
- GPS-dog was trained with a cocktail made from diesel fuel, gasoline, fuel oil, motor oil and paraffin/kerosene
- GPS-dog's mode of expression for hydrocarbons was lying down at the target point

FIELD STUDY

- Military training groups marked and reported the off-road refuelling and emplacement sites with GPS-coordinates and maps during the military exercise



GPS-cordinates:

E7960 N7830
E7805 N6090
E8100 N5070

FIELD STUDY

- After the exercise the pointed locations were inspected using a GPS-dog
- GPS-dog pointed out the contaminated sites
- GPS-dog was also used after environmental deviations for example caused by working vehicles at the construction site

FIELD STUDY

- Soil samples were taken from the spots pointed out by the GPS-dog and analyzed with a field analyzer PetroFLAG to find out the concentration of the contaminated soil.

CANINE SCENT DETECTION

- When sniffing for olfactory purposes the mobile part of the nose is moved and the shape of the nostrils is altered
- Air entering the nostril is diverted dorsally, medially, and ventrally around the obstructing alar fold, with a resultant increase in velocity and evaporative effect

Finnish Food Safety Authority, EVIRA

Kankaanpään valokuvaamo

CANINE SCENT DETECTION

- The right and the left nasal chambers are filled with fine scrolls of bone called turbinates or conchae
- When a dog deliberately wants to sample the environment, the nostrils are dilated, and with a forced inspiration the dog sniffs the air. This act provides a greater volume of inspired air, which takes a more dorsal course around the ethmoturbinates, where the olfactory receptors are most numerous.
- The mucous epithelium covering the turbinates has a rich supply of sensory nerve endings that are responsive to smell
- The paired vomeronasal organ, Jacobson`s organ, is located in the rostral base of the nasal septum as a tubular pocket of olfactory epithelium partially enclosed by a scroll of cartilage.

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FIELD ANALYZER RESULTS

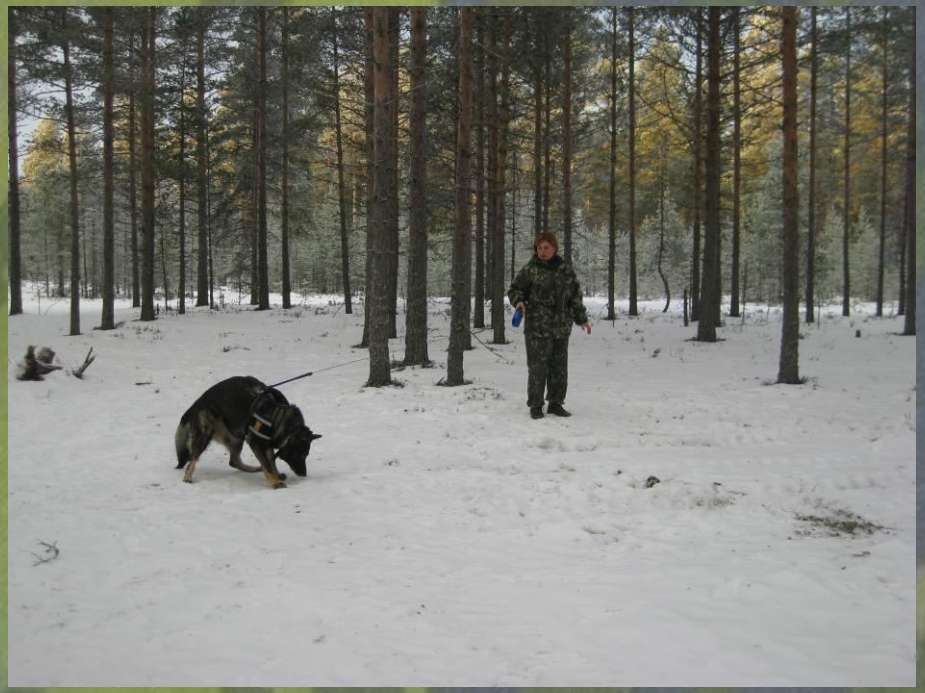
Table 1. On-site analysis results using field analyzer PetroFLAG.

