DOWNLOAD PDF BIOREMEDIATION OF CONTAMINATED SOILS (ENVIRONMENTAL SCIENCE AND POLLUTION CONTROL, 22.)

Chapter 1 : Dr. Teresa J. Cutright

consequences of the contaminated soils over environment measures large, viz. deforestation, poor vegetation, soil erosion, groundwater contamination, loss of habitation etc.

Aerobic[edit] Aerobic bioremediation is the most common form of oxidative bioremediation process where oxygen is provided as the electron acceptor for oxidation of petroleum , polyaromatic hydrocarbons PAHs , phenols , and other reduced pollutants. Oxygen is generally the preferred electron acceptor because of the higher energy yield and because oxygen is required for some enzyme systems to initiate the degradation process [3]. Numerous laboratory and field studies have shown that microorganisms can degrade a wide variety of hydrocarbons, including components of gasoline, kerosene, diesel, and jet fuel. Under ideal conditions, the biodegradation rates of the low- to moderate-weight aliphatic , alicyclic , and aromatic compounds can be very high. As the molecular weight of the compound increases, so does the resistance to biodegradation [3]. Common approaches for providing oxygen above the water table include landfarming , composting and bioventing. During landfarming, contaminated soils, sediments, or sludges are incorporated into the soil surface and periodically turned over tilled using conventional agricultural equipment to aerate the mixture. Composting accelerates pollutant biodegradation by mixing the waste to be treated with a bulking agent, forming into piles, and periodically mixed to increase oxygen transfer. Bioventing is a process that increases the oxygen or air flow into the unsaturated zone of the soil which increases the rate of natural in situ degradation of the targeted hydrocarbon contaminant. Recirculation systems typically consist of a combination of injection wells or galleries and one or more recovery wells where the extracted groundwater is treated, oxygenated, amended with nutrients and reinjected. Greater amounts of oxygen can be provided by contacting the water with pure oxygen or addition of hydrogen peroxide H_2O_2 to the water. In some cases, slurries of solid calcium or magnesium peroxide are injected under pressure through soil borings. These solid peroxides react with water releasing H_2O_2 which then decomposes releasing oxygen. Air sparging involves the injection of air under pressure below the water table. The air injection pressure must be great enough to overcome the hydrostatic pressure of the water and resistance to air flow through the soil [5]. This process involves the addition of an electron donor to: Similarly, reduction of sulfate to sulfide sulfidogenesis can be used to precipitate certain metals e. The choice of substrate and the method of injection depend on the contaminant type and distribution in the aquifer, hydrogeology, and remediation objectives. Substrate can be added using conventional well installations, by direct-push technology, or by excavation and backfill such as permeable reactive barriers PRB or biowalls. Slow-release products composed of edible oils or solid substrates tend to stay in place for an extended treatment period. Soluble substrates or soluble fermentation products of slow-release substrates can potentially migrate via advection and diffusion, providing broader but shorter-lived treatment zones. The added organic substrates are first fermented to hydrogen H_2 and volatile fatty acids VFAs. The VFAs, including acetate, lactate, propionate and butyrate, provide carbon and energy for bacterial metabolism [7] [2]. Heavy Metals[edit] Heavy metals including cadmium, chromium, lead and uranium are elements so they cannot be biodegraded. However, bioremediation processes can potentially be used to reduce the mobility of these material in the subsurface, reducing the potential for human and environmental exposure. The mobility of certain metals including chromium Cr and uranium U varies depending on the oxidation state of the material [8]. Microorganisms can be used to reduce the toxicity and mobility of chromium by reducing hexavalent chromium, Cr VI to trivalent Cr III [9]. Microorganisms are used in this process because the reduction rate of these metals is often slow unless catalyzed by microbial interactions [12] Research is also underway to develop methods to remove metals from water by enhancing the sorption of the metal to cell walls [12]. This approach has been evaluated for treatment of cadmium [13] , chromium [14] , and lead [15]. Additives[edit] In the event of biostimulation, adding nutrients that are limited to make the environment more suitable for bioremediation, nutrients such as nitrogen, phosphorus, oxygen, and carbon may be added to the system to improve effectiveness of the treatment. Low pH can interfere with pH homeostasis or increase the solubility of toxic metals. Microorganisms can expend cellular energy to maintain homeostasis or cytoplasmic conditions may change in response to external changes in pH. Some anaerobes have adapted to low pH conditions through alterations in carbon and electron flow, cellular morphology, membrane structure, and protein synthesis. Heavy metals and radionuclides are elements that cannot be biodegraded, but can be bio-transformed to less mobile forms. Additional research is required to develop methods to ensure that the products from biodegradation are less persistent and less toxic than the original contaminant. A field test for the release of the modified organism has been successful on a moderately large scale. Organisms can be modified such that they can only survive and grow under specific sets of environmental conditions.

