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Abstract

This study defines the environmental problems concerning the Seman basin. The present situation in the Seman basin is characterized by an evident biological and chemical pollution resulting both from human settlements and productive activity (chemical industry, oil extraction and agriculture). The environmental problem is mainly the consequence of oil-extracting activities. This study aims to evaluate the effect of new biological solutions, new system-restoring procedures based on bio-remediation using specific and appropriate plants and biodegrading bacteria. This study includes an in-situ investigation of the Seman river area, from the estuary to the production areas of oil extraction, identifying main problems regarding the environmental pollution. Moreover, it supplies possible solutions based on biological systems which could improve and / or resolve environmental pollution, such as restoring the natural green areas of the banks with native vegetation (naturalization), phytoremedetion and biological depuration systems. The effects of the biological solutions will result in a reduction of environmental contamination to the benefit of the environmental sustainability. The bioremediation is a very interesting technology in reducing the concentration of organic pollutants (EPA-Guideline, 2005), with a removal rate of 40% from contaminated soils. This study indicates phytoremedetion, hydrodepuration and biological depuration systems as an effective strategy in continuously lowering the rate of chemical and biological contaminants.

Introduction

The Seman river in western Albania, formed at the confluence of the rivers Osum and Devoll, flows west through Fier-Shegan, Mbrostar (near Fier), opening into the Adriatic Sea. The Seman river catchment areas is 5,658 km2, were its length reaches 281 km, and its basin is about 1/5of the Albanian territory. It crosses a large area characterized both by a complicated geological structure, fertile plaines and large urban settlementes (Bogdani Ndini, 2012).

The Seman basin is very large and features several urban and industrial sites, were several drainage channels were built along. The channels present in the northen part are joined by parallel systems and flow into the river, while related to the south river area the surface waters flow to the draining main channel turning from the Seman River.

Nevertheless, the Seman basin also includes a disused mining oil site in Kucova (fig1), terracing agricultural areas and a non-active quarry. The vast agricultural area is evident and characterized by a high fragmentation along the river path; towards the city of Fier with an expanded active mining site (fig2) were the Seman basin flows to its center. The area was characterized by the presence of different urban sites, including the city of Fier. In this area there was also a need in buidling a big channel (fig3), which was supplied by the river and was mainly used for the irrigation of agricultural lands.

Before reaching the Adriatic Sea, the Seman River crosses a very wide humid area, where coast erosion problem are evident along with the traces of oil (Beqiraj et all, 2010), posing many dangerous issues for the actual habitats in the area. Moreoever, pollution problems caused by the river provoke serious damages on its basin, such as: deforestation, erosion, alteration of natural habitats and gravel excavation, use of fertilizers in agriculture, urban discharges, untreated wastewater and especially oil-extraction sites.
As a consequence, the widespread situation of chemical and biological pollution has caused water pollution and erosion in the banks of Seman, where frequent flooding ocours.
Back in 2015, heavy and uninterrupted rains increased the levels of Vjosa, Devoll, Osum and Seman rivers which have inundated their banks, causing severe flooding in several areas, endangering villages, roads and also some major national highways.

Nevertheless, beach erosion is mostly related to natural factors: the corrosive effect of sea waves and especially the sea level rise due to global warming but are also related to human factor; the erection of dams on the river has reduced the feed (deposits) for beaches, disregarding the fundamental role of the river in also maintaining the sea coast (Miho, 2005; Balla, 2012).

According to the Classification of Norwegian Institute for Water Research (NIVA 1997) and Directive of European Community (CEE/CEEA/CE 78/659) for "Quality of fresh waters supporting fish life" a systematic environmental study of the water chemical parameters was presented at the conference of "Environmental Assessment of Water Quality of Albanian Rivers", on the classification of natural waters in Albania. (a). In this systematic environmental study, the main polluting sources are identified, obtaining an classification of a very (low), bad level of the water quality (class 5).
The most critical chemical parameters for nearly all studied rivers found were as such: (a) Total suspended solids (TSS) resulted more than 25 mg/L in many sampling points; caused from the intensive erosion of the land; (b) Nutrient compounds concentration in rivers near big towns. Also, very low content of dissolved oxygen (eutrophic levels) were found in the Ishmi river near the city of Tirana and Seman river near the city of Fier, caused by discharges of untreated sewage wastewaters.
The most polluted rivers referring to nearly all parameters resulted Lana (tributary of Ishmi) and Gjanica (tributary of Semani). (a) The main conclusions of the conference showed that both chemical and biological (parameters for diatoms) results need to monitored through a systematic program in needs of understanding the present environmental state of aquatic ecosystem in order to detect the main sources of pollution and set the basis for political guidelines which could improve the ecological situation.

