Kill•Spill

Integrated Biotechnological Solutions for Combating Marine Oil Spills

Deliverable D8.11

Report of utilization of response vessels and measured efficiencies of products & technologies during real incidents

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1 Introduction

Due to the fact that no sea incident occurred, where Kill•Spill Partners could tests their products, an alternative solution had be found for the execution of the Field tests.

2 Field tests

2.1 Field test site

The Field tests took place in Keratsini area of Piraeus Harbor, Greece. The testing site is a small fisherman harbor lying directly underneath the state owned Public Power Corporation Agios Georgios Plant. The power plant is no longer operating on Mazut (heavy, low quality fuel oil used in generating plants), but oil is still leaking from the ground. It is generally assumed that one of the plant's tanks that had been inactive since the early 70's has lost considerable quantities of Mazut to the underlying calcareous rock terrain. This has caused this chronic leakage into the small fishing port despite repeated attempts to pump the oil, and /or prevent the quantities from ending up into the sea by building concrete barriers.

Oil ascends out of the harbor's concrete walls and therefore the leakage rate cannot be exactly determined. However we tried to get an estimation of oil leakage before starting the field tests. We cleaned the leakage area, and measured the leaked oil quantities after 1 week (June 6th to 13th, 2016). The oil leakage rate in the area was 35 L per day.

2.2 Tested products

Following Kill•Spill products had been tested in the field tests:

Table 1 Tested Kill•Spill products

Kill•Spill products	Producer	Type of Agent	Form
Mesoporous Smart Gate Particles (SGP)	FHNW School of Life Sciences	Biostimulant, nutrient N/P supply, mesoporous silica particles	Powder
PH9/NANO MASS	BioBased Europe	Biosurfactant	Liquid
$fCaCO_3$	Microstech Switzerland	Sinking sorbent	Powder
BIO 10	BioBased Europe/ Ecohoof	Nonionic Surfactant Blend	Liquid

Following commercial products had been tested as reference products:

Table 2 Reference products

Reference products	Producer	Type of Agent	Form	Reference for
S-200C	RBL Environmental IE	Bioremediation Agent (Nutrient Additive)	Liquid	SGP
Marichem 3rd Generation Oil Spill Dispersant (Type II/III)	MARICHEM MARIGASES Worldwide Services	Oil Spill Dispersant	Liquid	PH9/NANO MASS, BIO10

2.3 Testing schedule

Table 3 Testing Schedule 1st Testing Period 18/7 2016 - 4/8/2016

Timing	**1 m² pools Mazut oil ~1L**			**Day 1 18/07/2016**	**Day 2 19/07/2016**	**Day 3 20/07/2016**	**Day 4 21/07/2016**	**Day 5 22/07/2016**	**Day11 28/7/2016**	**Day18 4/8/2016**
				1st application (pools construction - existing heavy oil was distributed 'equally' in the pools)	Cleaning from garbage	Pools were filled up by leaking mazut	**2nd application** of product ~1L	Sampling-Inspection	1 week after 2nd application Sampling -inspection	2 weeks after 2nd application Sampling -inspection
Kill.Spill Product	**Reference product**	**Type of agent**	**Visual observation**							
SGP (Smart Gate Particles) FHNW	**S200 RBL** Environmental IE **Liquid** /Sprayed on oil surface	Biostimulant, nutrient N/P supply, mesoporous **Powder**/cover oil surface layer	Within an hour the powder was absorbed in the oil phase. After 4 hours of the 2nd application the heavy oil was floating in the water column before it sinks completely within 24 hrs	The particles have been dispersed homogeneously on the oil surface which was covered by a uniform layer of powder. SGP 1:1 (10% Nitrogen) 1kg/1L (product/oil) Visual inspection of oil sinking	Cleaning from garbage Photos/ videos	Pools were filled up by leaking mazut Photos/videos	**SGP Sampling**: Sediment from **App#1** Sample of oil + SGPs after **App#2** **S200 Sampling:** S200 water in oil emulsion +sea water Photos/videos	**Sampling:** **SGPs:** 3x floating oil in the water column, Sediment **S200:** seawater sample Photos	**Nothing in the box**	**Nothing in the box**
Ph9-Nanomass BBE	**3rd Generation Oil Dispersant** Marichem **Liquid** /Sprayed on oil surface	Biosurfactant **Liquid**/Spraying oil Surface	The product dissolved only the light part of the oil (less than 10%)/worked immediately on thin film. The water column was blurry for several hours	1:2 ratio diluted product /oil **600mL** (200ml diluted to 600ml with water) The product was sprayed directly on the oil layer. Photos/videos +application on thin film	Cleaning from garbage	Pools were filled up by leaking mazut	**Application #2** 1:2 ratio diluted product /oil **600mL** (200mL diluted to 600ml with water) Photos/videos	------	------	------

