

Final Report

1.1 Final publishable summary report

Executive Summary

FP7 project SORBENT-DEMO (“Demonstration of soil remediation technique for in situ cleaning of soils contaminated with heavy hydrocarbon mixtures”, Grant Agreement No.: 605607) is targeted to demonstrate at full scale and bring to the soil remediation market a cost-effective and highly efficient soil remediation technique applied in-situ to remove accidentally or intentionally deposited oil as well as historical oil contamination. The technique consisting of three independent stages each based on different remediation approach has been developed under the activities of successfully implemented research project SORBENT¹ and has already proved it’s applicability to all types of oil (including crude and heavy oil) in different soil profiles and convenient use in areas difficult to approach.

Achievements:

The project activities at the first project period were dedicated for definition of demonstration strategy with the aim to evaluate the performance of separate SORBENT technique elements under different conditions with regard to geography, soil profile and oil pollutants, and identification of demonstration sites for defined strategy implementation. Six the most significant demonstration factors (type of contaminant and its concentration in the soil, scale of the demonstration, demonstration case, soil properties, and hydrogeology and climate conditions) were selected as a basis for eight demonstration scenario development and ten demonstration sites were selected for application of SORBENT technique and its elements combinations for oil hydrocarbon polluted soil remediation. Two large scale demonstration sites have been selected in Lithuania, and seven small scale demonstration sites were selected in Lithuania and Spain. The following four combinations of the SORBENT elements were chosen for scenarios development: a) SORBENT system + SORBENT bacterial preparation + phytoremediation, b) SORBENT system + SORBENT bacterial preparation, c) SORBENT bacterial preparation + phytoremediation, and d) SORBENT bacterial preparation alone. In parallel, basic requirements for the evaluation management and monitoring were determined, criteria for the demonstration scenarios evaluation were defined and the measures for SORBENT products validations and identification of operational and decision-making processes for getting the regulatory acceptance of the new SORBENT technique and its products were defined.

The activities at the second project period were concentrated on demonstration performance and the novel treatment approach implementation. The demonstration tasks were performed mainly by GROTA, CBIO and BC with the strong support from LUR, while WBE assisted testing with the aim to get acquainted with new technique and its components in order to be prepared for market introduction. Series of experiments were carried out to ensure maximum viability and efficiency of novel products on selected types of soil, contaminated with different kinds of oil pollutants. Verification and validation of achieved results was achieved by preparation of guidance document for verification of soil remediation and documentation of SORBENT integrated technique, estimation of eco-efficiency (by an environmental study) and preparation of the tools to assist contamination problem owners and remediation project managers in selecting remediation concept. For the preparation of the market uptake and competitive business development, the economic and financial evaluation has been performed and tactical market entry plan supported with cost-

¹ SORBENT: Soil remediation technique for in situ cleaning of soils contaminated with heavy hydrocarbon mixtures (GA number 232533, started in September 2009 and completed in August 2011, financed from FP7-SME-2008-01 call

benefit analysis had been prepared. Finally, referring to all the work done, Partners jointly prepared a set of recommendations how the SORBENT technique could be improved to ensure effective up-scaling.

At the end of the project Consortium consists of three SME partners (GROTA, WBE and CBIO) which share IPR received from both previous and current project, one other participant (BC) and one RTD partner (LUR). SME partners are ready to the SORBENT products market introduction. The products are being introduced under the trade name Oil Spill Fix Bioremediation which has been protected by Intellectual Property Office in London. The functionalities and cost-effectiveness of the products are tested and confirmed as a unique selling points which will be fundamental for entering the new markets while the environmental friendly approach will provide an added value for facilitating solution for serious ecological problems caused by both oil contamination issues and an abundant supply of pulp and paper mill industrial waste to be recycled.

Further information can be found at the websites <http://www.sorbent.lt> and <http://www.oilspillfix.eu/>. The promotional video is available at https://www.youtube.com/watch?v=pgDoK5_X2M4&feature=youtu.be.

1.2 A summary description of project context and objectives

1.2.1 Project context

There is an increasing understanding that the natural resources should be kept unspoiled, which makes polluted soil and groundwater unacceptable. Therefore, soil contamination is an increasing worldwide problem, which poses severe threats to ecosystem and human health. Through the EU, thousands of sites have been contaminated by previous industrial use, former military sites, storage bases of oil products, landfills and other sources of pollution. A huge amount of contaminated sites have been identified and require clean up; moreover, despite of different cleaning measures applied, area of contaminated land is constantly increasing as a result of almost all sort of human activities as well as inadequate practices and accidents. The European Commission has acknowledged that soil pollution in the EU is a major issue and currently soil remediation is one of the top priorities of EU environment policy².

The world soil remediation market is dominated by a several key-proven soil remediation technologies having two principal clean up approaches: in-situ, which is always done on site, and ex-situ, which can be done on- or off-site. Technologies itself include air spraying, soil vapour extraction, natural attenuation (in-situ), evacuation and landfill, thermal desorption, incineration, surface capping and containment (ex-situ) and bioremediation (both in- and ex-situ). These technologies are dominated due to convenience, ease to integrate into remediation systems and acceptance, but generally are limited by insufficient effectiveness, expensiveness and (or) long cleaning period. There is still a strong push for more effective in short term and cheap technology for soil remediation.



² Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. The implementation of the Soil Thematic Strategy and ongoing activities COM/2012/046 final

SORBENT-DEMO project aims to bring to the soil remediation market a cost-effective and highly efficient soil remediation technique applied in-situ to remove accidentally or intentionally deposited oil as well as historical oil contamination. This technique consisting of three independent stages³ each based on different remediation approach has already proved it's applicability to all types of oil (including crude and heavy oil) in different soil profiles and convenient use in areas difficult to approach. SORBENT-DEMO has demonstrated at full scale this novel SORBENT technique and its products developed under the activities of successfully implemented research project SORBENT financed from FP7-SME-2008-1 call.

1.2.2 Objectives

The overall objective of SORBENT-DEMO is to carry out the *targeted full-scale demonstration* of the novel cost-efficient SORBENT soil remediation technique applied in-situ to sites contaminated with heavy hydrocarbon mixtures for the bringing sites back to the acceptable environmental standards and to *develop the framework to get regulatory acceptance of the novel technique*. This objective is divided into **a set of demonstration, evaluation and non-technical objectives** targeted to overcome a number of remaining and real market barriers for market uptake of the SORBENT technique, mainly caused by the following obstacles:

- Uncertain demand from the market for the SORBENT technique and its elements leading to the uncertainty of return on further investment to SMEs involved;
- Lack of funds within the SMEs resulting in a considerably longer time-to-market (long-term developments that require a long time to mature from research to products and large-scale implementation);
- Too high risk to take for an individual partner (SME partners forming a supply chain from different Member States are prerequisite, as together has a larger potential to create confidence among both the soil remediation market players and policy makers at the operational and decision-making levels for the SORBENT technique and its products acceptance, and also to assure that the results will accommodate the needs and requirements of the customers);
- Lack of qualified personnel acquainted with an innovative products within the companies implying the need for further support from research institutions.

Therefore the main *demonstration objectives* of SORBENT-DEMO project are (Milestones MS1, MS2 and MS3):

- To evaluate the performance of separate SORBENT technique elements under different conditions with regard to geography, soil profile and oil pollutants;
- To verify the different combinations of the independent elements of SORBENT technique to solve the contamination problems depending on initial concentration, location, and other defined criteria.

Evaluation objectives are the following (Milestones MS4 and MS5):

- To define procedures to deploy the new SORBENT integrated technique and to gain regulatory acceptance for its usage;
- To prepare business plan for assessment of perspectives for SORBENT technique and market replication plan for competitive business development.

³ This technique consisting of three elements (SORBENT system, SORBENT bacterial preparation and SORBENT phyto-remediation) based on different remediation solutions is significantly faster, more efficient and less costly has been developed within the project SORBENT: Soil remediation technique for in situ cleaning of soils contaminated with heavy hydrocarbon mixtures (GA number 232533, started in September 2009 and completed in August 2011, financed from FP7-SME-2008-01 call).

Non-technical objectives of the project are (Milestone MS4):

- To raise awareness of soil contamination issues to gain more interest in the SORBENT technique and its products;
- To define the exploitation strategy to maximize the value of the project to participating SMEs.

1.3 A description of the main S&T results and foregrounds

1.3.1 The project progress

The main activities and results of the project consist of results obtained during demonstration activities performed under the WP1-WP4 as well as outcomes of dissemination and management activities performed within the WP5 and WP6.

WP1: The project activities started from definition of demonstration factors for future use for demonstration scenarios and strategies development. The work was performed successfully – eight demonstration scenarios and treatment approaches were designed for application of SORBENT technique and its elements combination for oil hydrocarbon polluted soil remediation in the eight preliminary selected sites according to the six major demonstration factors defined. Ten polluted sites in total were selected as candidates for SORBENT-DEMO demonstration areas. In parallel, the analysis of current EU polices and EU environmental legislation framework was performed. The outcomes of this study have enabled to define the SORBENT products validation tools and identify the operational and decision-making processes for getting the regulatory acceptance of the new SORBENT products.

The main objective of **WP2** was to prove the viability and reliability of SORBENT technique and its elements in seasonally cold and warm regions and to show potential for cost reduction. At the first reporting period ten potential demonstration sites were investigated with the aim to produce comparable data inventories for each demonstration scenario in order to specify requirements for each site remediation following the defined SORBENT products functionalities to be tested. The work done enabled to select nine definitive sites for technique demonstration, both at small and large scale, and the application of SORBENT products and its elements combination has been designed with specific requirements for each case. In order to get an effective control and evaluation of the treatment process and the results obtained, control and evaluation procedures were defined. Activities in this work package also covered modification of SORBENT products manufacturing procedures as going from laboratory to pilot scale, from very small quantities to more considerable amounts needed for demonstration activities, scaling up of all technological processes was essential.

