Integrated Biotechnological Solutions for Combating Marine Oil Spills

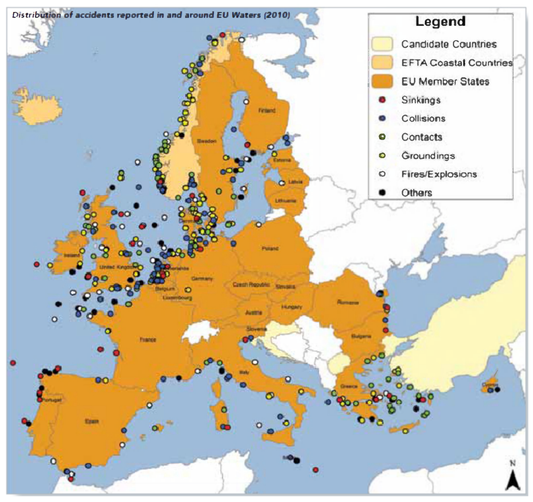
Nicolas Kalogerakis[1] and Philippe Corvini[2]

[1] Technical University of Crete, Department of Environmental Engineering, Polytechneioupolis, Chania 73100, Greece. E-mail: nicolas.kalogerakis@enveng.tuc.gr

[2] University of Applied Sciences and Arts Northwestern Switzerland, School of Life Sciences, Institute for Ecopreneurship, Gründenstrasse 40, 4132 Muttenz – Switzerland. Email: philippe.corvini@fhnw.ch

www.killspill.eu

Oil spill disasters are a worldwide problem and current technologies do not satisfactorily address the issue. It is important to recognize that "miracle microorganisms" and "magic elixirs" sprinkled on an oil spill will not do the job. An integrated approach considering at the same time: (1) metabolic requirements of biodegrading organisms alongside the properties of the oil, (2) environmental limitations on oil biodegradation and (3) innovative delivery mechanisms for agents that alleviate these bottlenecks is critical. This is the essence of the Kill•Spill project. It represents a European initiative fully committed to tackle oil spill disasters in an integrated and interdisciplinary fashion employing highly efficient remediation strategies.



OBJECTIVES & PRODUCTS:

The principal objective of Kill•Spill is to develop highly efficient, economically and environmentally viable solutions for the clean-up of oil spills caused by maritime transport or offshore oil exploration and related processes, which have been fully validated in large mesocosm facilities under controlled conditions and by application to real life oil spills. In general, once crude oil is spilled, it takes at least one week before biodegradation processes begin to take effect. Kill•Spill aims to shorten this start up period to the absolute minimum by providing technologies for example, that provide the necessary nutrients together with hydrocarbon degrading consortia and/or enhancing compounds (biosurfactants) to both accelerate and maximize bioremediation rates from the time of application. In addition, when the use of dispersants is recommended, the previously mentioned biostimulation and bioaugmentation formulations will be applied together with specific compounds acting as dispersants that take the oil from the surface to the water column and ultimately to the sea floor.

Taking into account that as we go deeper in the water column, the amount of dissolved oxygen is more difficult to replenish by diffusion, Kill•Spill also offers specific novel technologies (Oxygel™ and Aerobeads™) that release oxygen over longer periods of time. It maintains as a result greater bioremediation rates of dispersed oil in the water column, even when it reaches the sediments. In cases where it is not feasible, this approach will be complemented with the development of processes to stimulate oil biodegradation anaerobically in anoxic sediments. Once the dispersed oil reaches the sediments, bioremediation rates are substantially reduced due to the prevailing anoxic conditions. Kill•Spill provides a series of highly innovative technologies (e.g., "Kill•Spill snorkel", "Kill•Spill Robot", "Kill•Spill Sed-Cleaner") that overcome this problem and induce enhanced biodegradation rates in the sediments. These technologies can also be used for the remediation of recurrently polluted sediments (from old oil spills) in all types of environments from the Eastern Mediterranean to Disko Bay in Greenland. In addition, several other innovative products will be developed, e.g., "Kill•Spill All-in-One", "Kill•Spill Deep-sea", "Kill•Spill Bio-boom", besides the "Kill•Spill Biosensor" for in situ monitoring of oil degradation.