During site inspection it was verified that the real situation of environmental degradation, was caused by the presence of a large amount of waste especially that of a plastic nature.
Different sources and levels of pollution have been identified in the territory of the river coming from urban areas, resulting from non adatable management systems and disposal of solid urban waste, the presence of plastic material (fig4) and the lack of systematic sewerage.
Moreover, eutrophic levels linked to human contamination (fecal contamination) and non suitable wastewater drain system where more than apparent, putting in risk also human health in the area but also Seman basin.

Indeed the presence of microorganisms, markers of contamination as potential pathogens that may be etiologic agents of disease, is responsible for risks linked to the use of water (drinkable water and irrigation water). The risk of getting diseases caused by specific etiologic agents (viruses, bacteria, protozoa, metazoan) following the use of water is related to its degree of fecal contamination (potential source for transmission of many pathogens).
The chemical contamination includes the high concentration of heavy metals and hydrocarbons derived from oil extraction.
Most samples contained numerous toxic and persistent organic chemical pollutants, as well as very high levels of many toxic metals, as Mercury (Hg), Lead (Pb), Cadmium (Cd), Chromium (Cr). The nature and extent of chemical contamination found at sites in Seman River.
As a matter of fact, different species of the cyprinid fish of the Albanian river, (Barbus prespensis, Oxynoemachileus pindus, Alburnoides bipuntatus, Squalius cephalus and Pachichilon pictum), are used as food despite a high concentration of lead, chrome, cadmium, copper and mercury. In the last several decades the contamination

Fig1 / disused area of oil extraction / source photo by the author
Fig2 / active area of oil extraction / source photo by the author

of freshwaters with various pollutants has become an issue of great concern. Heavy metals are among the major pollutants that also accumulate in organisms and exhibit increased concentrations through the food chain.
The sources of heavy metal contamination derive only partially from natural factors due to the different rock types that may cause different background levels in the biota (flora and fauna) (Shumka, 2014), but they mainly result from industry, landfill of waste and phytosanitary treatments for agriculture.
Health issues from chemical and biological pollution, especially regarding food-borne diseases from pathogenes bacteria (Piro, 2013), can be very significant, as reported by the World Health Organization report "Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks". The environmental risk factors such as air, water and soil pollution, chemical exposures, climate change and ultraviolet radiation, contribute to the onset of more than 100 diseases and damage to health (b). Nevertheless, health-monitoring investigations in territories subject to mining activities show incidence rates from 2 to 2.5 times higher than the regional average of asthma, other severe respiratory conditions, ischemic heart disease and heart failure.

Aim

The main objective of this study is to produce a complete picture of the present environmental situation of the Seman basin, addressing environmental problems caused by human impact and evaluating the effect of new biolgical solutions.
The synergy between the special and appropriate plants and the biodegrading bacteria is the basis of the systems novel-restoring procedure both for the ground that for water.
Evaluate the applicability for restoring water and agricultural land not by natural systems or low- environment impact as a strategy for the reduction of chemical pollution that is economically sustainable and manageable respecting the urban sites and recovering the natural ecosystems.
Spreading information to increase awareness and knowledge of the environmental pollution hazard to human health could promote those systems novel-restoring procedure.

Methodology

The study is divided into two parts: The first one includes the river tour in order to evaluate on site the contamination of various areas of the Semani basin.
The second part aims in building an analysis of the possible environmental recovery projects and depollution though bio-remediation.
Preliminary phase focused in site inspection of the area in order to check the current situation. The observation allowed the research team to confirm a state of environmental degradation, mainly caused by disused industrial sites, activities, and solid waste (plastic) spread on the path of the Seman River.
During the survey, different sources and levels of pollution have been identified in the territory of the river coming from urban

Fig3 / channel built for irrigation
source / photo by the author

areas due to the wrong management and disposal of solid urban waste, the presence of plastic material (fig4) and the lack of a systematic sewerage.
The second phase focused on proposing possible solutions respecting the environment and human activities.
The described areas have different problems to which we could propose a restructuring plan to reduce environmental pollution and revaluate the river as a green area to be protected.
The first intervention action should focus on the river bed, through a reinforcement of the levees detention basin, restoring the natural green areas of the banks with native vegetation (naturalization) to compensate for the deforestation and exploitation of the river's natural material.