sample / date taken	soil	odor percep-tion	°C	humidity	wind	rainfall	date of analysis	sample g	result ppm
1 / 3.12.2010	sand	negative	-8	89	1 m/s	light snow	30.12.2010	10	1295
2 / 3.12.2010	sand	negative	-8	89	1 m/s	light snow	30.12.2010	10	1536
3 / 29.12.2010	sand	negative	-10	84	2 m/s	light snow	30.12.2010	10	483
4 / 29.12.2010	sand	negative	-10	84	2 m/s	light snow	30.12.2010	10	193
1 / 25.3.2011	sand	positive	-5	53	6-8 m/s	snow crystals	28.3.2011	10	106
2 / 25.3.2011	sand	positive	-5	53	6-8 m/s	snow crystals	28.3.2011	10	66
3 / 25.3.2011	sand	positive	-5	53	6-8 m/s	snow crystals	28.3.2011	10	35
1 / 29.4.2011	sand	negative	+11	36	2 m/s	dry weather	3.5.2011	1	13 590
III / 6.5.2011	sand	positive	+9	38	3 m/s	dry weather	9.5.2011	5	768
I 6.5.2011	sand	positive	+9	38	3 m/s	dry weather	9.5.2011	10	723
II 6.5.2011	sand	positive	+9	38	3 m/s	dry weather	9.5.2011	10	354
IV 6.5.2011	sand	negative	+9	38	3 m/s	dry weather	9.5.2011	10	1018
1 / 27.5.2011	sand	negative	+10	45	5-6 m/s	rain	9.6.2011	10	218
2 / 27.5.2011	sand	negative	+10	45	5-6 m/s	rain	9.6.2011	10	1561
3 / 27.5.2011	sand	negative	+10	45	5-6 m/s	rain	9.6.2011	10	754
4 / 27.5.2011	sand	negative	+10	45	5-6 m/s	rain	10.6.2011	10	2399
5 / 27.5.2011	sand	positive	+10	45	5-6 m/s	rain	10.6.2011	10	272
6 / 27.5.2011	sand	positive	+10	45	5-6 m/s	rain	10.6.2011	10	822
1 / 3.6.2011	sand	negative	+17	46	6-7 m/s	dry weather	10.6.2011	1	10 430
2 / 3.6.2011	sand	negative	+17	46	6-7 m/s	dry weather	10.6.2011	10	598
3 / 3.6.2011	sand	negative	+17	46	6-7 m/s	dry weather	10.6.2011	10	405
4 / 3.6.2011	sand	positive	+17	46	6-7 m/s	dry weather	10.6.2011	1	10 720
5 / 3.6.2011	sand	positive	+17	46	6-7 m/s	dry weather	10.6.2011	1	850
6 / 3.6.2011	sand	negative	+17	46	6-7 m/s	dry weather	10.6.2011	10	447
7 / 3.6.2011	sand	negative	+17	46	6-7 m/s	dry weather	10.6.2011	10	479
1 / 30.6.2011	sand	negative	+25	52	2-3 m/s	dry weather	30.6.2011	10	189
2 / 30.6.2011	sand	negative	+25	52	2-3 m/s	dry weather	30.6.2011	10	168
3 / 30.6.2011 5g	sand	negative	+25	52	2-3 m/s	dry weather	30.6.2011	5	2708
3 / 30.62011 1g	sand	negative	+25	52	2-3 m/s	dry weather	30.6.2011	1	2880
A / 21.10.2011	sand	negative	+5,8	78	3 m/s	dry weather	10.11.2011	10	1025
B / 21.10.2011	sand	negative	+5,8	78	3 m/s	dry weather	10.11.2011	10	1599
C / 21.10.2011	sand	negative	+5,8	78	3 m/s	dry weather	10.11.2011	10	824
D / 21.10.2011	sand	negative	+5,8	78	3 m/s	dry weather	10.11.2011	10	843