Once the integrated concept for small and large scale demonstration was developed, all demonstrations have started. The demonstration tests were carried out in 9 sites in total: in 6 small sites with the area less than 1000 sq.m. (4 in Lithuania, 2 in Spain), in 2 large sites where the demonstration area exceeded 1000 sq.m. (industrial zones in Lithuania: Mazeikiai oil refinery and Gariunai landfill) and in one simulated test area. Due to the short time period and very complicated system to get permission for any activity in the oil contaminated fields, initially planned demonstration in Kuwait during the project lifetime was not performed. However, the Consortium efforts during all project period resulted into very promising outcomes: at the end of the project, relations with the Kuwait Oil Company, responsible for the exploration, drilling and production of oil and gas within the State of Kuwait are established, frame of collaboration with the Kuwait University which is supposed to be an intermediary between Consortium and Kuwait Oil Company is set⁴ and samples from nine different oil contaminated fields are investigated and tested. To

⁴ The demonstration activities in Kuwait are still on the agenda but due to the lack of the time and not favorable climatic conditions (summer period) they are postponed to the post-project period

overcome the problem that the site with the extreme conditions for demonstration was not available, the said conditions were simulated in BC premises: the modular system simulating the conditions in Kuwait had been set and contaminated soil taken from Kuwait oil fields was treated with the SORBENT products following the scenario, designed for Kuwait environment. The summarized results from all demo sites are presented in WP2 documents, the conclusions and results of demonstration evaluation are reported in WP3 deliverables.

The activities in **WP3** were targeted to evaluate and verify project results. The remediation cost, decontamination efficiency and current and future soil use were set as a main criteria for the evaluation. The evaluation revealed that SORBENT products have a high competition potential both in costs and efficiency targets: the calculated costs are more than 30% lower in comparison with the competing technologies and the treatment efficiency is very promising – the decontamination rate of 75% in 30 days was observed in all demonstration areas. This is a very high competitive advantage and can be used as a major selling point in the forthcoming commercialization.

However, analysis of the results from the demonstration sites revealed several limitations. For example, demonstration results indicated that the new bioremediation approach is effective only to the depth of 0.3 m as the deeper soil remediation is complicated due to the lack of oxygen. In the cases when the deeper soil and groundwater are considerably contaminated, the complex solutions are required employing excavation, bioventing and (or) other methods. Looking for the other soil aeration ways for the biodegradation in-situ purposes could be the task for the future projects.

Other important WP3 outcomes are the registered trade mark (Oil Spill Fix Bioremediation, OSF), official validation of one of the products (OSF SORBENT system), the full set of documentation of SORBENT integrated technique, and the following two guidance documents targeted to the contamination problem owners and remediation solution and (or) services providers: Matrix of contaminated sites archetypes and the Handbook for in situ remediation management.

In **WP4**, during the first reporting period efforts were dedicated to preparation of an extensive market analysis including marketing mix and plan of customers' acquisition. On the basis of the findings, the Strategic Marketing framework was defined. At the second part of the project, the tactical marketing programmes were elaborated and the measures needed to implement the SORBENT-DEMO business strategy were set. The preformed cost-benefit analysis confirmed, that the prepared business plan to launch a start venture for the commercialization of the outputs of the project is viable and has a potential to be scaled up. The calculated values of all key performance indicators demonstrate that key business objectives are achievable: ROI percentage of 8.4 shows that the planned investment is safe and stable; IRR of 24.3% confirms that Consortium SME partners are well aware about the business subject and are working in established area; benefit-cost ratio of 1.58 means, that the investor (EC and SORBENT-DEMO Consortium partners in the project implementation phase and project SME partners in three years after the project) can expect 1.58 € benefits for every 1 € of costs.

The main activities in **WP5** throughout the all project duration were focused on design and implementation of a dissemination and exploitation plan that allows the promotion of SORBENT-DEMO results as widely and as effectively as possible while protecting partners' business interests. WP5 objectives were achieved through implemented dissemination agenda using defined dissemination channels such as fully operational project and product websites, visibility of SORBENT-DEMO in various meetings, conferences, events and press and media coverage. At the end of the project it is obvious, that by following the defined strategic direction, the Consortium will meet its future goals for commercialisation. Moreover, dissemination has already commenced despite almost inexistent public information available providing the Consortium with an encouraging amount of interest from the industry. The targeted regions for initial field tests are affluent regions which can provide the Consortium with a profitable commercial development and most important: ensuring future growth and continuity.

1.3.2 Core foreground: Introduction

Oil Spill Fix sorbent system (OSF-s:s)

OSF-s:s (Figure 1) is a newly designed organic system consisting of sorbent material developed from paper mill wastes short fibres, biosurfactant, microbial cells producing biosurfactant, and enriched with nutrients: nitrogen and phosphorus. Due to immediate sorption activity and high sorption capacity it enables to lessen or localize spread of oil hydrocarbons in case of accidents, extreme situations or their liquidation, hence, can be effectively used in cases required immediate response. Other significant advantages of this product are (1) indifference both for the nature of hydrocarbons, soil type and concentration level and (2) biodegradability: being fully biodegradable it allows the achievement of close ecological cycle and therefore can be considered as beneficial for the environment. OSF-s:s can be applied as soon, as the average temperature reaches $-10\text{ }^{\circ}\text{C}$ to begin sorption process, but biosurfactant producing microbes starts to operate only from $4\text{ }^{\circ}\text{C}$.