The solutions developing from the Kill•Spill project are evaluated against current industry solutions, and promoted to the European spill industry through conferences and seminars. Thus, Kill•Spill consortium will generate new industrially driven foreground and deliver innovative processes and services to policy makers and European citizens. The Kill•Spill project has also much to offer to the Marine Strategy Framework Directive (MSFD). For example, all the technologies developed for hydrocarbon polluted sediments can be part of the mitigation measures to return marine environments to Good Environmental Status (GES). Furthermore, the monitoring tools can be used by Member States in the requested initial assessment to identify current environmental status. Moreover, many of the Kill•Spill biostimulation strategies can be applied to sea areas faced with chronic pollution.

The KILL•SPILL Consortium

Partner (& Contact)	Country	Type
Technical University of Crete (Nicolas Kalogerakis)	Greece	RTD
University of Applied Sciences and Arts Northwestern Switzerland (Philippe Corvini)	Switzerland	RTD
University of Bologna (Fabio Fava)	Italy	RTD
University of Newcastle upon Tyne (Ian Head)	UK	RTD
Geological Survey of Denmark and Greenland (Jens Aamand)	Denmark	RTD
Sapienza University of Rome (Mauro Majone)	Italy	RTD
The Spanish Research Council (CNB: Fernado Rojo, EEZ: Juan Luis Ramos, ICP: Manuel Ferrer)	Spain	RTD
University of Ulster (Imbrahim Banat)	UK	RTD
The National Research Council (IAMC: Michail Yakimov, ISRA: Valter Tandoi & Federico Aulenta)	Italy	RTD
University of Milan (Daniele Daffochio)	Italy	RTD
Ghent University (Nico Boon)	Belgium	RTD
Institute of Chemical Technology Prague (K. Demnerova)	Czech Rep.	RTD
University of Copenhagen (Jan Christensen)	Denmark	RTD
Bangor University (Peter Golyshin)	UK	RTD
Helmholtz Centre for Environmental Research (Martin Elsner)	Germany	RTD
Marine Biological Association of the UK (Michael Cunliffe)	UK	SME
Catholic University of Louvain (Spiros Agathos)	Belgium	RTD
National University of Ireland Galways (Mark Johnson)	Ireland	RTD
Biobased Europe Ltd (Chris Hunter & Lee D'Arcy)	UK	SME
Biorem Engineering (Wim De Windt)	Belgium	SME
Gorton Consultancy (Joe Small)	UK	SME
Creative Research Solutions (Rob Onderwater)	Belgium	SME
Environmental Protection Engineering SA (Vassilis Mamaloukas)	Greece	SME
Madep SA (Trello Beffa)	Switzerland	SME
HeiQ Materials AG (Murray Height)	Switzerland	SME
MMB AS (Odd-Gunnar Jørgensen)	Norway	SME
Institute of Physical Biology (Ales Lepanje)	Slovenia	SME
EcoTech Systems SRL (Mirko Magagnini)	Italy	SME
UK Spill Association (Roger Mabbott)	UK	Assoc.
Vermicon AG (Claudia Beimfohr)	Germany	SME
Actygea SRL (Fabrizio Beltrametti)	Italy	SME
Microstech (Nicola Di Maiuta)	Switzerland	SME
State University of New York at Buffalo (P. Alexandridis & Marina Tsianou)	USA	RTD

The Kill•Spill Approach to Combat Oil Spills

First Response Actions	**Primary Goal: Contain & recover oil OR disperse oil AND initiate biodegradation at high rates**		
	Booms & Skimmers (contain and recover)	**Novel dispersants (disperse oil in the water column and initiate biodegradation**	**No action (oil dispersion accomplished by strong waves)**
	Innovation: The biodegrading booms for small oil spills	**Innovations**: (i) Biosurfactant based, (ii) biodegradable, (iii) "All-in-one" multifunctional agent, (iv) mineral sorbent	**Innovations**: Monitor portion of dispersed oil Add oleophilic fertilizers ONLY
Follow Up Actions	**Primary Goal: Maintain enhanced bioremediation rates until complete clean up (for all types of oils & marine environment)**		
	Novel Bioremediation Agents	**High efficiency integrated approaches employing bioremediation agents**	**Immediate clean up of contaminated sediments**
	Innovations: Biostimulation & Bio-augmentation agents, novel carriers	**Innovations**: B&B agents, novel carriers (gel, mineral), O2 carriers: Aerobeads™	**Innovations**: Bioelectrochemical platform, IAMC sediment cleaner, increased anaerobic degradation
Longer Term Actions	**Sediments decontamination & environmental monitoring**	Kill•Spill provides proof of robust, reliable and predictable oil spill remediation in large scale tests facilities (Messina) and in real life oil spills (Eastern Mediterranean Sea, North Sea, Norwegian Sea)	
	Innovations: Kill•Spill robot, passive fuel cells, long-term oxygenators, in fauna degraders		