LABORATORY RESULTS

Table 2. Laboratory results Laboratory results in SGS Inspection services Oy in Finland.

sample / date	depth (m)	soil	odor perception	°C	humidity	wind	rainfall	date of analysis	hydrocarbons C10-C21, mg/kg	hydrocarbons C22-C40, mg/kg
LA 1 / 27.8.2008	0,5	sand	positive	+13.4	75	1 m/s	dry weather	29.8.-1.9.2008	1100	20
LA 2 / 27.8.2008	0,1	sand	positive	+13.4	75	1 m/s	dry weather	29.8.-1.9.2008	<20	50
LA 3 / 27.8.2008	0,5	sand	positive	+13.4	75	1 m/s	dry weather	29.8.-1.9.2008	<20	<20
1. / 2.9.2008	0,1	sand	–	+7,5	82	2 m/s	light rain	24.9.2008	<20	50
2. / 2.9.2008	0,1	sand	–	+7,5	82	2 m/s	light rain	24.9.2008	90	3450
3. / 2.9.2008	0,1	sand	–	+7,5	82	2 m/s	light rain	24.9.2008	20	140



RESULTS

- According to on site analysis the GPS-dog could
  - detect oil spills from 35 mg/kg to 13 590 mg/kg
  - locate fresh and older oil spills
  - point out oil spills from top and even deeper layers of ground
  - work every time of the year (-10 °C - +25 °C)

THE AMOUNT OF MEASURED HYDROCARBONS DAY 1

Liite 1. Ensimmäisenä päivänä kammion jälkeen ilmasta mitatut hiilivetypitoisuudet.

Yhdiste			
Benzene, 1,2,3-tr			
Undecane			
Benzene, 1-meth			
Octane, 2,6-dime			
trans-Decalin, 2-r			
Benzene, 1,2,4,5-			
Nonane			
Nonane, 2-methy			
Benzene, 1-ethyl			
Dodecane			
Decane, 4-methy			
Benzene, 1-ethyl			
Benzene, 1-ethyl			
Benzene, 1,2,3-tr			
Cyclopentasiloxa			
n-Amylcyclohexa			
Naphthalene, de			
Cyclopentane, 1,			
Benzene, 1-meth			
Cyclopentane, pe			
Benzene, 1-meth			
Cyclohexane, but			
Benzene, 1,2,3-tr			
Cyclohexane, 1,4			
Nonane, 3-methy			
Nonane, 4-methy			
Decane, 3-methy			
Naphthalene, 1,2			
Decane, 4-methy			
Indan, 1-methyl-			
Benzene, 1-meth			
Benzene, 2-ethyl			
Cyclohexane, 1-m			
Benzene, 1,2,4,5-			
Cyclohexane, 1,4			
Undecane, 5,6-di			
Undecane, 5-met			
Benzene, 1-ethyl			
Benzene, 1-methyl-4-propyl-			
Benzene, 1-ethyl-2-methyl-			

Undecane, 4-meth			
Benzene, 1-ethen			
Undecane, 2,6-din			
10-Undecen-1-ol			
Spiro[4.4]nonane-			
Benzene, 1,3-diet			
Undecane, 2,7-din			
1-Tetradecanol			
Cyclohexane, 1-et			
endo-2-Methylbic			
Trans-1,4-diethylc			
Cyclohexene, 1-bu			
1-Chloro-2-methy			
1H-Indene, 2,3-dil			
p-Xylene			
Benzene, 2-ethyl-			
6-Octenal, 3,7-din			
Nonane			
Ethylidenecycloh			
Heptane, 3-ethyl-			
Heptadecane			
Benzene, propyl-			
Trans-1,4-diethylc			
Undecane, 3-meth			
Cyclooctane, meth			
Cyclohexane, 1-m			
Benzene, butyl-			
Cis-1,3-di(n-hexyl			
Naphthalene, dec			
Decane, 3,7-dime			
Benzene, 1-methy			
Cyclohexane, 2-pr			
Octane, 2-methyl-			
1-Ethyl-2,2,6-trim			
2-Butene, 3-chlor			
Cyclohexane, 1,4-			
Benzene, 1-methy			
Benzene, (1,1-din			
Cyclohexene, 1,2-			
Naphthalene, dec			
Benzene, (2-meth			
Cyclohexane, 1-et			
Cyclododecene			
p-Xylene			