Timing	1 m^2 pools Mazut oil ~1L			Day 1 18/07/2016	Day 2 19/07/2016	Day 3 20/07/2016	Day 4 21/07/2016	Day 5 22/07/2016	Day11 28/7/2016	Day18 4/8/2016
				1st application (pools construction - existing heavy oil was distributed 'equally' in the pools)	Cleaning from garbage	Pools were filled up by leaking mazut	**2nd application** of product ~1L	Sampling-Inspection	1 week after 2nd application Sampling -inspection	2 weeks after 2nd application Sampling -inspection
Kill.Spill Product	**Reference product**	**Type of agent**	**Visual observation**							
$CaCO_3$ MicrosTech		Sinking sorbent **Powder**/cover oil surface layer	Within an hour the powder was absorbed in the oil phase and started sinking vertically. Some powder remained on the surface 1-2 days after application	The particles have been dispersed homogeneously on the oil surface which was covered by a uniform layer of powder. 1.5:1 ratio product / oil 1.5 kilo Photos/videos	Cleaning from garbage	Pools were filled up by leaking mazut	**Application #2** Photos/videos Sediment in the box	Sediment in the box and residual $CaCO_3$ product on sea surface Photos	Sediment in box Photos/sampling	Sediment in box Photos/sampling
Bio-10 BBE/Ecohoof	**3rd Generation Oil Dispersant** Marichem **Liquid** /Sprayed on oil surface	Non ionic Surfactant Blend **Liquid** Sprayed on oil surface	The product dissolved only the light part of the oil (less than 10%)/worked immediately on thin film. The water column remained blurry for several hours	1:2 ratio product/oil 500mL **of the** product was sprayed as is at the oil surface Photos/videos +Thin film application	Cleaning from garbage	Pools were filled up by leaking mazut	**Application #2** Photos/videos	------	------	------
	S200 RBL Environmental IE Reference product for **SGP**	Bioremediation Agent (Nutrient Additive) **Liquid** /Sprayed on oil surface	A white yellow emulsion was created almost immediately The product emulsified a considerable amount of the heavy oil pollution within hours and dispersed it in the water column. Worked very efficiently on thin film	1.3**L.:**1 L product / oil **(**product was sprayed as is at the oil surface) Photos/videos +Thin film application	Cleaning from garbage	Pools were filled up by leaking mazut	**Application #2** Photos/videos	------	------	------

Timing	1 m^2 pools Mazut oil ~1L			Day 1 18/07/2016	Day 2 19/07/2016	Day 3 20/07/2016	Day 4 21/07/2016	Day 5 22/07/2016	Day11 28/7/2016	Day18 4/8/2016
				1st application (pools construction - existing heavy oil was distributed 'equally' in the pools)	Cleaning from garbage	Pools were filled up by leaking mazut	**2nd application** of product ~1L	Sampling-Inspection	1 week after 2nd application Sampling -inspection	2 weeks after 2nd application Sampling -inspection
Kill.Spill Product	**Reference product**	**Type of agent**	**Visual observation**							
	3rd Generation Oil Dispersant Marichem Reference product for **PH9/Nano Mass and Bio 10**	Oil Spill Dispersant **Liquid** Sprayed on oil surface	The product dissolved only the light part of the oil (less than 10%)/worked immediately on thin film. Extensive foaming was observed Worked equally well on thin film as our products did	1L per 15m^2 200mL concentrated product was sprayed as is at the oil surface Photos/videos +Thin film	Cleaning from garbage	Pools were filled up by leaking mazut	**Application #2** Photos/videos	------	------	------
Control		Nothing added		Two samples were collected	Cleaning from garbage	Pools were filled up by leaking mazut	------	------	------	------

