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Pollution mitigation for hydrocarbons of petroleum through the bioremediation

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ABSTRACT

Environmental contamination by hydrocarbons resulting from activities related to the oil sector is one of the great problems of our time and with the growth of production, distribution and consumption in recent years accidents involving oil or its derivatives have been increasingly steady. This environmental problems and frequent have become increasingly critical, since as can reach the soil, air and bodies of surface and underground water. Besides that, contain compounds with high level of toxicity, mobility and persistence in the environment, and generate a major ecological impact, these pollutants hinder the treatment of contaminated areas. The objective this work is to analyze from the law involved in the prevention of environmental damage this work also sought to introduce control measures and repair of the impacts caused by the oil industry, with emphasis on bioremediation technology as a mitigation measure, working in the recovery of degraded areas. Several studies developed in Brazil and the world has shown good results in restoring environments that have been polluted by hydrocarbons. It was also demonstrated the importance of the choice of technique bioremediation that followed the most used techniques for the biodegradation of hydrocarbons, both in situ and ex situ, as well as the processes involved for the bioremediation occurs effectively and safely. The development of studies like this can help generate new technologies or improve those that already exist, which is fundamental for the enrichment of new environmental decontamination projects.

Keywords: bioremediation technology, environment, contaminants

INTRODUCTION

Worldwide, more and more areas are at constant risk of environmental degradation due to industrial and port activities. Over history of human civilization, the creation of new ways of environmental exploitation, means of production and technologies that facilitated the economic, industrial development and quality of life was revealing some negatives to the environment (MONTE et al., 2015).

Among these activities, there is the petrochemical industry, the transportation of oil and its derivatives. Oil production involves numerous and serious risks to the environment from the extraction process to consumption, to the generation of gases that pollute the atmosphere (ADAME; GAMBINI, 2007).

In the state of Pernambuco already in operation since December 2014, the Refinery "Abreu e Lima" located in the Industrial Port Complex of Suape, one of the main centers of the country's investments, is responsible for the production of petroleum products. Causing an even greater risk to this area that has gone through a series of physical and structural changes since the installation of the port, as well as to adjacent areas of great potential for tourism, ecological and historical (SILVA; SILVA; SILVA, 2012).

To avoid environmental damage is necessary to carry out an adequate management of the exploitation of natural resources, in this case oil, which during the industrial process eventually generates numerous waste that pollutes the environment. For this, they should follow certain basic rules, predicting damage, for to minimizing (CUNHA; GUERRA, 2002).

Because of the frequency of the oil spill and its derivatives, over the years has been developed new techniques aimed mainly decontamination of the most battered areas (HEIDERSCHEIDT et al., 2016).

Currently a biotechnological remediation process have been thoroughly researched and recommended by the scientific community as a viable alternative for the treatment of contaminated environments, such as surface water, groundwater and soils, as well as waste and industrial waste in landfills or containment areas, this technology it is known as bioremediation. This process involves living organisms, usually microorganisms or plants which are technologically used to remove or reduce

the environmental pollutant (GAYLARDE; Bellinaso; MANFIO, 2005). There are some contaminants that are easily biodegraded by microorganisms than others, but in the case of petroleum hydrocarbons, many of the contaminated areas have a complex mixture of organic compounds, in this way, most will not be metabolized at the same rate, depending on the degree of concentration of the dopant and the quality of the catalyst species used in the process (HEIDERSCHEIDT et al., 2016).

REVIEW

1. OIL AND DERIVATIVES

Oil is a major constituent of Brazil's economy and the world, that is, this fossil fuel is an energy resource responsible for much of the currencies which make up the national economy (MARTINS et al., 2015).

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Oil is a complex mixture containing various compounds, and hydrocarbons represent the major fraction. Mainly due to the complexity of this mixture, typically the treatment of areas contaminated by these substances is quite difficult and problematic (ANDRADE; AUGUSTO; JARDIM, 2010).

This oil rich in hydrocarbons formed from the organic matter undergoes changes under anaerobic conditions and when subjected to elevated pressures (WEBER, SANTOS, 2013).