p-Xylene			
Octane, 3-methyl-			
Cyclohexane, 2-butyl-1,1,3-tri			
1-Ethyl-4-methylcyclohexane			
Cyclohexane, 1-methyl-4-(1-n			
cis, cis-3-Ethylbicyclo[4.4.0]de			
Naphthalene, 1,2,3,4-tetrahyd			
Decalin, anti-1-methyl-, cis-			
Tridecane			
3-Methyl-2-(2-oxopropyl)fura			
Naphthalene, 1,2,3,4-tetrahyd			
Benzene, 1-methyl-4-(1-meth			
Benzene, (1-methylethyl)-			
Cyclohexane, 1-methyl-2-pen			
Cyclopentane, 1-ethyl-3-meth			
1H-Indene, 2,3-dihydro-1,6-di			
6-Octen-1-ol, 3,7-dimethyl-, p			
Undecane, 5-methyl-			
Benzene, 1-methyl-4-(1-meth			
1-Hexadecanol, 2-methyl-			
1,3-Dimethylcyclopentanol			
Naphthalene, decahydro-2,3-			
Octane			
Octane, 1,8-dibromo-			
1-Decene			
Nonane, 5-methyl-			
1H-Indene, 2,3-dihydro-4,7-di			
4-Decene			
3-Heptene, 4-propyl-			
3-Octene, 2,2-dimethyl-			
Cyclohexene, 1,2-dimethyl-			
Cyclohexane, (1-methylpropy			
2-Methyl-3-ethyl-2-heptene			
1-Docosene			
Cyclohexane, 1-ethyl-4-methy			
Cyclopropane, 1-butyl-1-meth			
Heptane, 2,3-dimethyl-			
Cyclohexane, ethyl-			
Dodecane, 4-methyl-			
Undecane, 2,5-dimethyl-			
Heptane, 2,4,6-trimethyl-			
Naphthalene, decahydro-2,6-			
Bicyclo[2.1.1]hexane-1-carbox			
Benzene, 1,3-dimethyl-5-(1-m			
Naphthalene, 1,2,3,4-tetrahyd	001680-51-9		
Ethylbenzene	000100-41-4	90	38.9
Aziridine, 1-acetyl-2-methyl-	013416-47-2	49	38.7

Benzene, 1,3-dimethyl-5-(1-methyle	004706-90-5		
Naphthalene, 1,2,3,4-tetrahydro-6-	001680-51-9		
Ethylbenzene	000100-41-4		
Aziridine, 1-acetyl-2-met			
cis,cis-1,6-Dimethylspirol			
Octane, 3,6-dimethyl-			
Cyclopentane, 2-isopropy			
trans,trans-1,6-Dimethyls			
Cyclohexane, 1,1,2-trime			
Cyclopentane, 1-pentyl-2			
Naphthalene, decahydro-			
Ethanone, 1-(2,2-dimethy			
Octane, 2,3,7-trimethyl-			
Cyclotrisiloxane, hexame			
Cyclopentane, 2-isopropy			
Heptane, 2,6-dimethyl-			
Cyclohexane, 1,3,5-trime			
2-Octene, 2,6-dimethyl-			
1-Decene			
Glutacononitrile, 4-(amin			
Cyclohexane, 1,1,3-trime			
10-Methylnonadecane			
cis,trans-1,6-Dimethylspi			
Cyclohexane, 1,2,4-trime			
2-Ethyl-2,3-dihydro-1H-in			
Toluene			
cis,trans-1,6-Dimethylspi			
Benzene, 4-(2-butenyl)-1			
Naphthalene, 2-methyl-			
1,1,4-Trimethylcyclohexa			
Cyclohexane, 1-ethyl-4-m			
Octane, 4-methyl-			