Table 4 Testing Schedule 2nd Testing Period

Testing Schedule 2nd Testing Period 19/10/2016 - 23/11/2016						
Timing	**1 m² pools Mazut oil ~1L**	**Application – Day 1 19/10/2016**	**Day 2 20/10/2016**	**Day 4 22/10/2016**	**Day 7 25/10/2016**	**After 1 month**
Product	**Application**					
SGP (Smart Gate Particles) FHNW	Application of 842 grams for ~ 1L. of oil	The particles have been dispersed homogeneously on the surface and it was covered by a more or less uniform layer of powder. 100 mL samples have been taken from the surface of the pools.	A remarkable quantity of heavy oil has been dispersed from the surface but remains of powder were marked. After the application	The amount of SGP had dispersed the oil but sediment was noticed at the bottom. Some intact powder was still visible floating at the surface of the pool. 100 ml samples have been taken from the surface of the pools.	The oil of the pool had almost been dissolved at all and its bottom was covered with oil coagulations that sank. No residues were remaining at the surface of the pool. 100 mL samples have been taken from the surface of the pools.	The pool had even after a month only very light pollution.
	Application of 842 grams for ~ 1L. of oil	The particles have been dispersed homogeneously on the surface and it was covered by a more or less uniform layer of powder. 100 mL samples have been taken from the surface of the pools	A remarkable quantity of heavy oil has been dispersed from the surface but a small amount of powder were marked.	Most of the quantities of oil were still on the. The pool was still full of oil when there was no appearance of product's residues. 100 mL samples have been taken from the surface of the pools.	The pool was still full of heavy oil and garbage. No residues were remaining at the surface of the pool. 100 mL samples have been taken from the surface of the pools.	The pool was filled after a month with high pollution.
Reference Product S-200C RBL Environmental IE	Application of 1.114 mL for ~ 1L. of oil. It was sprayed at the surface of oil phase at pool	A few minutes after the application a white yellow emulsion was created at the surface of the pool. 100 ml samples have been taken from the surface of the pools.	The day after application a great amount of heavy oil remained on the surface despite the disappearance of emulsion.	Most of the oil quantities were still on the surface and there was no appearance of product's residues. 100 mL samples have been taken from the surface of the pools.	The pool had still remaining oil at the surface but a great amount of it had been dispersed. No residues were remaining at the surface of the pool. The whole quantity of the product was totally absorbed. 100 mL samples have been taken from the surface of the pools.	The pool had even after a month only very light pollution.
	Application of 132 mL for ~ 1L. of oil. It was sprayed at the surface of oil phase at pool	A few minutes later a white yellow emulsion was created at the surface of the pool. 100 mL samples have been taken from the surface of the pools.	The day after application a great amount of heavy oil remained on the surface despite the disappearance of emulsion.	Most of the oil quantities were still on the surface and there was no appearance of product's residues. 100 mL samples have been taken from the surface of the pools.	The pool was still full of heavy oil and garbage. No residues were remaining at the surface of the pool. The whole quantity of the product was totally absorbed. 100 mL samples have been taken from the surface of the pools.	The pool was filled after a month with high pollution.

3 Product testing and observations

On Monday the 18th of July 2016 field tests four Kill Spill products (Mesoporous Smart Gate Particles, PH9 Nanomass, $fCaCO_3$, and Bio10) along with two commercial products (S-200C and Marichem) started in Keratsini, Piraeus, Greece.

The testing pools were constructed using booms that were placed on the one concrete side of the harbor from which Mazut is leaking continuously. Each pool was dedicated from the start to a specific product.

On the 1st Testing Day (July 18th) we applied each product according to their application protocol on heavy pollution. However first results showed that the oil was extremely weathered and a considerable amount of floating plastics had been attached to it (e.g. bags, small bottles). Therefore, the pools were cleaned up and the 2nd product application was done after fresh oil refilled the pools by ascending from the harbor concrete walls. On the 2nd Testing Day all pools were cleaned from the remaining oil and floating garbage. On the 3rd Testing Day all pools were refilled with approximate 1 liter of fresh heavy oil.