One of the possibilities is to intervene on the entire basin by enhacing the territorial characteristics (land use changes, broadcast hedges, rows, grassy strips), and the self-purifying capacity of river water (renaturalization, creation of wetlands in the river bed). Creation of zones acting as overflow basins in case of heavy rainfall could protect the urban centers located further downstream using non-active quarry and part of agricultural land located beyond the area of cultivated terracings.
Moreover, the flooding areas may be foster for cultivation (forestry), as the white poplar (Populus alba), used often in wetlands, riparian trees or for energy purposes (biomass). (d)
In this case natural bioremediation system is consider useful: the phytoremediation include the use of plant species for remediation of soils contaminated by heavy metals in particular (Piro, 2013; Tchounwou, 2014).
The biological depuration system can be defined as a natural process for purifying wastewater, using plants as biological filters that reduce pollutants in them with the use of bacteria useful in assisting the organic degradation.
The effect of microbial cleaning, containing spores of food grade for example bacteria spore – forming Bacillus subtilis (fig5).
Microbial cleaning resulted in a reduction in the pathogen load that is stable over time.
Moreover, using microbial or remediation activities systems alternatively are beneficial as, this study demonstrates that microbial cleaning is a more effective and sustainable alternative to chemical cleaning. (f) (g)
Designing a system of constructed wetlands always includes the consideration of several parameters, such as the plant location (geographic location), the conformation of the soil and geology, the amount of rainfall, the chemical status of surface waters and the environmental impact.

Also important is the consideration of ecological diversity in ensuring the presence of a wide range of native plants and animal species; and if possible, increase the number of plant species present, without increasing the presence of species not typical of the area at the expense of typical species.
The projects should include mechanisms to control or eliminate undesirable species.

Fig4 / Plastic waste
source / photo by the author

The phytodepuration system is one way of spreading pathogenic microorganisms to the water of the rivers, mainly from untreated urban discharge, which flow directly into the rivers without any previous treatment. Phytodepuration is an effective treatment for domestic sewage, which exploits the evapotranspiration of the soil and vegetation.

Still, phytodepuration systems have been developed utilizing the aquatic plants (macrophytes), in reproducing natural purification processes typical of humid areas. In this case, macrophytes can be floating, flooded or emerging. The systems can have superficial or sub-superficial streams, were sub-superficial stream can be horizontally or vertically oriented. Superficial streams support all the types of macrophytes, were sub-superficial ones only enhance the emerging macrophytes, including here the use of plant species for remediation of soils contaminated by heavy metals.

So in this case, the cause of environmental contamination by heavy metals can be redistributed by natural geological and biological cycles (soil formation processes). However, the principal cause of heavy metal pollution is linked to human activities (industrial, combustion processes, agriculture).
Biological treatments include bioremediation (microorganisms against organic pollutants) and phytoremediation (using plants against organic and inorganic pollutants) (Manno, 2010).
Phytoremediation is a technology that employs plant species for "in situ" treatment of soils, sediments and contaminated water and is the process carried out by plants able to degrade organic and inorganic contaminants. It is based on different biological processes such as phytodegradation (or fitotrasformazione), phytostabilization, phyto-volatilization, phytoextraction, rizo-degradation (degradation of organic contaminants by microbial which is present in the rhizosphere of the plant) and rizo-filtration (Vamerali, 2012).

According to theoretical recommendations from the literature regarding this topic, recommendations regarding phytoremediation is seen as a useful program including: the correct selection of plants, the characteristics of the territory and type of pollutants, the capture rate of the contaminant and the recovery time.
Laboratory interest using pot experiments (phase preliminary "in vitro"), have both evaluated the efficiency of each type of plant in the extraction of the pollutants that monitor the concentrations present in the contaminated soil and in the plant (Ventorino, 2012; Peer, 2003).