Cyclohexane, 1,1,3,5-tetrame			
Cyclohexene, 1-pentyl-			
1H-Indene, 2,3-dihydro-5,6-di			
Cyclohexane, 1,3,5-trimethyl-			
Naphthalene, 1-methyl-			
Cyclopentane, 1-ethyl-3-meth			
2-Propanone, 1,1,1,3,3,3-hexa			
(5-Ethylcyclopent-1-enyl)met			
1,1'-Bicyclohexyl			
7-Tetradecyne			
Naphthalene, 1,2,3,4-tetrahyd			
Heptane, 2-methyl-			
1H-Indene, 2,3-dihydro-4,5,7-			
Naphthalene, decahydro-2,6-			
Heptane, 3-methyl-			
Heptane, 3-ethyl-2-methyl-			
Cyclohexane, 1,1,3-trimethyl-			
Naphthalene, 1,2,3,4-tetrahyd			
3-(But-3-enyl)-cyclohexanone			
Naphthalene, decahydro-2,6-			
Cyclohexene, 1,6-dimethyl-			
Cyclohexane, 1,3-dimethyl-, c			
Heptylcyclohexane			
Cyclohexanone, 4-ethyl-			
1H-Indene, 2,3-dihydro-1,4,7-			
Cyclohexane, 1,2-dimethyl-, t			
Benzene, 1,4-dimethyl-2-(2-m			
Tetradecane			
Cyclohexane, 1,2,4-trimethyl-			
2-Hexene, 3,4,4-trimethyl-			
Benzene, 1-(1-methylethenyl			
cis,cis-1,9-Dimethylspiro[5.5]u			
Cyclopentane, 1-methyl-3-(1-			
7-Tetradecyne			
Benzene, 4-(2-butenyl)-1,2-di			
Cyclohexane, methyl-			
trans-1,3-Diethylcyclopentane			