Chapter 2 : Journal of Bioremediation and Biodegradation- Open Access Journals

Agricultural soils can become contaminated due to pesticide use or via the heavy metals contained within agricultural products. A visible example of where bioremediation has been used to good effect can be found in London's Olympic Park.

Received Jul 13; Accepted Sep 8. This article has been cited by other articles in PMC. Abstract Environmental pollution has been on the rise in the past few decades owing to increased human activities on energy reservoirs, unsafe agricultural practices and rapid industrialization. Amongst the pollutants that are of environmental and public health concerns due to their toxicities are: Remediation of polluted sites using microbial process bioremediation has proven effective and reliable due to its eco-friendly features. Bioremediation can either be carried out ex situ or in situ, depending on several factors, which include but not limited to cost, site characteristics, type and concentration of pollutants. Generally, ex situ techniques apparently are more expensive compared to in situ techniques as a result of additional cost attributable to excavation. However, cost of on-site installation of equipment, and inability to effectively visualize and control the subsurface of polluted sites are of major concerns when carrying out in situ bioremediation. Therefore, choosing appropriate bioremediation technique, which will effectively reduce pollutant concentrations to an innocuous state, is crucial for a successful bioremediation project. Furthermore, the two major approaches to enhance bioremediation are biostimulation and bioaugmentation provided that environmental factors, which determine the success of bioremediation, are maintained at optimal range. This review provides more insight into the two major bioremediation techniques, their principles, advantages, limitations and prospects. Bioremediation, Environment, Pollutants, Techniques Introduction In the past two decades, there have been recent advances in bioremediation techniques with the ultimate goal being to effectively restore polluted environments in an eco-friendly approach, and at a very low cost. Autochthonous indigenous microorganisms present in polluted environments hold the key to solving most of the challenges associated with biodegradation and bioremediation of polluting substances Verma and Jaiswal provided that environmental conditions are suitable for their growth and metabolism. Environmentally friendly and cost saving features are amongst the major advantages of bioremediation compared to both chemical and physical methods of remediation. Thus far, several good definitions have been given to bioremediation, with particular emphasis on one of the processes degradation. Nevertheless, in some instances, the term biodegradation is used interchangeably with bioremediation; the former is a term, which applies to a process under the latter. In this review, bioremediation is defined as a process, which relies on biological mechanisms to reduce degrade, detoxify, mineralize or transform concentration of pollutants to an innocuous state. The process of pollutant removal depends primarily on the nature of the pollutant, which may include: Apparently, taking into consideration site of application, bioremediation techniques can be categorized as: Pollutant nature, depth and degree of pollution, type of environment, location, cost, and environmental policies are some of the selection criteria that are considered when choosing any bioremediation technique Frutos et al. Apart from selection criteria, performance criteria oxygen and nutrient concentrations, temperature, pH, and other abiotic factors that determine the success of bioremediation processes are also given major considerations prior to bioremediation project. Although bioremediation techniques are diverse Fig. Besides, it is possible that other remediation techniques Pavel and Gavrilescu , which might as well be more economical, and efficient to apply during remediation, are considered when remediation of sites polluted with pollutants aside from hydrocarbons are involved. Furthermore, given the nature of activities leading to crude oil pollution, it is likely that pollution of the environment with pollutants excluding hydrocarbons can easily be prevented and controlled. Moreover, the dependence on petroleum and other related products as major sources of energy seems to have contributed to increased pollution resulting from this class of pollutant Gomez and Sartaj ; Khudur et al. The aim of this review is to provide a comprehensive knowledge on the two major bioremediation techniques with regards to site of application, highlighting their principles, advantages, limitations and possible solutions. The prospects of bioremediation are also discussed.