Figure 1: Oil Spill Fix SORBENT system (OSF-s:s)

Application guidance:

- OSF-s:s absorbs relatively small (up to 200 L or more) amount of free oil hydrocarbons, so it should be spread directly on the contaminant from the original package.
- In case of ex-situ decontamination, the OSF-s:s along with absorbed contaminant should be collected to impermeable container and taken away to take care of in conformity to standing laws.

- In case of application in-situ in large contaminated areas, it should be spread directly on the contaminated soil from the original package and then the entire contaminated area should be ploughed 10–30 cm deep.
- In case the oil is spilled on the artificial surface, OSF-s:s has to be applied on the whole contaminated area and mixed with oil mechanically. Then, OSF-s:s together with the absorbed oil has to be gathered and safely transported (in a durable plastic bag) to utilization area.

Concentration/application rate:

Soil type	Oil concentration	
	> 200 g/kg	100–200 g/kg
Loam	3–10 cm OSF-s:s on the top of ground	NA
Clay	3–10 cm OSF-s:s on the top of ground	NA
Sand	3–10 cm OSF-s:s on the top of ground	1–3 cm OSF-s:s on the top of ground

Amount of OSF-s:s depending on a volume of contaminant on artificial surface:

Amount of oil hydrocarbons, L	Amount of OSF-s:s, kg
1 L	0.30–0.34
10 L	3.0–3.4
50–100 L	17–34
100–200 L	32–65
>200 L	>65

If the oil hydrocarbons are spilled onto a wet surface and the water percentage is up to 50%, the OSF-s:s amount must be doubled for the same amount of hydrocarbons need to be sorbed.

Important tips:

- As the temperature of decontamination environment approaches the freezing point of oil pollutant, the sorption process slows down and ultimately stops altogether. Sorption process is most rapid in temperatures above +5 °C.
- If the moisture of surrounding environment is relatively high (i.e. rainy seasons, marsh, riverbank etc.), the sorption process slows down. The ratio of 1:4 (v/v) of oil and water in the environment reduces the sorption capacity of OSF-s:s from 40% to 60%.
- If the initial concentration of heavy oil hydrocarbons is very high (above 220 g/kg), OSF-s:s can be used as a fast and effective tool to reduce the contaminants concentration (for the first-step treatment in cases requiring immediate response) until the concentration is reduced to an acceptable level to start the bioremediation process.
- In case of relatively small spillage, OSF-s:s can absorb all types of oil products.
- OSF-s:s is very beneficial for the soil quality and plants augmentation because mixed with soil it enhances roots aeration and accelerates microorganism activity, improving plants ability to assimilate nutriment.
- OSF-s:s is not suitable for aqueous or aggressive liquids: strong acids, caustic oxidizers or reactive chemicals. In particular, there is a risk of degradation with the following: oleum, chlorosulphonic acid, fuming nitric acid, chromic acid, sulphuric acid and hydrogen peroxide.

- OSF-s:s itself is not a hazardous product, however, it takes on the characteristics of the liquids it absorbs. Adequate precautions should be taken and appropriate personal protective equipment should be worn when handling or storing hazardous/inflammable materials.

Oil Spill Fix bacterial preparation (OSF-s:bp)

The **OSF-s:bp** (Figure 2) is a mixture of microbial cells, targeted for the decontamination of hydrocarbon polluted environment. The main advantage of this product is that it is not selective for the nature of hydrocarbons (normal, branched, aromatic and etc.) in different soil profile media; and subsequently not only crude oil heavy fractions and their heavy products but also light fractions which can migrate rapidly through soil are dissolved. OSF-s:bp is completely compatible with the OSF-s:s and performs well with the different levels of contaminant concentrations: for the low initial concentrations of oil hydrocarbons (10–20 g/kg), the hydrocarbons degradation rate is 0.10–0.14 g-hydrocarbon per day, and for the high initial concentrations (100–300 g/kg) the hydrocarbons degradation rate is 0.61–0.70 g-hydrocarbon per day. OSF-s:bp can be used from the concentration of 220 g/kg, which is the optimum value required to achieve contaminant concentration levels innocuous enough for microbial strains hydrocarbon degraders to start up the biodegradation processes.



Figure 2: OSF-s:bp in liquid and powder form

Application guidance

Conditions for use:

	Working range	Optimum
Soil salinity	Up to 3%	Less than 1%.
Temperature	+4 to 40 °C	+15 to 25 °C
pH	(4 to 9).	6 to 8
Moisture level	20% and 60%	60%
Nutrients C:N:P (molar ratio)	100:1:0.1	120:10:1
Concentration of pollutants	up to 220 g/kg	

Carbon content in contamination (C) is calculated by multiplying concentration of hydrocarbons in soil by 0.8, while nitrogen (N) and phosphorus (P) contents are calculated according to the chemical formula of compounds used.