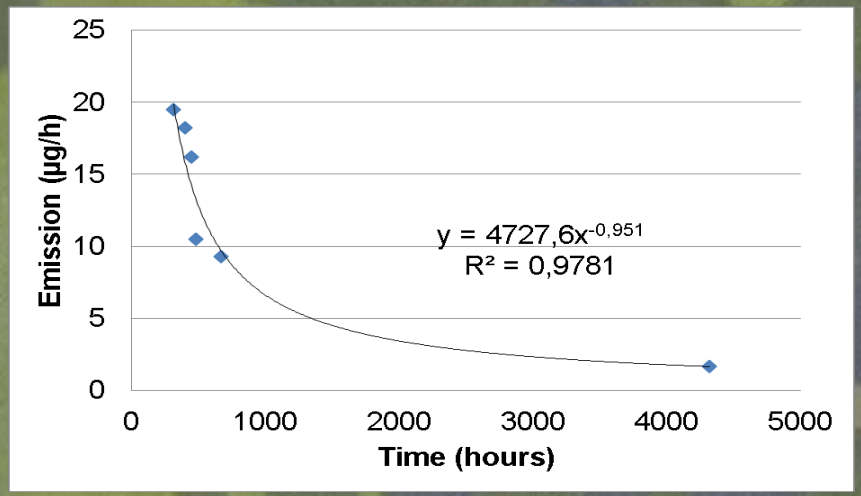
Naphthalene, 6-ethyl-1,2,3,4-tetra	022531-20-0	86	9.1
Benzene, cyclohexyl-	000827-52-1	91	8.4
Cyclohexane, 1,2,4-trimethyl-, (1.	007667-60-9	52	8.3
Cyclopentane, 1-ethyl-3-methyl-, c	002613-66-3	95	8.1
1H-Indene, 2,3-dihydro-4,5,7-trime	006682-06-0	53	8.0
Cyclohexane, 1,4-dimethyl-, trans-	002207-04-7	94	7.9
Cyclohexane, 1,3-dimethyl-, trans-	002207-03-6	94	7.9
Heptane	000142-82-5	91	7.8
Naphthalene, 2-ethyl-1,2,3,4-tetra	032367-54-7	55	7.8
Perhydrophenalene, (3a.alpha., 6a.	040250-64-4	95	7.7
Cyclopentane, 1-methyl-3-(1-methyl	053771-88-3	90	7.7
Heptane, 2,4-dimethyl-	002213-23-2	93	7.5
Cyclopentane, 1-ethyl-2-methyl-, c	000930-89-2	95	7.3
Disulfide, di-tert-dodecyl	027458-90-8	53	7.1
Heptane, 4-methyl-	000589-53-7	91	6.7
5H-Benzocycloheptene, 6,7-dihy			
p-Xylene			
Naphthalene, 2-butyldecahydro-			
Cyclohexane, (2,2-dimethylcyclo			
Cyclopentane, 1-ethyl-3-methyl-			
Cyclopentane, 1,1,3-trimethyl-			
Naphthalene, 1,2,3,4-tetrahydro-			
Tridecane, 4-methyl-			
Cyclopentane, 1,2-dimethyl-3-(1			
Cyclohexane, 1,2,4-trimethyl-			
Naphthalene, 1,2,3,4-tetrahydro-			
Cyclopentyl acetylene			
Cyclopentane, 1,2,3-trimethyl-, (			
Naphthalene, 1,2,3,4-tetrahydro-			
Naphthalene, 2,7-dimethyl-			
Cyclopentane, ethyl-			
Hexanal, 3,3-dimethyl-			
Naphthalene, 5-ethyl-1,2,3,4-tet			
2-Pentanol, 1-(2-methylenecyclo			
Cyclopentane, 1-ethyl-2-methyl-			
Naphthalene, 1,6-dimethyl-			
Naphthalene, 1,6-dimethyl-			
cis,cis-2,9-Dimethylspiro[5.5]und			
1,5-Methano-8H-pyrido[1,2-a][1,			
9-Undecen-2-one, 6,10-dimethyl			
Thiophene, 2,5-bis(2-methylprop			
cis,syn,cis-Perhydrophenanthren			
Benzene			
Undecane			
Acetic acid,			
Pentadecane	000629-62-9	97	2.3

Pentadecane	000629-62-9	97	2.3
Ethanol, 2-(hexadecyloxy)-	002136-71-2	41	2.3
Cyclopentane, 1,2,3-trimethyl-, (1	002613-69-6	53	2.2
Cyclopentane, 1,2,4-trimethyl-	002815-58-9	93	2.1
1H-Indene, 2,3-dihydro-4,5,7-trime	006682-06-0	70	2.1
Naphthalene, 2,7-dimethyl-	000582-16-1	96	1.9
3,4-Dihydroxymandelic acid, ethyl	1000071-70-2	43	1.8
Hexane, 3-methyl-	000589-34-4	94	1.8
1,3-Benzenediol, 4-chloro-5-(hydro	035354-28-0	90	1.8
Cyclopentane, (2-methylpropyl)-	003788-32-7	46	1.7
Phenylmaleic anhydride	036122-35-7	87	1.6
Hexane, 2,3,5-trimethyl-	001069-53-0	53	1.6
Formic acid, 3,7,11-trimethyl-1,6,	1000132-11-0	38	1.5
Hexane, 2,3-dimethyl-	000584-94-1	90	1.2
Diethyl Phthalate	000084-66-2	38	1.2
Hexane	000110-54-3	70	1.1
Hexane, 2,5-dimethyl-	000592-13-2	64	1.0
3-Hexene, 2,3-dimethyl-	007145-23-5	58	0.9
Hexane, 2,4-dimethyl-	000589-43-5	93	0.9
Hexadecane	000544-76-3	98	0.9
Cyclopentane, 1,3-dimethyl-, cis-	002532-58-3	83	0.8
Ethanol, 2-(trimethylsilyl)-	002916-68-9	59	0.6
Cyclopentane, 1,3-dimethyl-	002453-00-1	93	0.6
3-[5-(Pyridin-3-yl)-2-thienyl]prop	1000267-23-5	38	0.6
1-Heptadecanol	001454-85-9	38	0.5
Cyclopentane, methyl-	000096-37-7	68	0.4
Eicosane	000112-95-8	87	0.4
1-Butanol	000071-36-3	53	0.3
2-Heptanol	000543-49-7	59	0.3
Heptadecane	000629-78-7	94	0.3