Chapter 3 : Bioremediation: The pollution solution? | Microbe Post

Author information: (1)College of Environmental Science and Engineering, Hunan University, Changsha, , People's Republic of China. cyn@blog.quintoapp.com (2)Key Laboratory of Environmental Biology and Pollution Control (Hunan University), Ministry of Education, Changsha, , People's Republic of China. cyn@blog.quintoapp.com (3)College of.

International Conference on Recycling: Journal renders novel, clear connection to environmental and occupational medicine and related studies in microbiology, bioremediation, biodegradation and environmental pollution. The journal includes a wide range of fields in its discipline to create a platform for the authors to make their contribution towards the journal and the editorial office promises a peer review process for the submitted manuscripts for the quality of publishing. The journal is using Editorial Manager System for quality peer-review process. Editorial Manager is an online manuscript submission, review and tracking systems. Authors may submit manuscripts and track their progress through the system, hopefully to publication. Reviewers can download manuscripts and submit their opinions to the editor. Biodegradation Biodegradation is the chemical dissolution of materials by bacteria fungi or biological means While biodegradable simply means to be consumed by microorganism, "compostable" makes the specific demand that the object break down under composting conditions. Bioremediation Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site. Waste Degredation Water degradation decreases water quality and water quantiy, which results in the growth of pathogens and leads to great risk of both human and animals health. Organic material can be degraded aerobically with oxygen, or anaerobically without oxygen. Related Journals of Waste Degredation Epidemiology: Heavy Metal Bioremediation Heavy metal bioremidation is the process of removal of heavy metals from contaminated domestic industrial effluent indigenous bacteria islated from acclimatized activated sludge, four resistant strains are used as a mixture to remove heavymetals. Phytoremediation Phytoremidation is the direct use of living green plants for insitu, or in place, removal, degradtion, contaminats in soils, sludges sediments surface water and ground water. A low cost, solar energy driven cleanup technique without the need to excavate the contaminant material and dispose of it elsewhere. Journal of Pharmacognosy and Phytochemistry, International Journal of Phytoremediation, Phytochemistry Mycoremediation Mycoremediation is a form of bioremidation ,process iof using fungi to degrade or to remove contaminants in environment stimulating microbial and enxyme activity, myceliumand to reduse toxins in-situ. Bioremediation Oil Spills Oil spills have become serious problem in cold environments with ever increse in resource exploitation, transportation, storage and accidental lekage of oils Bioremidation is a promising action for remidation it is effective and economic in removing oils with less undue environmental damages. Oil spills major problem of which is affecting the environment and it also has dangerous impact on human beings. This can be done in 2 ways; Solid Phase: It consists of placing the excavated materials into an above ground enclosure. In this the contaminated soil is excavated and removed from the site as completely as possible. Types of Upwelling Upwelling process involves the rise of deep, cold and nutrient rich water towards the surface. Coastal Upwelling, Large-Scale driven upwelling, upwelling associated with eddies, topographically associated upwelling, broad-diffusive upwelling, equatorial upwelling are the types. This is achieved when microorganisms in the environment metabolize and break down the structure of biodegradable plastic. Biodegradable confetti is completely safe, water soluble, and it does not pose harm to birds and animals. We can made these confetti, at our home itself wihout causing harm to the environment. Biodegradable diapers do not biodegrade in a landfill, and will only decompose if they are composted. Non Biodegradable Non-biodegradable substances are those which cannot be transformed into harmless natural state by the action of bacteria. And burning of these fuels causes more pollution in the environment. They can be useful if recycled. Xenobiotics Xenobiotics are the chemical compounds which are not endogeneously produced and therefore foreign to a given biological system. With resepect to environment it includes synthetic pesticides, herbicides, and industrial pollutants. Bioremediation Plants Pytoremediation involves treatment of environmental problems through the use of plants, without the need to excavate the contaminant media and dispose of it elsewhere. Phytoremediation consists of mitigating pollutant concentrations in contaminated soils, water, or air, with plants able to contain, degrade, or eliminate metals, pesticides etc. Bioremediation Products Alabaster Corp. Bioremediation Products for oil spill cleaning, Bio Tech, Inc. Biohidrica; Developer of products for the detection and control of environmental contamination. The process whereby microorganisms use a chemical other than oxygen as an electron acceptor. Current Research, Journal of Biological Inorganic Chemistry , Inorganic Chemistry Communication, International Journal of Inorganic Materials , Advances in Inorganic Chemistry OMICS Group International Conferences are instrumental in providing a meaningful platform for the world renowned scientists, researchers,students, academicians, institutions, entrepreneurs and industries through its events annually throughout the globe.