On the 4th Testing Day the products have been reapplied on their separate pools on 1 liter of fresh heavy oil. On the sea bottom underneath SGP and $fCaCO_3$ test pools, metal boxes have been placed for collection of sediment. The results were monitored for the next days. Long-time monitoring of the pools was not possible due to the open bottom of the pools, as they were slowly refilled with oil over the next days. However we followed up with photos and videos for two weeks for the fCaCO3 and Smart Gate Particles (SGPs).

Since on the 1st Testing Period sampling was not possible for SGP, we rearranged a 2nd Testing Period for the SGP and its reference product that started on Wednesday 19th of October at the same testing site. In order to stop the refreshing of pools with fresh oil, circular boom formations (pools) were manufactured with an approximate inner surface of $1m^2$, which were equipped with a net bottom. Five pools were placed against the concrete dock at the leaking side of the harbor and were filled with approximate 1 liter of Mazut, taken in account that the collected oil might have different degrees of weathering. The 1st pool was used as control area and filled in with just oil without any oil degrading product. The pools 2, 3, 4 and 5 were filled each with approximate 1 liter of heavy oil, in order to test different product applications. Samples were taken on 1st, 3rd and 6th Testing Day and the pools were observed up to 1 month after the product application.

Photos and Videos have been taken during all Product tests.

3.1 SGP - Smart Gates Particles (produced by amorphous silicon dioxide particles)

3.1.1 Description

SGP is a product produced by amorphous silicon dioxide particles at the phase of powder, by University of Applied Sciences Northwest Switzerland.

Lab experiments have shown that 10 mg of mesoporous for 100 mg of oil is the maximal ratio of loaded silica that can be applied without leading to aggregate formation and precipitation.

Application on 1 kg crude oil per m^2: The crude oil has a content of 88% of carbon. 880 g of C are contained per square meter. We need 88 g of N per square meter of boom. The characteristics of the batch received are:

Mass before loading = 2 kg; Mass after loading = 3.13 kg. In total 1.13 kg of urea and K_2HPO_4 were loaded and total weight was 3.186 kg after functionalization. The batch contained 414.98 g of K_2HPO_4 (equivalent to 74 g of P) and 715.01 g of urea (equivalent to 333 g of N).

3.1.2 Application Protocol

1. Transport the powder in a closed box and do not mix with any solvent before use.
2. Disperse the particles homogeneously at the surface of the oil phase. If we assume 1 kg oil per week per m^2 is released then the batch product containing 209.92 g of N in a total weight of 1975 g is enough for two applications of 10% N per kg of oil. First application on time 0 and the second two weeks after.
3. Take photos and movie twice per week.
4. Take 100 mL samples and analyze for TPH

Under the pool a dedicated to SGPs metal box was placed to capture the sediment during the application.

3.1.3 Observations during application

	1st application	**2nd application**
Application	For the approximate oil volume 1 L, 1.0 kg of product was applied. The entire surface was covered by a sufficient layer of the powder.	For the approximate oil volume 1 liter, 1.0 kg of product was applied. The entire surface was covered by a sufficient layer of the powder.
1st Day	No remaining powder was on the sea surface the next day of the application (the pool was almost clean of oil and the floating plastics were only left). Most of the heavy oil (more than 80%) was not on the surface and there was no sediment in the box that was placed underneath the pool	No remaining powder was on the sea surface the next day of the application (the pool was almost clean of oil). Most of the heavy oil was not on the surface (~90%) and there was no sediment in the box that was placed underneath the pool After observing the SGPs pool 4 hours after the application it was noticed that in the external pool there was a significant amount of oil floating in the water column.

The following days the oil was lost in the harbor, therefore we could not sample to monitor degradation. A second testing session was planned and executed with pools that had a net bottom and didn't allow oil to get in or out of the pool.

At application | After 3 hours | After 1 day

Picture 1 Impression of the SGP testing 1st Application (July 18th, 2016)

2nd Application - Pool 2 – 4hours after application

2nd Application - Outside Pool 2 – Oil in water column

Picture 2 Impression of the SGP testing 2nd Application (21st July, 2016) –There was a significant amount of oil floating in the water column 4 hours after the application.