Marko Hyttinen, University of Eastern Finland

EMISSIONS OF FUEL OIL

	4 tuntia	6 tuntia	24tuntia	27 tuntia	315 tuntia	484 tuntia
TVOC	23629	15501	7249	5458	325	175
Trimetyylibentseeni / dekaani[1)]	1554	963	80			
Undekaani	805	582	296			
2-propyyli-1-metyylibentseen	415	280	51			
Dodekaani	382	288	457			
2,6-dimetyylioktaani	413	247	5			
tetrametyylibentseeni	413	303	216			



CANINE SCENT DETECTION

- The concentrations of the lighter hydrocarbons were high at the beginning, but sank very quickly
- Also the emission components varied from lighter to heavier ones
- Presumably it is the amount of emissions that make the dog react to the find when hunting after the target odor
- In our field study the detected locations for oil spills were older than a couple of hours, rather days to weeks. Still it did not make it difficult for our GPS-dog to detect them. This would indicate that it is not the most volatile compounds the dog has made an odor memory from
- In our results the biggest ppm concentration was measured with hydraulic oil product which was not taught the dog in the beginning
- The assumption is that the GPS-dog made a generalization between other oil compounds and hydraulic oil

THE ADVANTAGES OF USING FIELD ANALYZER PETROFLAG

- Fast analyses
- Economical
- Easy to use

BENEFITS OF USING A GPS-DOG

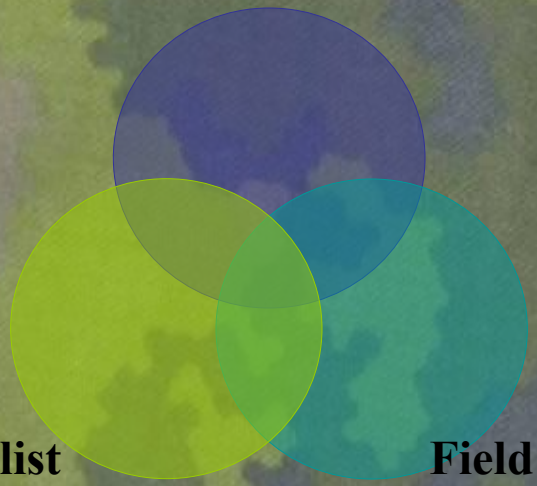
- A GPS-dog could reliably point out oil contaminated spots in the ground
- Soil investigations and sampling were targeted in right areas immediately
- Saves time and money
- Not dependable on weather, no need of a calibration

RESULTS

- According to the field study, a trained dog can reliable point out oil contaminated spots in the ground
- With the help of a GPS-dog, soil investigations and sampling were targeted in right areas immediately
- Dog's sensitive sense of smell and focused field measurements together make an excellent combination and tool for environmental monitoring, which is time and money saving

A combination of a GPS-dog, specialist and a field analyzer

GPS-dog



Specialist

Field analyzer

FUTURE

- In the future the use of a GPS-dog could extend to areas as for example spatial planning, real estates under renovation and leakages in heating oil systems
- In Artillery Brigade the GPS-dog project lives on!

CANINE SCENT DETECTION IN USE OF LOCATING CONTAMINATED SITES IN FINNISH DEFENCE FORCES

Thank you for your attention!

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