In environments contaminated by oil and oil products, some contaminants stand out for demanding greater environmental concern, they are benzene, toluene, ethylbenzene and xylenes, these compounds are known as BTEX, which have high toxicity, mobility and persistence in the environment (ANDRADE; AUGUSTO; JARDIM, 2010). Another class of contaminants that are also given attention are the polycyclic aromatic hydrocarbons (PAH), which are among the most persistent pollutants, toxic properties, mutagenic and carcinogenic to humans (TONINI; REZENDE; GRATIVOL, 2010).

In recent years the oil industry has been progressively increasing and thus were generated with increasing oil derivatives and oily waste to the environment.

Among the main groups of pollutants found in contaminated areas stand out aromatic solvents, liquid fuels, polycyclic aromatic hydrocarbons (PAH), metals and halogenated solvents. Among liquid fuels, stand-derived oil: Diesel oil and gasoline (CETESB, 2015).

The impact of the oil sector is a factor of great concern not only for the petrochemical industries that deal with this problem on a daily basis as well as for society.

The damaged sites and contaminated by toxic elements increases soil degradation, resulting in water and wind erosion, as well as leaching of contaminants into the water table (MACHADO et al., 2013).

2. LEGAL ASPECTS AND CONTROL MEASURES AND REPAIR OF IMPACTS

With regard to legal issues, from the beginning of oil exploration and production activity of the right tried not only to repair all kinds of damage to the environment that could come about as has standardized means of prevention. It is the provisions of article 44, item I of law 9,478, requiring that contracts for award of bid blocks is expected that the dealer must take the necessary measures for the conservation of reservoirs and other natural resources, for security people and the environment protection (MARTINS; OLIVEIRA, 2011).

Brazilian law also requires methods of prevention and mitigation of environmental damage, since the damage occurred, contaminated areas should be remedied to minimize environmental interference and restore ecosystems. For this, you need the diagnosis, analysis and monitoring of the impact and remedial measures are taken.

The resolution CONAMA 265 considers the need to establish secure strategies for prevention and management of environmental impacts generated by establishments, activities and oil and oil facilities in the country (CONAMA, 2000). Large

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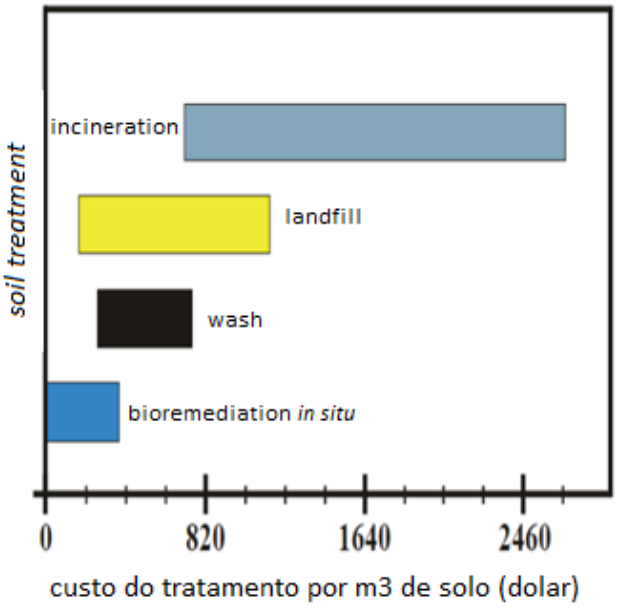
amounts of waste oil and its derivatives are improperly deposited showing clear evidence that organic compounds may remain in place for long periods of time (Machado et al., 2013).

Currently, the techniques most used for disposal of industrial processes comprise the removal of contaminated material from the affected areas, followed by chemical or physical treatment of the waste, and return to the environment.

Waste that can not undergo this treatment are incinerated or landfilled, which according to Costa (2015) have a shortage of areas for implementation and its cost is very high as shown in Figure 1.

Figure 1. Comparison between soil treatment costs using different remediation techniques. Source: Andrade; Augusto; Garden, 2010.



Furthermore, these methods generate wastes and exacerbates the problem because incineration leads to the generation of toxic gases and transfer of pollutants to the atmosphere. In addition to the contamination of water and subsoil (OLIVEIRA et al, 2008).

In search of alternatives have been sought solutions that besides encompass: efficiency, simplicity, time required in the operation and costs, bring more security and less impactful actions to the environment (MELO et al., 2012). In this context grows increasingly interest in the use of bioremediation, which uses living microorganisms to recover degraded areas, compared to other conventional methods (TONINI; REZENDE; GRATIVOL, 2010).