Chapter 4 : Phytoremediation - Wikipedia

Environmental Pollution. Environmental pollution is defined as "the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected.

Bioremediation by Higher Plants Phytoremediation is well suited for applications in low-permeability soils, where most currently utilized technologies have a low level of success, as well as in combination with more conventional removal technologies foam migration, electromigration, etc. In appropriate situations, phytoremediation can be a substitute to the much harsher physical and chemical remediation technologies of thermal vaporization, solvent washing, incineration or other soil washing techniques, which essentially degrade the biological constituents of the soil and can intensely change its physical and chemical properties as well, generating a comparatively nonviable solid waste. Phytoremediation actually improves the soil, leaving a better, effective, soil ecosystem at costs estimated at around one-tenth of those presently acquired methods. Conclusion Soil and water are being polluted by various organic and inorganic pollutants due to rapid industrialization and use of agrochemicals in imbalanced proportions. Restrictive and clean up measures to avert hazards from contaminated soil belong to the curative soil protection. Bioremediation is a unique and cost-effective technique for cleaning up pollution by intensifying the natural biodegradation processes. So developing an understanding of microbial and plant communities with their response to the natural environment and contaminants, elaborating the knowledge of the genetics of the microorganisms helps to increase capabilities to degrade pollutants and recovery of land and ground water. Bioremediation Journal 12 2: Discovery Nature 6 International Journal of Environmental Biology 4 2: Indian Journal of Experimental Biology 41 9: International Microbiology 3 1: Bulletin of Environmental and Scientific Research 1 Cookson JT Bioremediation Engineering. Environmental Science and Technology 28 The influence of emulsifiers on hydrocarbon biodegradation by Pseudomonadacea and Bacillacea strains. Spill Science and Technology Bulletin 8 5: Bioresource Technology 67 3: Ijah UJJ Studies on relative capabilities of bacterial and yeast isolates from tropical soil in degrading crude oil. Waste Management 18 5: Water Environment Research 70 3: Patent and Trademark Office. Indian journal of experimental biology 41 9: Journal of Chemical Technology and Biotechnology 76 International Biodeterioration and Biodegradation 44 2: Biotechnology Bioinformatics and Bioengineering 1 3: Sinha SN, Paul D Heavy metal tolerance and accumulation by bacterial strains isolated from waste water. Journal of Chemical, Biological and Physical Sciences 4 1: Sinha SN, Biswas K Bioremediation of lead from river water through lead-resistant purple-nonsulfur bacteria. Global Journal of Microbiology and Biotechnology 2 1: Bioresource Technology 78 3: Fu Y, Viraraghavan T Fungal decolorization of dye wastewaters: Bioresource Technology 79 3: Biotechnology Advances 22 1: Aranda E, Ullrich R, Hofrichter M Conversion of polycyclic aromatic hydrocarbons, methyl naphthalenes and dibenzofuran by two fungal peroxygenases. Microbiological Research 1: Journal of Bioscience and Bioengineering 6: Hirano T, Honda Y, Watanabe T, Kuwahara M Degradation of bisphenol A by the lignin-degrading enzyme, manganese peroxidase, produced by the white-rot basidiomycete, Pleurotus ostreatus. Bioscience, Biotechnology, and Biochemistry 64 9: Enzyme and Microbial Technology 30 6: Darah I, Ibrahim CO Lignin-degrading enzyme production by entrapped cells of Phanerochaete chrysosporium in submerged culture system. Folia Microbiologica 39 2 , Bulletin of Environmental Contamination and Toxicology 57 3: Environment Science and Technology 16 3: Cobbett C, Goldsbrough P Phytochelatin and metallothioneins: Roles in heavy metal detoxification and homeostasis. Annual Review of Plant Biology 53 1: Pearson RG Hard and soft acids and bases. Survey of Progress in Chemistry 5 1: Purkayastha RP, Mitra AK Metal uptake by mycelia during submerged growth and by sporocarp of an edible fungus, Volvariella volvacea. Indian Journal of Experimental Biology 30 Jagadevan S, Mukherji S Successful in-situ oil bioremediation programmes â€" key parameters. Indian Journal of Biotechnology 3 4: Ajayan KV, Selvaraju