3.1.4 Repetition of test in November 2016

	Application Pool 2	**Application Pool 3**
Application	For the approximate oil volume 1 L, we applied 842 g of the product. The particles have been dispersed homogeneously on the surface which was covered by a more or less uniform layer of powder. After the application 100 mL samples have been taken from the surface of the pools.	For the approximate oil volume 1 L, we applied 100 g of the product. The particles have been dispersed homogeneously on the surface which was covered by a more or less uniform layer of powder. After the application 100 mL samples have been taken from the surface of the pools.
2nd Day	A remarkable quantity of heavy oil has been dispersed from the surface but remains of powder were marked.	A remarkable quantity of heavy oil has been dispersed from the surface but a small amount of powder was marked.
4th Day	The amount of SGP had dispersed the oil but sediment was noticed at the bottom. Some intact powder was still visible floating at the surface of the pool. 100 mL samples have been taken from the surface of the pools.	Most of the quantities of oil were still on the surface. The pool was still full of oil when there was no appearance of product's residues. 100 ml samples have been taken from the surface of the pools.
7th Day	The oil of pool 2 had been dissolved almost 100% and its bottom was covered with oil coagulations that sank. No residues were remaining at the surface of the pool. 100 mL samples have been taken from the surface of the pools.	The pool was still full of heavy oil and garbage. No residues of the product were remaining at the surface of the pool. 100 mL samples have been taken from the surface of the pools.
1 month	Pool 2 had after a month only very light pollution.	Pool 3 was filled after a month with high pollution.

Picture 3 SGP with the higher amount of agents had after a month only very light pollution

Analyses of the samples are currently performed. Independently of the results that will be obtained, one has to face one experimental challenge prior to conclusion on the applicability of SmartGate

particles to respond to heavy oil spill. The aggregation and subsequent sedimentation of oil-SmartGate aggregates requires thoroughly designed fate studies. While significant portion of heavy components might first be transported in the water column far away from the contaminated site, non-negligible amount might be recovered in sediment at the contaminated site. The first question arising from this reasonable hypothesis is: will sediments at the oil spill site be heavily contaminated by these aggregates? The second question is: how fast is the oil-SmartGate aggregates in sediment, if any and does it pose a problem of ecotoxicity to the sediment ecosystem?

3.2 PH9/NANO MASS

3.2.1 Product description

PH9/NANO MASS a dispersant like product produced by BioBased Europe in UK.

3.2.2 Product application instructions according to producer:

BBE suggested:

- Dilute up to two times and spray on surface oil contamination on sea water
- Spraying uniformly and distribute the agent on an area of one square meter
- Take photos before and after of the surface and bottom of sea bed
- Other application testing may be on surface oil contamination on rocks such as oil washed up on costal rocks
- Other than photos to show what is happening, may be video shots of a few minutes

3.2.3 Observations during application

	1st application	**2nd application**
Application	For the approximate oil volume of 1 liter, we applied 600 mL (1:2 ratio product to water) of diluted product. The water in the pool looked blurry after the application for several hours. The oil as the time passed was slowly diluting in the water column since contamination was very heavy. No more than 10-20% of oil was dissolved. The product was also applied on thin film and worked nicely showing the same behavior as the Marichem - commercial product. The film disappeared immediately upon contact with the product.	For the approximate oil volume of 1 liter, we applied 600 mL (1:2 ratio product to water) of diluted product. The water in the pool looked blurry after the application for several hours. The oil as the time passed was slowly diluting in the water column. No more than 10-20% of oil was dissolved. The product was also applied and worked nicely on thin film showing the same behavior as the Marichem - commercial product. The film disappeared immediately upon contact with the product.
1st Day	Part of the heavy oil was dispersed in a thinner film	

Picture 4 The water in the pool looked blurry after the application for several hours. Due to high contamination the oil was slowly diluting in the water column.

3.3 Functionalised calcium carbonate (fCaCO3)

3.3.1 Product description

fCaCO3 is a sinking sorbent agent in powder form produced by Microstech in Switzerland

3.3.2 Product Application instructions

1. Ensure that the ration of $fCaCO_3$: crude oil is 1.5 : 1.
2. Spread the $fCaCO_3$ over the oil carpet on the water surface.
3. Simulate sea waves by shaking the testing vessel -> this will accelerate the adsorption and sinking of the „$fCaCO_3$ + oil“ to the ground.
4. Measure the biodegradation according to an OECD Standard or measure the degradation of hydrocarbons after defined interval.