Among the contaminants that can be treated successfully biologically we can mention the crude oil and oil products like gasoline, diesel oil, aircraft fuel, various solvents and other xenobiotics. Thus bioremediation has been highlighted in hydrocarbon oil removal, as well as maintenance simplicity, applicability to large areas and low cost, this treatment has the possibility of causing the complete destruction of the contaminant (SILVA et al., 2012).

3. TECHNIQUES BIOREMEDIATION

The choice of a technique to remedy a contaminated area will depend on a large number of variables, including type of pollutants, the affected environment, soil types, in addition to the nature of the risk to human health and ecosystems from the presence of these pollutants in the environment (PEDROTI, 2007).

A wide variety of technologies used in the remediation of impacted environments for oil and its derivatives is known. Before an incident involving the release of large quantities of crude oil or oil products, measures are taken initially Physical through mechanical oil removal.

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Then, chemicals used may be capable of dispersing contaminants such as chemical surfactants. In theory, biotechnological techniques are used in a third time to the biotransformation of other material, reaching the mineralization phenomenon characterized by the conversion of hydrocarbons into carbon dioxide (CO_2) and water (PEREIRA JR.; GOMES; SORIANO, 2009).

Before its implementation it is necessary to evaluate in the laboratory and using the data is chosen the most appropriate technique and are then field tests to verify the efficiency of the process. Such techniques may be in situ, occurring on site, such as the natural attenuation and ex situ, where the material is treated off-site. In these cases, they may be used biopiles, bioreactors and biofilters. It is also worth noting the importance of applying the techniques of bioaugmentation and biostimulation, which can be performed in both situations. (PEREIRA JR.; GOMES; SORIANO, 2009).

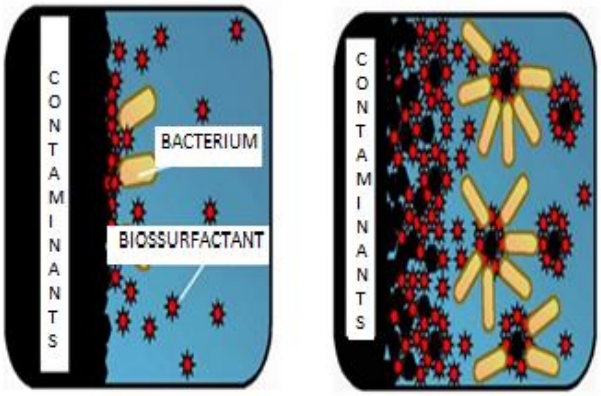
Natural attenuation is the process where indigenous micro-organsimos transform contaminants into less toxic substances by biodegradation. Its use requires the characterization of geology, hydrology and microbial ecology sites, and also the knowledge of biochemical processes. Its biggest advantage is the low cost and to be a technique with minimal intervention (COUTINHO et al., 2015).

The bioaugmentation technique involves introducing microorganisms that already have the potential to transport various hydrocarbons into a contaminated system may be derived from a contaminated site or from a stock culture. It is imperative that these microbial agents are not pathogenic and do not produce toxic substances during the process (OLIVEIRA, 2008).

Since the biostimulation involves the addition of nutrients or surfactants with the objective of increasing microbial activity or bioavailability of the pollutant (GAYLARDE; BELLINASO; MANFIO, 2005). Any correction of environmental conditions, such as N, P , K (nitrogen, phosphate, potash), oxygen and moisture as the use of synthetic surfactants or produced by micro-organisms (biosurfactants), wherein the biosurfactants have the advantage they have low toxicity and are biodegradable, aimed at accelerating the process of biodegradation of pollutants (TONINI; REZENDE; GRATIVOL, 2010).

The biosurfactant compounds act as emulsifiers, reducing surface tension, increasing the contact area between the carbon source and microbial cell (Figure 2) and thus increasing the degradation of hydrophobic compounds.

Figure 2 - Action Representation of biosurfactants on the contaminant. Source: Natureswaygreen Adaptation, 2016.