Application method

- OSF-s:bp in frozen form

Prior to use, the microbes are to be thawed at room temperature and diluted with water. For maximum performance, revival of microorganism in 20–30 °C temperature water for 2–4 hours is highly recommended. Mixing and supply of air will improve revival process.

- OSF-s:bp in lyophilized form

Resuspend 100g of lyophilized product in 1 liter of warm water (20–30 °C) for 2–4 hours. Mixing and supply of air will improve revival process.

After dilution and revival, OSF-s:bp can be sprayed using standard spray equipment, such as hand sprayers, mechanical sprayers, fire response equipment, pressure washers, etc. Contaminated soil may require tillage to both, properly mix the preparation with soil and make air more available for the oil degraders.

Nutrient (N and P) levels need to be maintained for optimal bacterial activity. Thus, depending on the results of site monitoring, nutrients may be needed to be applied more than once. Suggested C:N:P ratio must be at least 100:1:0.1

Concentration/application rate

OSF-s:bp preparation must be diluted using one part of the product to nine parts of clean water prior to application. Product dosage will vary according to level of contamination, area of application, and schedule required for cleanup.

Type of soil	Oil concentration		
	100–200 g/kg	50–100 g/kg	up to 50 g/kg
Loam	3.0 l/m ²	2.0 l/m ²	1.5 l/m ²
Clay	2.8 l/m ²	1.6 l/m ²	1.2 l/m ²
Sand	4.5 l/m ²	3.5 l/m ²	1.8 l/m ²

Increased quantities of the product and multiple applications may be required to meet shorter cleanup time or in cases, when soil is heavy polluted with hydrocarbons and environmental conditions are unfavorable for vitality of the bacteria.

Important tips

- The bacteria used in this product are naturally occurring and belonging to 1 group of risk (Directive 2000/54/EC); these bacteria do not pose any known environmental risk.
- Materials to avoid: Strong acids or alkali compounds, formaldehyde and chlorine bleach may render the bacterial cultures inactive or even destroy them.
- Personal protection: Avoid eye contact. Wear protective clothing and gloves, wash hands with soap and water after handling the product. Wash contaminated clothing and footwear before reuse. The bacterial preparation must not be used in direct contact with food or fodder.

Oil Spill Fix Phytoremediation

It is process found to be the most effective with the two plant species: *Phleum pretense* (timothy) and *Lolium perenne* (ryegrass).

Application guidance

Operational conditions:

- Can be applied only if the level of contamination is low (from 50 g/kg);
- Decontaminant has to be able to achieve full ecological cycle;
- Decontaminant has to be compatible with the soil designated for agricultural or otherwise sensitive use after the treatment (the decontamination process must not have any negative impact on the area regarding its purpose).

Application procedure:

Seeds should be sowed in the period from early spring to the end of summer. The recommended amount of seeds, depending on soil type and initial oil hydrocarbons concentration, are:

Type of soil	Oil concentration		
	up to 50 g/kg	20–35 g/kg	up to 20 g/kg
Loam	25–30 kg of seeds, /ha	25 kg of seeds/ha	18 kg of seeds /ha
Clay	25–30 kg of seeds /ha	25 kg of seeds/ha	18 kg of seeds/ha
Sand	28–33 kg of seeds/ha	26–28 kg of seeds/ha	20 kg of seeds/ha

Important tips

- If the contamination of soil is higher than 20 g/kg the germination of plants is lower (germination degree is lower than 80%).
- The optimum soil pH range is between 5 and 7.5.

1.4 Potential impact and main dissemination activities and exploitation results

During the project, SORBENT-DEMO consortium has tested and demonstrated the SORBENT products (OSF-s:s, OSF-s:bp and OSF-sPh) and a new bioremediation solution (SORBENT integrated technique) applicable in-situ to treat accidentally or intentionally deposited oil as well as historical oil contamination. The products were tested on different types of oil (including crude and heavy oil) in different treatment scenarios – nine scenarios in total in cold, warm and hot climatic conditions.

The novel SORBENT technique for cleaning up of heavy oil hydrocarbons was shown to have high consumer acceptance and to confer potential economic advantage to the participant SMEs. The acceptance was shown both for the in-situ remediation in sandy soils and for in-situ remediation in low-permeability or highly heterogeneous soil formations. The question remains how much the price can be reduced by manufacturing at a large production scale (producing items per month) and also what price range will be acceptable for smaller in-situ remediation where economies of scale could not be achieved. The estimations have indicated a potential for lowering costs due to a larger production scale by 50–70%. Following the estimates provided by the UK Centre for Economic and Environmental Development, that from 2015 the cost across the remediation cycle are split approximately 20% on initial assessment, 60% on remediation and 20% on final validation, the SORBENT products contribute directly to long-term cost reduction.