M, Thirugnanamoorthy K Growth and heavy metals accumulation potential of microalgae grown in sewage wastewater and petrochemical effluents. Pakistan Journal of Biological Sciences 14 Journal of Fisheries and Aquatic Sciences 22 Journal of Environmental Biology Environmental Monitoring and assessment 6: Journal of Environmental Quality 21 3: Journal of Environmental Quality 28 3: Journal of Soil Contamination 7 4: Journal of Hazardous Materials 2: Bioresource Technology International Journal of Environmental Science and Technology 8 3: Environmental Pollution 3: A case study of Kaduna Refinery and Petrochemical Company polluted stream. Journal of Applied Biology and Biotechnology 3 1:

Chapter 5 : Bioremediation - Wikipedia

Bioremediation and Bioeconomy provides a common platform for scientists from various backgrounds to find sustainable solutions to environmental issues, including the ever-growing lack of water resources which are under immense pressure due to land degradation, pollution, population explosion, urbanization, and global economic development.

While researching for a policy briefing, Rebecca learnt a lot about bioremediation. She explains a little about it in this blog. Our Pollution Problem The global population continues to rise at an astonishing rate, with estimates suggesting it will be in excess of 9 billion in The intensive agricultural and industrial systems needed to support such a large number of people will inevitably cause an accumulation of soil, water and air pollution. The world generates 1. We need to control our pollution; thankfully, microbes might be the answer. Micro-organisms are well known for their ability to break down a huge range of organic compounds and absorb inorganic substances. The Invisible Workforce Bioremediation uses micro-organisms to reduce pollution through the biological degradation of pollutants into non-toxic substances. This can involve either aerobic or anaerobic micro-organisms that often use this breakdown as an energy source. There are three categories of bioremediation techniques: Soil Industrial soils can be polluted by a variety of sources, such as chemical spillages, or the accumulation of heavy metals from industrial emissions. Agricultural soils can become contaminated due to pesticide use or via the heavy metals contained within agricultural products. The grounds that held the Olympics had previously been heavily polluted, after hundreds of years of industrial activity. Groundwater polluted with ammonia was cleaned using a new bioremediation technique that saw archaeal microbes breaking down the ammonia into harmless nitrogen gas. Natural biodegradation processes can be limited by many factors, including nutrient availability, temperature, or moisture content in the soil. Biostimulation techniques overcome these limitations, providing microbes with the resources they need, which increases their proliferation and leads to an increased rate of degradation. Cleaning up oil-polluted soil is an example of where stimulating microbial growth can be used to good effect. Research has shown that poultry droppings can be used as a biostimulating agent, providing nitrogen and phosphorous to the system, which stimulates the natural growth rate of oil-degrading bacteria. Systems like these may prove cheaper and more environmentally friendly than current chemical treatment options. Air Air is polluted by a variety of volatile organic compounds created by a range of industrial processes. This method involves passing polluted air over a replaceable culture medium containing micro-organisms that degrade contaminates into products such as carbon dioxide, water or salts. Biofiltration is the only biological technique currently available to remediate airborne pollutants. Water In the UK, access to clean, potable water and modern sanitation is something we take for granted. However, there are billions of people on Earth for which this is a luxury. The WHO estimate that each year , people die as a result of diarrhoeal diseases, many of which could be prevented if they had access to clean water and proper sanitation. Sewage treatment plants are the largest and most important bioremediation enterprise in the world. In the UK, 11 billion litres of wastewater are collected and treated everyday. Major components of raw sewage are suspended solids, organic matter, nitrogen and phosphorus. Wastewater entering a treatment plant is aerated to provide oxygen to bacteria that degrade organic material and pollutants. Microbes consume the organic contaminants and bind the less soluble fractions, which can then be filtered off. Toxic ammonia is reduced to nitrogen gas and released into the atmosphere. The Future Bioremediation is not a new technique, but as our knowledge of the underlying microbial reactions grow, our ability to use them to our advantage increases. Bioremediation has technical and cost advantages, although it can often take more time to carry out than traditional methods. Bioremediation can be tailored to the needs of the polluted site in question and the specific microbes needed to break down the pollutant are encouraged by selecting the limiting factor needed to promote their growth. This tailoring may be further improved by using synthetic biology tools to pre-adapt microbes to the pollution in the environment to which they are to be added. Pollution is a threat to our health and damages the environment, affecting wildlife and the sustainability of our planet. Damage to our soils affects our ability to grow food, summarised in our policy briefing on Food Security. Bioremediation can help to reduce and remove the pollution we produce, to provide clean water, air and healthy soils for future generations.