Heavy metals are not degraded, but are extracted from the soil and accumulated in plant tissues or immobilized in the rhizosphere of plants. This proposal for a phytoremediation should include the reusable parts of the plants and their eventual disposal, so they could be used for energy purposes derived from biomass or as thermal insulation of buildings.

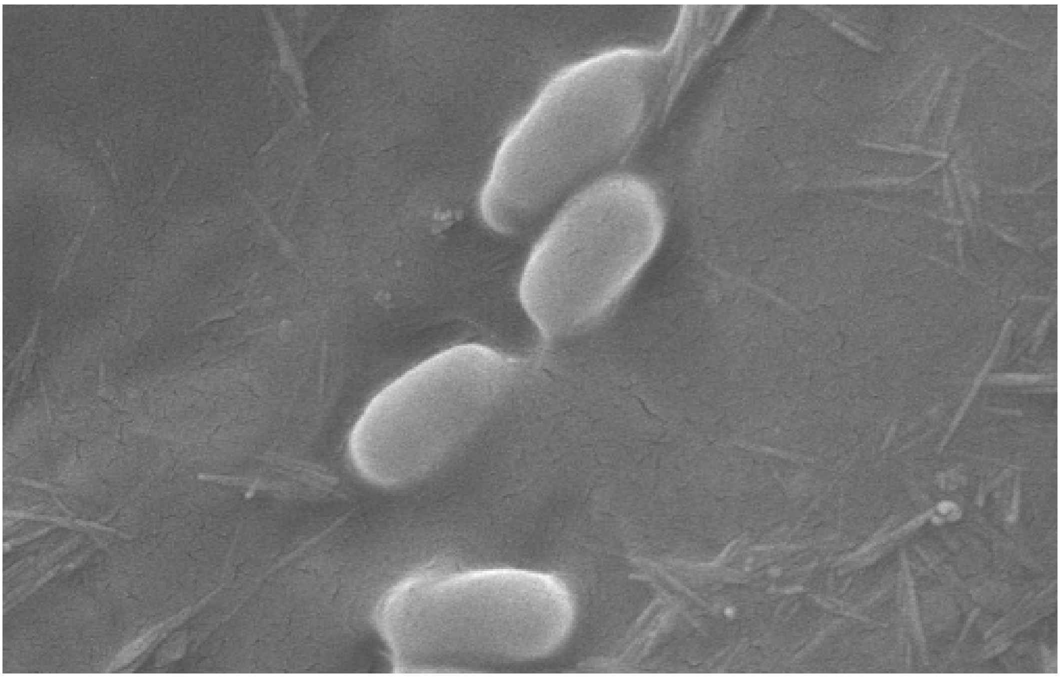

Fig5 / bacteria spore – forming Bacillus subtilis
source / photo by the author

Nevertheless, other plants can be used in the rehabilitation and environmental remediation of polluted land, each corresponding to a specific feature extraction, such as vetiver (Chrysopogon zizanioides), hemp (Cannabis sativa), wild sunflower (Helianthus Rigidus) that absorb nickel and chromium. The most efficient plant species iperaccumulatori belong to the Brassicaceae family (Thlaspi caerulescens, Thalaspi rotundifolium, Alyssiumwulfenianum, Brassica juncea), the grasses (tall fescue). This species often experiences a slow growth and have low biomass, thus typical agricultural species may be used in representing a minimum accumulation of heavy metals and high biomass (eg. sorghum (Sorghum vulgare), corn (Zea mays), sunflower (Helianthus annuus) and alfalfa (Medicago sativa)) (Lievens, 2008; EPA, 2000; Grispen, 2006).

Results

The effects of the biological solutions will result in a reduction of environmental contamination to the benefit of creating sustainability.
The cultivation of poplar, as the white poplar (Populus alba), can allow bioremediation due to the ability to absorb and accumulate a considerable amount of metal in its tissues during its life cycle, used in the production of bioenergy.
In addition, the cultivation of plants in symbiosis with nitrogen-fixing microorganisms and mycorrhiza can positively affect soil fertility in terms of supporting agriculture through additional incentives for the agricultural economy. (d)
A very interesting technology, Bioremediation reduces the concentration of organic pollutants (EPA-Guideline, 2005), with a removal rate of 40% from contaminated soils. (f)
However, setting up this technology requires a long time due to its connection to the growth of the hyper accumulator plants and the slow degradation caused by the harsh environmental conditions, influenced by the efficiency of the natural system with high values of toxins of the terrain, but after decontamination the quality and the appreciation of the soil after contamination are higher.
The natural method is considered more safe, enhancing a long-term sustainable (EPA, 2000).