1.4.1 Potential impact

The market estimations in Europe are based on the following calculations and assumptions:

- Total expenditure on site remediation in Europe – 10.7 €/capita⁵;
- Total population of the EU – 508.2 million;
- Total market value for site remediation in Europe – 5.4 billion €;
- A revenue share of chemicals and microbial preparation – 3%;
- Total market value for chemicals and microbial preparation – 162 million €;
- 42% of expenditure comes from the public budgets, 58% from private investments;
- Total B2B market value for chemicals and microbial preparation – 94 M€;
- Average amount spent on remediation site – 37.1 k€ (7.5–232 k€) per year, if the total expenditure is calculated, large projects: 50–500 k€, small projects: 5–50 k€);
- Hence, chemical and microbial preparation revenue from large sites – on average 1.1 k€ per site (1.5–15 k€ for large projects, and 150–1.5 k€ for small projects);
- Hence, the total estimated market in terms of site is 94 M€/1.1 k€/site = 85;
- Total units estimation – 5 €/m², 94 M€/5 = 18.8 million m²;
- OSF Sales forecasts: 2017 – 44 k m² (0.23% of the total market), 2018 – 436 k m² (2%), 2019 – 674 k m² (3.5%).

The market estimations in East Asia are based on the following calculations and assumptions:

- Total market value for soil remediation in Asia – 2.64 billion €: 2.2 billion in the targeted market – East Asia (the Gulf region)⁶;
- A revenue share of chemicals and microbial preparation – 3%⁷;
- Total market value for chemicals and microbial preparation – 66 M€;
- Total units estimation – 5 €/m², 66 M€/5 = 13.2 million m²;
- OSF Sales forecasts: 2017 – 26.4 k m² (0.23%) 2018 – 264 k m² (2%), 2019 – 462 k m² (3.5%).

The market estimations in Canada are based on the following calculations and assumptions:

- Total expenditure on site remediation in Canada – 7.7 billion USD (6.77 billion €) per 15 years (2.21 billion €/year)⁸;
- A revenue share of chemicals and microbial preparation – 3%;
- Total market value for chemicals and microbial preparation – 66.3 M€;
- Total units estimation – 5 €/m², 66.3 M€/5= 13.26 million m²;
- OSF Sales forecasts: 2017 – 26.5 k m² (0.23% of the total market), 2018 – 265 k m² (2%), 2019 – 464 k m² (3.5%).

⁵ Source: <http://www.hindawi.com/journals/jeph/2013/158764/>

⁶ Source: <https://home.mcilvaineconomy.com/index.php/component/content/article/7-news/700-nr1921>

⁷ Source: <https://home.mcilvaineconomy.com/index.php/component/content/article/7-news/376-nr1697>

⁸ Source: <https://home.mcilvaineconomy.com/index.php/component/content/article/7-news/376-nr1697>

Sales forecasts and profit predictions are based on the results of performed market research and are calculated on the basis of the existing capacity of the pilot equipment and the planned capacity (due to a planned capital investment in the machinery):

- Year 1 production capacity is ca. 200 l/week which meet the demand of 2000 units sold, sufficient for $2000 \times 52 = 104$ sq. m/year;
- Year 2 production capacity is planned to reach ca. 2200 l/week (due to the 2000 l capacity equipment purchased with the help of the attracted investment from an institutional investor) which could meet the demand of ca. 1144 units (a surplus of 108 units could be added to the stock for Year 3);
- Year 3 production capacity is planned to reach ca. 3200 l/week benefiting from a full capacity of the installed equipment and the pilot equipment that could meet the demand for some 1746 units (1664 units from Year 3 production and 108 units from a stock from Year 2). After Year 3 the maximum capacity would be reached and there would be a need to install an additional line (with the total capital expenditures of 552,000 €).

According to market data and assumptions based on them, the project SME partners will gain 4.5 M€ in net profit during the first three years after the project. The internal rate of return (IRR) of the project is 24.3%, return of investment (ROI) is 8.4% and the benefit and cost ratio (BCR) is 1.58 over a three year period. In conclusion, as the net present value of the project is significantly positive and IRR is relatively high, the key SORBENT business objectives are achievable and plan for commercialization of the outputs of the project is viable and has a potential to be scaled up.

1.4.2 Social impact

Successfully implemented SORBENT-DEMO project contributes to the following Community objectives.

Contribution to ENVIRONMENTAL protection:

- The Convention on Biological Diversity identifies soil biodiversity as an area requiring specific attention; therefore an International Initiative for the Conservation and Sustainable Use of Soil Biodiversity has been established.
- Contaminated soil itself can impact the environment in various ways, including:
 - Subsequent contamination: contaminated soil that is not (or not properly) remediated has the potential to migrate from the impacted area significantly and possibly contaminate surrounding soils, surface waters and even ground water;
 - Irreversible environmental damage;
 - Human health: hazardous chemicals may enter food chains;
 - Land use: the contaminated land is no longer in use as an asset and becomes a long-term treat to surrounding environment.

Direct contribution to SOCIAL sector:

Soil remediation sector employment level in 2013 within EU 27 was equal to 16,000. On the basis of evaluations made by Ernst & Young⁹, the 7 new jobs are created per 1M€ invested in the soil remediation sector. Consequently, high increase of expenditures soil remediation would stimulate the market and ensure not only an acceleration of remediation processes but also job creation.