Chapter 6 : Biological Agents of Bioremediation: A Concise Review :: Science Publishing Group

ES&E Magazine provides vital information for professionals that are engaged in the design, construction and operation of municipal water and wastewater treatment systems, stormwater management, industrial/hazardous waste management and air pollution.

Bioremediation which occurs without human intervention other than monitoring is often called natural attenuation. This natural attenuation relies on natural conditions and behavior of soil microorganisms that are indigenous to soil. Biostimulation also utilizes indigenous microbial populations to remediate contaminated soils. Biostimulation consists of adding nutrients and other substances to soil to catalyze natural attenuation processes. Bioaugmentation involves introduction of exogenic microorganisms sourced from outside the soil environment capable of detoxifying a particular contaminant, sometimes employing genetically altered microorganisms Biobasics, During bioremediation, microbes utilize chemical contaminants in the soil as an energy source and, through oxidation-reduction reactions, metabolize the target contaminant into useable energy for microbes. By-products metabolites released back into the environment are typically in a less toxic form than the parent contaminants. For example, petroleum hydrocarbons can be degraded by microorganisms in the presence of oxygen through aerobic respiration. The hydrocarbon loses electrons and is oxidized while oxygen gains electrons and is reduced. The result is formation of carbon dioxide and water Nester et al. When oxygen is limited in supply or absent, as in saturated or anaerobic soils or lake sediment, anaerobic without oxygen respiration prevails. Generally, inorganic compounds such as nitrate, sulfate, ferric iron, manganese, or carbon dioxide serve as terminal electron acceptors to facilitate biodegradation State of Mississippi, Department of Environmental Quality, Three primary ingredients for bioremediation are: Generally, a contaminant is more easily and quickly degraded if it is a naturally occurring compound in the environment, or chemically similar to a naturally occurring compound, because microorganisms capable of its biodegradation are more likely to have evolved State of Mississippi, Department of Environmental Quality, Petroleum hydrocarbons are naturally occurring chemicals; therefore, microorganisms which are capable of attenuating or degrading hydrocarbons exist in the environment. Development of biodegradation technologies of synthetic chemicals such DDT is dependent on outcomes of research that searches for natural or genetically improved strains of microorganisms to degrade such contaminants into less toxic forms. Microorganisms have limits of tolerance for particular environmental conditions, as well as optimal conditions for pinnacle performance. Factors that affect success and rate of microbial biodegradation are nutrient availability, moisture content, pH, and temperature of the soil matrix. Inorganic nutrients including, but not limited to, nitrogen, and phosphorus are necessary for microbial activity and cell growth. However, it has also been shown that excessive amounts of nitrogen in soil cause microbial inhibition. Addition of phosphorus has benefits similar to that of nitrogen, but also results in similar limitations when applied in excess State of Mississippi, Department of Environmental Quality, All soil microorganisms require moisture for cell growth and function. Availability of water affects diffusion of water and soluble nutrients into and out of microorganism cells. However, excess moisture, such as in saturated soil, is undesirable because it reduces the amount of available oxygen for aerobic respiration. Anaerobic respiration, which produces less energy for microorganisms than aerobic respiration and slows the rate of biodegradation, becomes the predominant process. Soil pH is important because most microbial species can survive only within a certain pH range. Furthermore, soil pH can affect availability of nutrients. Temperature influences rate of biodegradation by controlling rate of enzymatic reactions within microorganisms. There is an upper limit to the temperature that microorganisms can withstand. Most