Work Packages

WP1	In depth analysis of current knowledge and identification of technological gaps		
WP2	Development of biosensors and in-situ monitoring tools to determine biodegradation efficiency		
WP3	Development of novel dispersants and sorbent materials		
WP4	Microbial and additive formulations for enhanced bioremediation		
WP5	Efficient clean up of contaminated sediments due to oil spills		
WP6	Development of multifunctional remediation agents for oil spills		
WP7	Impact assessment of developed technologies		
WP8	Field Testing of Most Promising Technologies and Benchmarking with existing products		
WP9	Dissemination	**WP10**	Management

Kill•Spill PRODUCTS & TECHNOLOGIES

No.	Technology	Application
1	"Kill•Spill Biosensor" (Biosensors for HC-monitoring)	On-site monitoring of oil degradation
2	"Kill•Spill FISH-Kit" (Cultivation-independent microbial diagnostic kits)	CARD-FISH diagnostic kit for on-site monitoring of microbial communities
3	"Kill•Spill FCM-Kit" (Cultivation-independent microbial diagnostic kits)	FISH + FCM diagnostic kit for on-site monitoring of microbial communities
4	"Kill•Spill Chip" (Microarray chip)	On-site monitoring of microbial communities
5	CHEMSIC	Monitoring of oil degradation
6	Polymer-based non-woven fabrics	Sorbent material (shoreline and near-shore)
7	Mineral-based powders	Sorbent material, accelerated bioremediation (oxic and anoxic environments)
8	Oxygen-releasing dispersants (OXYGEL™)	Dispersant, accelerated bioremediation (oxic and anoxic environments)
9	Porous granular sorbent (AEROBEADS™)	Sorbent (floating oil), accelerated bioremediation (oxic and anoxic environments)
10	Plant-based biosurfactant blends (SC1000™, SUPERSOLV™, EASYSOLV™)	Emulsification and mobilization of oil, sand washing, accelerated bioremediation
11	Microbial biosurfactants and emulsifiers	Emulsification and mobilization of oil, sand washing, accelerated bioremediation
12	Formulated HC-degrading MOs and consortia	In-situ bioaugmentation (incl. ABA), further technology development
13	High-pressure reactor	Lab-scale testing environment for deep-sea cases
14	Microdroplet reactor	Improvement/isolation of degrading MOs
15	Low cost biostimulant formulations	Accelerated bioremediation, further technology development
16	"Kill•Spill ElectrO_2" (Electrode-based oxygen supply)	In-situ sediment cleanup
17	"Kill•Spill snorkel" (Microbial electrochemical snorkel)	In-situ sediment cleanup
18	"Kill•Spill Robot" (Bio-electro-chemical roaming system)	In-situ sediment cleanup
19	Infauna accelerated degradation	In-situ sediment cleanup
20	"Kill•Spill Sed-Cleaner" (Modular system for enhanced biodegradation)	In-situ bioaugmentation and biostimulation for sediments
21	Sequestering sorbents	Sorbent material for oil sequestration in sediments
22	"Kill•Spill Deep-sea" (Multi-functional bioremediation agents)	Enhanced bioremediation of HC-"clouds" formed in deep-sea oil releases
23	"Kill•Spill Mesoporous" (Mesoporous silica (nano)particles)	Enhanced bioremediation though bioaugmentation and biostimulation on silica
24	"Kill•Spill SlowRelease" (Slow release microparticles)	Enhanced bioremediation though bioaugmentation and slow-release fertilizers in lipophilic carriers
25	"Kill•Spill All-in-One" ("All-in-One" multifunctional carrier)	First response measure for enhanced bioremediation and oil dispersion
26	"Kill•Spill MineralSorb" (Multifunctional sorbent materials)	Mineral based Sinking and agent (Oil transferred to sediments) and enhanced bioremediation
27	"Kill•Spill Bio-carriers " (Porous bio-carriers)	Biomaterials for immobilization of HC degraders and biostimulants for sea water & sediments
28	"Kill•Spill Bio-boom" (Improved biodegrading booms)	Oil barriers (booms) and with enhanced sorbent & bioremediation capabilities.

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