Discussion

According to the "Environmental Assessment of Water Quality of Albanian Rivers" conference, the water quality parameters and heavy metal levels monitored during 2002-2004 on eight tours along the most impacted rivers of the Adriatic lowland, including here Seman river with its effluents Gjanica and Osumi, and also the Seman basin, lead to the conclusion that phytoremediation is an appropriate technology for environmental recovery. (a)
In fact, the study conducted in the Seman area, reassure that the chemical and biological issues could find some biological solution, considering their impact on the environmental sustainability and ethical development in the Seman area which is rich in water, interesting habitat for the flora and fauna, and its biodiversity.
Hence, Phytoremediation is a low-impact

economic system: low costs for the plant, including trenching, inactive waterproof material for draining, piping, purchase of trees and re-usable soil cover are inexpensive, thus no need for further manufactures, or electrical equipment.
Low costs for the management includes low-limited electric consumption due to absence of electrical and mechanical apparatus and the presence of air-insufflating system; where there is no need for chemical reagents nor of specialised workforce or sludge production.

Conclusions

The widespread presence of contaminated areas create incentives in finding effective and sustainable remediation techniques both economically and environmentally compared to previously used remediation techniques which have not solved the problem of pollution.
This study presents biological solutions based on different systems using various vegetable plants and microorganisms with repair capabilities for improving the environment of the Seman basin contaminated by human activity.
Phytoremediation includes solutions that contextually allow exerting the action of removing the contaminants from the water and the soil and rebuilding natural-looking environments.
The phytoremediation technology can be applied to the resolution of a wide range of environmental problems such as secondary or tertiary civil waste water purification; industrial waste purification; treatment of certain liquid wastes (such as landfill leachate); elimination of widespread pollutants; remediation of contaminated soils (phytoremediation); and river system and flood protection.
Phytoremediation is a technique which is suitable for the remediation of large areas with contamination both in terms of depth (the plants take roots to a maximum of 3 meters) and in entities, since plants have limited efficiency and can be subject to toxic effects, which do not allow the colonization of environmental problems caused by infestation of non-autochthonous plants and thereby adversely affect the territory's biodiversity.

This "green" remedy, beside having a low-environmental impact (environmental sustainability), and lower cost compared to other treatments (savings in terms of materials' construction and shipbuilding works) has both the ability to reuse the contaminated plants as a way of energy recovery (the use of contaminated soils for sustainable production of biomasses for energy) and the advantage of the wellbeing of the local community (Zhan, 2013; Alkanok, 2014; Verma, 2007; Aguilar-Virgen, 2014).

This proposal of the phytoremediation system may be inserted into a nature protection program and biodiversity, according to the specific directions laws and European guidelines (EU), (such as Directive 92/43 / EEC - "Conservation of natural habitats and of wild fauna and flora" (5/21/92) and "Biodiversity Action Plan for the conservation of natural resources".

References

Alkanok G., Demirel B., Onay T. T., (2014) Determination of biogas generation potential as a renewable energy source from supermarket wastes. Waste management, 34, 134-140.

Aguilar-Virgen Q., Taboada-González P., Ojeda- Benítez S., Cruz-Sotelo S. (2014) Power generation with biogas from municipal solid waste: prediction of gas generation with in situ parameters. Renewable and sustainable energy reviews, 30, 412-419.

Balla, A., Bulliqi, S. (2012) Erosion of Beaches on the Albanian Coast, Causes, Consequences, and Measures for Their Improvement. J. Int. Environmental Application & Science, Vol. 9(3): 365-372.

Beqiraj, I., Drushku, S., Seiti, B., Topi, D. and Muçaj, A. (2010) Environmental Problems In Albanian Fields Of Production And Processing Of The Petroleum, Natura Montenegrina Podgorica, 9(3):673-685.

Bogdani Ndini, M. (2012) Analysis of Surface and Ground Water Exchange in Two Different Watersheds. Journal of Environmental Science and Engineering, 434-439 Formerly part of Journal of Environmental Science and Engineering, ISSN 1934-8932.