bacteria found in soil, including many bacteria that degrade petroleum hydrocarbons, are mesophiles which have an optimum temperature ranging from 25 degree C to 45 degree C Nester et al. Thermophilic bacteria those which survive and thrive at relatively high temperatures which are normally found in hot springs and compost heaps exist indigenously in cool soil environments and can be activated to degrade hydrocarbons with an increase in temperature to 60 degree C. Contaminants can adsorb to soil particles, rendering some contaminants unavailable to microorganisms for biodegradation. Thus, in some circumstances, bioavailability of contaminants depends not only on the nature of the contaminant but also on soil type. Hydrophobic contaminants, like petroleum hydrocarbons, have low solubility in water and tend to adsorb strongly in soil with high organic matter content. In such cases, surfactants are utilized as part of the bioremediation process to increase solubility and mobility of these contaminants State of Mississippi, Department of Environmental Quality, Additional research findings of the existence of thermophilic bacteria in cool soil also suggest that high temperatures enhance the rate of biodegradation by increasing the bioavailability of contaminants. It is suggested that contaminants adsorbed to soil particles are mobilized and their solubility increased by high temperatures Perfumo et al. Soil type is an important consideration when determining the best suited bioremediation approach to a particular situation. In situ bioremediation refers to treatment of soil in place. It is imperative that oxygen and nutrients are distributed evenly throughout the contaminated soil. Soil texture directly affects the utility of bioventing, in as much as permeability of soil to air and water is a function of soil texture. Fine-textured soils like clays have low permeability, which prevents biovented oxygen and nutrients from dispersing throughout the soil. It is also difficult to control moisture content in fine textured soils because their smaller pores and high surface area allow it to retain water. Bioventing is well-suited for well-drained, medium, and coarse-textured soils. In situ bioremediation causes minimal disturbance to the environment at the contamination site. In addition, it incurs less cost than conventional soil remediation or removal and replacement treatments because there is no transport of contaminated materials for off-site treatment. However, in situ bioremediation has some limitations: Ex situ bioremediation, in which contaminated soil is excavated and treated elsewhere, is an alternative. Ex situ bioremediation approaches include use of bioreactors, landfarming, and biopiles. In the use of a bioreactor, contaminated soil is mixed with water and nutrients and the mixture is agitated by a mechanical bioreactor to stimulate action of microorganisms. In each of these methods, conditions need to be monitored and adjusted regularly for optimal biodegradation. Use of landfarming and biopiles also present the issue of monitoring and containing volatilization of contaminants. Like in situ methods, ex situ bioremediation techniques generally cost less than conventional techniques and apply natural methods. If the challenges of bioremediation, particularly of in situ techniques, can be overcome, bioremediation has potential to provide a low cost, non-intrusive, natural method to render toxic substances in soil less harmful or harmless over time. Currently, research is being conducted to improve and overcome limitations that hinder bioremediation of petroleum hydrocarbons. On a broader scope, much research has been and continues to be developed enhance understanding of the essence of microbial behavior as microbes interact with various toxic contaminants. Additional research continues to evaluate conditions for successful introduction of exogenic and genetically engineered microbes into a contaminated environment, and how to translate success in the laboratory to success in the field US DOE, The Science and the Issues. Pearsall, and Martha T. Perfumo, Amedea, Ibrahim M. Banat, Roger Marchant, and Luigi Vezzulli. Department of Environmental Quality. Fundamental Principles of Bioremediation. Department of Energy, Office of Science.