⁹ ec.europa.eu/environment/enveco/eco_industry/pdf/ecoindustry2006.pdf

Contribution to POLICY objectives:

The area of contaminated land is increasing despite of various cleaning measures taken. This is considered to be a result of soil contamination currently being produced by inadequate practices and various accidents. The main consequences of soil contamination consists of risk to human health, most prominent to people living on or nearby a contaminated site, contamination of surface water and groundwater, risk of ecotoxicity for the flora and fauna, causing loss of biodiversity and biological activity, limitations of contaminated land use and etc.

Keeping in mind that as much as 53.4% of the contaminated soil in EU countries is affected by oil pollutants, it is evident, that SORBENT-DEMO project addresses these concerns directly and successful implementation of the project results can be expected to have a significant impact on the situation improvement.

Ethical and gender issues

Throughout the duration of the project, there were no known ethical or gender issues and, considering project subject, it is not likely to occur in the future.

Although equality of rights is not directly expressed in project objectives and tasks, equal rights have been ensured between all project Partners for both male and female participants, disregarding their social status, religion, race, physical or mental disorder and any other characteristic.

1.4.3 Dissemination activities

The main purpose of dissemination efforts in SORBENT-DEMO project is to raise awareness of SORBENT-DEMO in order to maximise its impact and encourage acceptance of its results by the targeted stakeholders. This plan is intended to ensure that the dissemination activities within project SORBENT-DEMO are closely oriented to the current and future market opportunities and to prepare the target audience including potential users, customers, researches and strategic partners for SORBENT results adoption.

A policy of broad dissemination of project results has been particularly focused on potential customers, remediation practitioners (technology developers, technology vendors, technology users, technology verifiers, and technology investors), funding agencies and authorities making decisions on small and large-scale soil remediation projects.

The dissemination actions were aimed to:

- Introduce the main results of the project in the form of face-to-face meetings, technical publications and conference presentations to the European and national audience with the aim to exchange views on the project, to seek for the common understanding and to raise awareness about the project in order to maximize its impact;
- Facilitation of the take-up of project results by participating SMEs through onsite trainings;
- Attract researchers and environment sector players to use SORBENT results in planning and execution of environmental actions and promote SORBENT results through workshops, panels, seminars and etc.

Dissemination activities were planned in accordance with stage of the development in the project. Although a number of dissemination activities took place during the first 9 months of the project, the most significant dissemination actions were performed during the second project period. Dissemination was done by:

- Project presentation by dissemination the written information;
- Project Web site, and
- Market exchange.

1.4.4 Dissemination channels

SORBENT-DEMO has been promoted through presentation at both academic and industry venues. The consortium organized different meetings and sessions and an integral part of the dissemination activities was also the cooperation with other EU projects, organizations and professionals working in the field of common interest. These dissemination opportunities represent general dissemination channels.

With respect to nature of SORBENT-DEMO project the following dissemination channels were selected and developed in this dissemination strategy:

- Internet;
- Events and
- Press and media.

Internet

To disseminate the results and all the information about SORBENT-DEMO project, the web site at <http://www.sorbent.it>, which is the main dissemination tool of the project has been created. It serves to inform the stakeholders, scientific community as well as any other interested third parties.

As result of product development during SORBENT-DEMO project, a trademark has been created and logo and mark protected by patent register. On the basis of this trademark, a new product website has been created, hosted at <http://www.oilspillfix.eu>. As a corporate website it is in constant evolution and contents are updated and modified to adapt to market needs.

Events

Essential to the promotion of SORBENT-DEMO is its presence at the regional, national or international events focusing particularly on the above listed field of interests. SORBENT participation at events took two forms in particular. Firstly, representatives of SORBENT presented ongoing work, progress and results reached during the project, while the other form was more formal and consisted of a distribution of SORBENT-DEMO promotional materials. In most cases both forms were applied at once.

Especial attention was given to environmental sector as it will mainly benefit from the results developed during the project. The aim is to promote results of SORBENT to relevant commercial organizations in order to influence the market and create opportunities for future exploitation and use of SORBENT results. To achieve this, dissemination activities had been focused on the events (conferences, workshops, trades, exhibitions etc.) that are more environmentally oriented.

Project events took place in a form of public workshops, networking sessions, conferences and exhibitions. The most outstanding event where project and SORBENT products were introduced was GEO-2016's 12th Middle East Geosciences Conference & Exhibition. Consortium was represented by GROTA and WBE.

The two main objectives were set for participation in this event:

- To introduce the SORBENT-DEMO consortium and Oil Spill Fix products to a wider international audience, in particular targeting oil companies. More than 30 one to one meetings and contacts with chairman's and business managers of different oil companies;
- To strengthen the relation with representatives of targeted market region (Kuwait University and Kuwait Oil Industry): to show the Consortium is truly interested in a business cooperation it is essential to maintain a regular presence in the area.