Under the pool a dedicated to $fCaCO_3$ metal box was placed to capture the sediment during the application:

Picture 5 Metal box under f CaCO3 testing pool

3.3.3 Observations during application

	1st application	**2nd application**
Application	For the approximate oil volume 1 L, we applied 1.5Kg of the product. The entire surface was covered by a sufficient layer of the powder.	For the approximate oil volume 1 L, we applied 1.5Kg of the product. The entire surface was covered by a sufficient layer of the powder.
1st Day	By the next day most of the heavy oil was not on the surface. The powder absorbed on the oil and sunk it on the sea bed. There was sediment in the box that was placed underneath the pool	By the next day a significant amount of the heavy oil was not on the surface. There was sediment in the box that was placed underneath the pool. Samples were taken from the metal box underneath the pool.
1 week		Samples were taken from metal box underneath the pool.

	1st application	2nd application
2 weeks		Samples were taken from metal box underneath the pool.

The producer informed us that the biodegradation measurement and analysis have been done by the company, and therefore no additional analysis of the samples had to be made.

Picture 6 **The picture on the left is taken 4 hours after the application.**
On the right there was some remaining powder on the sea surface the next day of the application

3.4 BIO 10

3.4.1 Product description

BIO 10 is a Nonionic Surfactant Blend in liquid form by BioBased Europe/Ecohoof.

3.4.2 Product Application instructions

Apply on 1:2 ratio of product to crude oil.

3.4.3 Observations during application

	1st application	**2nd application**
Application	For the approximate oil volume of 1 L, we applied 500mL of the product as is. We applied on thin film and there was some left over foam on the surface	For the approximate oil volume of 1 L, we applied 500mL of the product as is. The oil contamination was light. The product dissolved efficiently the thin film but the heavy oil remained.

Picture 7 The picture on the left is from the 1st Application, while the right from the 2nd Application

3.5 S-200C - Bioremediation Agent

3.5.1 Product description

S-200C is Bioremediation Agent (Nutrient Additive) produced by International Environmental Products USA.

3.5.2 Product Application instructions

S-200CC has 7.9% N, therefore 1liter of S-200C includes 79 g of N. Therefore 2.65 L of S-200C is needed if N composition is OK. Take photos and movie twice per week.

Take 100 mL samples and analyze for TPH (ask for certified lab for alkane and PAH analysis) twice a week.

3.5.3 Observations during application

	1st application	**2nd application**
Application	For the approximate oil volume 1 L spread in 1m^2, 1.3L of the product was applied. A white yellow emulsion was created almost immediately.	For the approximate oil volume 1 L spread in 1m^2, we applied 1.3L of the product. A white yellow emulsion was created almost immediately.
2nd Day	By the next day a lot more of the heavy oil was dissolved and there were no signs of emulsion.	By the next day a lot more of the heavy oil was dissolved. This product works well with dissolving this really heavy oil pollution, compared to the biosurfactants sprayed on the same pollution or Marichem dispersant. On thin film S-200C was very efficient.

3.5.4 Repetition of test in November 2016

	Application Pool 4	**Application Pool 5**
Application	For the approximate oil volume 1 L, we applied 1.114 mL of the product. S-200C is a white water liquid and was sprayed with traditional liquid spraying equipment. It was sprayed at the surface of oil phase at pool 4 in the appropriate proportion. A few minutes later a white yellow emulsion was created at the surface of both pools. 100 ml samples have been taken from the surface of the pools.	For the approximate oil volume 1 L, we applied 132 mL of the product. S-200C is a white water liquid and was sprayed with traditional liquid spraying equipment. It was sprayed at the surface of oil phase at pool 5 in the appropriate proportion. A few minutes later a white yellow emulsion was created at the surface of both pools. 100 ml samples have been taken from the surface of the pools.
2nd Day	The day after application a great amount of heavy oil remained on the surface despite the disappearance of emulsion.	The day after application a great amount of heavy oil remained on the surface despite the disappearance of emulsion and pool 5 was full of oil even 24 hours later.