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The biopiles consist of the construction of cells or soil contaminated cells to stimulate aerobic microbial activity through aeration. During the treatment it is necessary to control the leaching and runoff of liquids from these cells. It has the advantage of easy maintenance and display reduced implementation cost and time of relatively low treatment: three weeks to six months for light hydrocarbons (TOMASSONI et al, 2014).

The biodegradation in bioreactors is made with the contaminated material mixed with water to form a suspension with 10 to 40 % solids, which is mechanically agitated, increasing aeration, the homogeneity of pollutants to microorganisms and their availability. Physical and chemical parameters are adjusted for maximum biomass production, and can also bioaumentar the substrate.

The technique has the advantage of pollutants degrade very quickly. It should, however, consider that the amount of treated substrate is limited by the size of the bioreactor; in some cases, pre-treatment of the substrate to remove toxic compounds to micro-organisms is required; Besides the high cost due to the high technology employed (JACQUES et al., 2007, TONINI; REZENDE; GRATIVOL, 2010).

For the treatment of atmospheric pollutants is recommended that biofiltration is the transfer of volatile components of a liquid phase, and then the degradation thereof by micro-organisms. Besides having lower operating costs and produce minimal by-products polluting it can treat a wide variety of organic volatile components from aliphatic hydrocarbons, aromatic hydrocarbons, such as BTEX compounds as well as volatile organic components derived from the gas.

The system consists of a single packed bed structure intensively involved with a culture of immobilized microorganisms, through which polluted air will flow. The immobilized micro-organisms form a biofilm on the surface of the porous filter matrix, where the pollutants are biologically degraded (ALVES, 2005; TONINI; REZENDE; GRATIVOL, 2010).

It notes that bioremediation is based on three basic principles: the presence of the micro-organism with metabolic capacity to degrade the contaminant, the availability of the contaminant and the appropriate environmental conditions for the growth and activity of biorremediador agent.

One should also consider that many times, each microbial species is responsible for degrading a single oil component, requiring the use of pure consortia (only fungi or bacteria) or mixed (fungi and bacteria) to improve the efficiency of bioremediation (LIMA; OLIVEIRA; CRUZ, 2011). This can provide a complete degradation of the contaminants. Since micro-organisms that do not have the potential to completely degrade certain compound may turn it into a degradable substance for a second microorganism (LEONEL et al., 2010).

Therefore, the biodegradation of petroleum or its derivatives in natural environments or in the laboratory, should not be performed by a single microbial species, since this pollutant consists of various types of hydrocarbons and any microorganism able to degrade all alone compounds there gifts.

Therefore it is essential to form consortia with microorganisms of different genera and species, each specialized to degrade one or more oil

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fractions, due to the complexity of the metabolic processes necessary for the degradation of petrogenic source of hydrocarbons (TONINI; REZENDE; GRATIVOL, 2010).

Later during the monitoring of the bioremediation processes is necessary for analysis are done to detect the effectiveness of the biodegradation process.

Among the methods of oil degradation analysis and derivatives, chromatography occupies a prominent place, because of its efficiency in effecting the separation, identification and quantification of chemical species. Gas chromatography and high-performance liquid chromatography (HPLC) have been two techniques used by many authors for the hydrocarbon biodegradation analysis (COLLA, 2012;.BRITO et al., 2010).

Since effective bioremediation conducting ecotoxicity tests is required for the evaluation of adverse effects of chemical agents on the terrestrial and aquatic biota and evaluating the pollutant impacts on soil organisms and receptor bodies. Thus, these tests measure the contaminant bioaccumulation potential providing information toxicity and bioavailability, and can be an important tool in helping the monitoring of degraded areas (RAMOS; EGLER; CASTILHOS, 2007).

The performance of such tests before and after bioremediation process is of great importance to compare the levels of contamination and evaluate quality of the system reached after the biological treatment.

The oil industry is among the most important for the economy, but along the production chain are involved numerous risks to the environment.

Knowing that Brazilian law requires the prevention of impacts generated and once the damage occurred to mitigation is necessary, the use of micro-organisms through bioremediation deserves evidence.

Among the other advantages bioremediation allows the complete removal of petroleum hydrocarbons causing little change in physical, chemical and biological environment.

To occur efficiently and securely to choose the appropriate technique should be taken after the assessments relating to the treatment and the affected site. After the process is important to monitor the degraded area to monitor the system decontamination.

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