Unintentionally, Consortium partners provided a good level of bioremediation education to various secondary schools students that visited our stand. 2016 Exhibitor list, where SORBENT-DEMO consortium is included is available at <http://geo2016.com/exhibition/exhibitor-list-2016/>.



Figure 3: SORBENT-DEMO stand at GEO2016

A summary of all dissemination events with the brief description of them is included in Plan for use and dissemination of foreground.

Press

The dissemination activities were extended with the publications in national and local press and on-line publications. The brief summary is in the table below:

Media	Place / date	Activity	Partner involved
Association des journalistes scientifiques de la presse d'information	01/12/2015 Paris & other France regions	Media briefings	WBE
Agence Europe	01/11/2015 France, EU	Media briefings	WBE
Demonstration of soil remediation technique for in situ cleaning of soils contaminated with heavy hydrocarbon mixtures (SORBENT-DEMO)	Lurederra Annual Report 2015	Publication	LUR
Catalogo de ingeniería sostenible http://issuu.com/zuhaitzasustainablede/sign/docs/ingeniaritza_jasangarria_2014	On Line 2016	Publication	CBIO

1.4.5 Exploitation of project results

All exploitation activities performed within the project were directly targeted to SORBENT products commercialization. The results that may have commercial or industrial applications are:

Products:

- OSF-s:s: SORBENT system for soil application. Composition: Sorbent material, biosurfactant, microbial cells and nutrients. Bag (25-850 kg) / Big Bag (1000 kg) / container.
- OSF-s:bp: SORBENT bacterial / microbiological preparation. Mixed culture of hydrocarbon degrading microorganisms for application on soil and water. Liquid and powder form.
- OSF-s:Ph: SORBENT phytoremediation specially selected plants for final application on Soil. Packaged seeds.
- OSF-bs: Biosurfactant produced to be mixed with Sorbent. Liquid form.



Figure 4: Oil Spill Fix Products (Demo format)

Service / technology

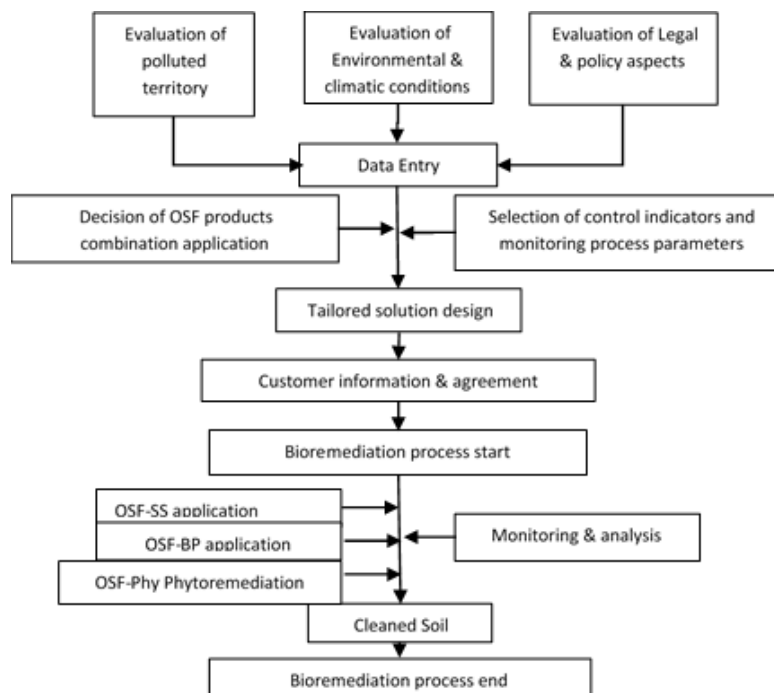


Figure 5: Oil Spill Fix Service scheme

1.5 Project public website

The public SORBENT-DEMO website is hosted at <http://www.sorbent.lt> is designed in a clear and consistent way, so that visitors can easily locate all information intended for them. Upon entering the homepage of the Project, users are able to browse the Public area content, while access to Partners area requires entering password in a standard login interface that is located below the subsections list. All subsections of Public area can be accessed by all users. However, all public content within the website is read-only – changes to texts and files therein can be made by administrator only.

The OSF products website (www.oilspillfix.eu) is designed as a corporate web in a way that visitors can easily locate information about product, results and contact form. The web is translated into 4 languages (English, Spanish, Arabic and French) that covers, after Chinese, the most spoken languages in the world.

The consortium contact details are in the table below:

Partner	Partner's company		
GROTA	UAB GROTA	Danguole Draguniene Antanas Marcionis	danguole.draguniene@gmail.com antanas@grota.lt
WBE	Wild Berry Enterprises Ltd	Antonella Cane	antonella.cane@gmail.com
CBIO	CLEAN-BIOTEC SLL	Nathalie Beaucour	nathalie@cleanbiotec.com
BC	UAB Biocentras	Vilma Cipinyte Saulius Grigiskis	cipinyte@biocentras.lt grigiskis@biocentras.lt
LUR	L'UREDERRA, Fundacion Para el Desarrollo Tecnologico Y Socia	Marta Mateo	marta.mateo@lurederra.es