	Application Pool 4	**Application Pool 5**
4th Day	The 3rd day of observation most of the quantities of oil were still on the surface. Pool was still full of oil when there was no appearance of product's residues. 100 mL samples have been taken from the surface of the pools.	The 3rd day of observation most of the quantities of oil were still on the surface. Pool was still full of oil when there was no appearance of product's residues. 100 mL samples have been taken from the surface of the pools.
7th Day	The combination with the highest potency was pool 4 with 1.113 mL of S-200C. Pool 4 had still remaining oil at the surface but a great amount of it had been dispersed. No residues of the product were remaining at the surface of the pool. The whole quantity of the product was totally absorbed. 100 mL samples have been taken from the surface of the pools.	Pool 5 was still full of heavy oil and garbage. No residues were remaining at the surface of any pool. The whole quantity of the product was totally absorbed. 100 mL samples have been taken from the surface of the pools.
1 month	In Pool 4 only very light pollution remained after a month.	Pool 5 after a month was still filled with high pollution.

3.5.5 Results of chemical analysis

Analyses of the samples are currently performed (paragraph 3.1.4)

3.6 3rd Generation (Type II/III) oil spill dispersant

3.6.1 Product description

The 3rd Generation (Type II/III) oil spill dispersant is in liquid form and is being produced by MARICHEM MARIGASES Worldwide Services in Greece.

3.6.2 Product Application instructions according to producer

Dosing Procedure at Sea: The quantity of MARICHEM OIL SPILL DISPERSANT to be used depends on three main factors: the quantity of oil spilled, the type of oil spilled and the weather conditions (prevailing and forthcoming). However, experience and expertise have proved that an adequate volume of MARICHEM OIL SPILL DISPERSANT to be used is 1litre per 15–20m (1 gallon per 75–100 square yards) as tested on a spillage of Kuwait crude oil.

Cleaning Procedure at Sea:

1. Determine the oil–spillage size and kind.
2. Prepare the tools necessary to apply the product, undiluted, as specified, using the MARICHEM OIL CLEAN KIT equipment.
3. Spray the required quantity of the product, with the appropriate spraying equipment, over the oil spill.
4. Wait for a few minutes until oil spill has emulsified.
5. In the case of a persistent/stubborn oil spill, repeat cleaning process until oil spill elimination is complete.

3.6.3 Observations during application

	1st application	**2nd application**
Application	For the approximate oil volume of 1 L, we applied 300mL of the product as is. The product worked well on the thinner parts of the contamination and not on the very thick and heavy it (less than 20% was dissolved). A significant amount of foam was left on the sea surface. Marichem did not work better in any case (thin film or heavy contamination) in comparison to the biosurfactant products Bio10, PH9-Nanomass. On the contrary it was very foamy compared to the other two.	For the approximate oil volume 1 L, we applied 300mL of the product as is. Marichem dispersed the lighter contamination in the pool on the 2nd application but the thick parts were not significantly affected (less than 20% was dissolved). Marichem did not work better in any case (thin film or heavy contamination) in comparison to the biosurfactant products Bio10, PH9-Nanomass. On the contrary it was very foamy compared to the other two.

4 Product results summary

Table 5 Product results summary

Product	Test Results	Comparison to Reference Product
Mesoporous Smart Gate Particles (SGP) (Reference product - S-200C)	SGP showed in the tests the best results. SGP had in adequate quantity dispersed all oil from the surface however sediment was noticed at the bottom. The testing pool after a month had only very light pollution.	SGP had better test results in comparison to S-200C, since it showed even from the 1st Day that a remarkable quantity of heavy oil has been dispersed, while the S-200C had still a great amount of heavy oil on the surface despite the disappearance of emulsion
PH9/NANO MASS (Reference product -Marichem Oil Spill Dispersant)	PH9/NANO MASS showed visually good test results. The oil as the time passed was slowly diluting in the water column. The product was also applied on thin film and worked efficiently on thin film.	PH9/NANO MASS showed the same behavior as the Marichem - commercial product, which however was very foamy.
$fCaCO_3$	fCaCO3 showed visually good results, since a significant amount of the heavy oil (more than 70-80%) was not on the surface after the application.	No commercial product for comparison
BIO 10 (Reference product - Marichem Oil Spill Dispersant)	The product dissolved efficiently thin film, however the heavy oil remained.	BIO 10 showed the same behavior as the Marichem - commercial product which however was very foamy.