Grispen, V.M.J., Nelissen H.J.M. Verklei J.A.C. (2006) Phytoextraction with Brassica napis L.: a tool for sustinable manegemente of heavy metal contaminated soils. Environ. Pollut; 144 (1), 77-83.

Lievens, C., Yperman, J., Cornelissen, T., Carleer, R. (2008) Study of the potential valorisation of heavy metal contaminated biomass via phytoremediation by fast pyrolysis: Part II: Characterisation of the liquid and gaseous fraction as a function of the temperature Fuel 87, 1906-1916.

Manno, M., Viau, C. in collaboration with Cocker, J., Colosio, C., Lowry, L., Mutti, A., Nordberg, M., Wang, S. (2010) Biomonitoring for occupational health risk assessment (BOHRA)_ Toxicology Letters 192, 3-16.

Miho, A., Çullaj, A., Hasko, A., Lazo, P., Kupe, L., Bachofen, R., Brandl, H., Schanz, F., Baraj, B. (2005) Environmental State of Some Rivers of Albanian Adriatic Lowland, Tirana, 235 pp.

Peer, W. A. et al. (2003) Identifying model metal hyperaccumulating plants: germplasm analysis of 20 Brassicaceae accessions from a

Fig6 / Plants used fot phytoremedation: sorghum (Sorghum vulgare), corn (Zea mays), sunflower (Helianthus annuus) and alfalfa (Medicago sativa) / source Alberta Vandini

wide geographical area. New Phytology, 159, 421 – 430.

Piro, Ç., Puto, K., Azemaj, E. (2013) Microbiological pollution of vjosa and drino rivers and the fresh vegetable contamination by irrigation. International Journal of Agriculture and Crop Sciences. Available online at www.ijagcs.com IJACS/6-19/1347-1352 ISSN 2227-670X IJACS Journal.

Shumka, S., Sandlund, O.T., Aleksi, P. and Dervishi, I. (2014) Heavy Metal Concentrations in Tissues of Freshwater Fishes in a Central River System of Albania. World Journal of Fish and Marine Sciences 6 (2): 131-135, 2014 ISSN 2078-4589 © IDOSI Publications, DOI: 10.5829/idosi.wjfms.2014.06.02.76158.

Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K., Sutton, D.J. (2014) Heavy Metals Toxicity and the Environment. EXS 101: 133–164. doi: 10.1007/978-3-7643-8340-4_6.

Vamerali, T., Marchiol, L., Bandiera, M., Fellet, G., Dickinson, N.M., Lucchini, P., Mosca, G., Zerbi, G. (2012) Advances in agronomic management of phytoremediation: methods and results from a 10-year study of metal-polluted soils. Italian Journal of Agronomy 2012; volume 7:e42.

Ventorino, V., Sannino, F., Piccolo, A., Pepe, O. (2012) Isolation and selection of Plant Growth Promoting Rhizobacterium strain for the cecontamination of polluted soils. Atti del XXX Convegno Nazionale Società Italiana di Chimica Agraria. Milano, 18-19 settembre 2012.

Verma V. K., Singh Y. P., Rai J. P. N., (2007) Biogas production from plant biomass used for phytoremediation of industrial wastes. Bioresource technology, 98, 1664-1669.

U.S. EPA Enviromental Protection Agency (2000) – Constructed Wetland Treatment of Municipal Wastewater treatment – EPA/625/R-99/010 Office for Research and Development, Cincinnati, Ohio.

Zhan H., Tian Y., Wang L., Zhang L., Dai L., (2013) Ecophysiological characteristics and biogas production of cadmium-contaminated crops. Bioresource technology, 146, 628-636.

a.https://www.researchgate.net/publication/235353348_Environmental_Assessment_of_Water_Quality_of_Albanian_Rivers

b.http://apps.who.int/iris/bitstream/10665/204585/1/9789241565196_eng.pdf?ua=1/

c. report del World Health Organization, "Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks".

d. http://www.populus.it

e. http://www.geneticagraria.it

f. The International Conference on Environmental Pollution and Clean Bio/PhytoRemediation (EPCR 2010), June 2010, Pisa, Italy.

g. www.cnr.it / Focus CNR Report2003 Oil eating bacteria in bioremediation page 214-215.