PROBLEMS ASSOCIATED WITH OIL EXPLORATION IN OGBALAND, RIVERS STATE NIGERIA: THE USE OF BIOREMED1ATION TECHNOLOGY

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Abstract

Ogbaland is one of the largest oil producing tribes in the Niger Delta region of Nigeria and made up of three groups Usomini, Igburu and Egi (which differ in customs, traditions and speech not-with-standing the universal territorial spread of the Onubdos) in Rivers State of Nigeria. Millions of tonnes of hazardous waste are added to soil and even reach underground water. Several dumping sites become veritable health hazards and unrecoverable loss of the concerned land results. The problem is severely felt by Ogba people today and will be apparent elsewhere as the industrial progress and economic growth occur. Pollution prevention is an ideal situation for an environmental protection but where it fails, remediation becomes inevitable. Since biodegradation is the ultimate fate of any of the contaminants that enters into environment, biotechnology can give effective solutions in our remediation efforts.

Introduction

Pollution of soil and ground water is a major problem with up the 60 sites needing urgent treatment across Ogbaland. All these sites need a cleanup. The importance of development of better technologies is because of huge required sites for clean-up.

Bioremedialion has proved effective for treating soil and groundwater contamination at numerous sites throughout the world and is accepted as a viable remediation strategy by the United States Environmental Protection Agency, Environment Canada and other regulatory agencies worldwide. Bioremediation technology emerged on commercial scale technology in mid 1950s.

Bioremediation encompasses biological methods for clean — up of contaminated soil and ground water and even marine environment (in case of oil spills). It is also referred to as biorestoration which means giving nature a helping hand.

Biorestoration involves establishing condition in contaminated environment such as the appropriate micro-organisms flourish and carry out metabolic activities to detoxify the contaminants. During bioremediation, micro-organisms are introduced into the contaminated area and these micro-organisms may not use the contaminants as nutrients or energy source or it may be degraded by co metabolism.

Establishing suitable conditions for bioremediation may mean adding nutrients to promote the growth of particular organisms, adding terminal electron acceptor (O_2 or NO_3), adjusting moisture conditions or raising the temperature and so on. The basic concept is to provide critical environmental requirement which may be adverse in a particular site.

Unavailability of critical environmental factors for microbial activity may be responsible for the persistence of the otherwise degradable substances in many places.

Bioremediation is expected to degrade toxic hazardous organic contaminants from the site to environment safe levels.

Bioremediation has a vast potential to treat soil and ground water contaminated by variety of hazardous chemicals including refractory organic, benzene, styrene, vinyl chloride, pentachloro phenols, polaromatic hydrocarbons (PAHS), Aolucne, xylene, phenel etc.

Advantages of Bioremediatiosns

1. Bioremediation harnesses natural biogeochemical processes
2. Cost - effective alternative
3. Toxic chemicals are destroyed or removed from the environment and not merely separated.
4. Low capital expenditure

5. Less energy required when compared with other technologies
6. Less manual supervision.

Constraints to Bioremediation

1. The process of bioremediation is slow. Time required is in days to months.
2. Heavy metals are not removed
3. For in situ bioremediation site must have soil with high permeability
4. It does not remove all quantities of contaminants
5. Substantial gaps exist in understanding of microbial ecology, physiology and genetic expression and site engineering.

A stronger scientific base is required for rational designing of process and success.

Conditions Required Before Bioremediation

1. Understanding what regulations govern the problem and what action needs to occur.
2. Characterization of the site, including the types and volume of the matrix to be treated, concentration of the contaminants and other interfering problems
3. Tractability of feasibility studies to determine the best - technology to be used (often biotreatment will be combined with technologies).
4. Design the engineering of the system based on treatment ability results.
5. Innovative biotreatment technologies should be responsive to public concern.

Various micro-organisms are useful in bioremediation. The use of rlute rot fungus in the biodegradation of benzo (a) pyrene.

DDT and PCBS in an example of the practical application of fungi for waste sue clean-up. The abilities of the white rot fungi chryso poruim lignorum, trametes versicolar and phen-erochacte chrysospotuim to mineralize 3,4 - dichlorianiline, dicldrin and phenanthrene were investigated by Morgan et al (1991). Highest rates are achieved when minerals and vitamins are available.

Pseudomouasputida has shown to be effective cometabolisim of tricholorethylene (TCE) when phenol or toluene is added. Pseuclomonas acielovorans, pseudomonas fluroscent, psendomonas aerugenosa, pseudomonas mendocina are found to be methane oxidizing bacteria for vinyl chloride, dicholorothylene and tricholoroethylene.

Types of Bioremediation

Bioremediation operations can be on site or off-site, in situ or exsitu. Bioremediation may be required of surface soil and sludges or subsurface soil. Bioremediation is the naturally occurring proces's by which micro-organisms transform environmental contaminants to innocouous end products. For sites at which contaminants of concern pose no significant risk of sensitive receptors such as water supply wells and surface water bodies, in situ treatment may be an appropriate remediation strategy. For other sites at which receptors are at risk, ex situ treatment may be appropriate.

Ex Situ Technologies

Processes for surface soils and sludges are either (1) Solid phase processes (land treatment) land farming and soil banking.

(2) Liquid- Solid slurry process: The land farming and soil banking process are used to treat the waste from coal gasification/liquification, food processing, leather tanning, paper and pulp production, petroleum refining, municipal waste and sludge, kerosene contaminated soil etc. Volatilization, leaching water run-off is prevented from the area of treatment. Hydrolysis, photolysis, chemical degradation also may occur along with bio-degradation. Last attention required during the process is the advantage of these methods while longer time duration is the disadvantage.

Land farming

The simplest biotechnological solution in use today is the land farming. In this process the contaminated soil is spread in this layers on a plot and is supplemented by nutrients and micro organisms and proper PH. Land farming involves degradation in upper 6-12 inches of contaminated soil. The actual treatment zone may be several feet deep. Tilting is done periodically for mixing. The technology is done periodically for and mixing. The technology requires more land space and more time.

Land farming is suggested for oil sludges as a low cost disposal method. Here oil, water and solids etc oil sludges from oil refining industries are treated with micro-organisms after addition of lime, nitrogen-phosphorus fertilizers.

Soil Banking (Compositing)

Waste are excavated and treated in one meter high heaps, sometimes mixed in with a layer of normal soil on high-density plastic liners. It has a drainage and leachate collection system. Run - off lecheate is collected and may be recycled on heap or treated separately in a bioreactor. The mixture is carefully cultivated, encouraging the microbes within the soil to degrade the waste nutrients and microbes may be added to the unoc.

Compositing waste. Waste are stabilized to less complex materials and water content and mass decrease. Waste from brewing, food processing, sewage sludge, antibiotic fermentation wastes, soils contaminated with petroleum products are treated by composting. Trinitrotoluene (TNT), hexaahydro 1,3,5, trimtro, 1,3,5, triazine (RDX) and Octa hydro 1,3,5,7 tetranitro 1,3,5, tetra azorcine (HMX) are the explosive which are significantly transformed by composting process.

Windrow Compositing

Windrow compositing was successfully demonstrated to be effective intreating explosive contaminated soils in US in 1992, USAEC demonstrated windrow compositing to reduce explosive concentrations over 99% and toxicity over 90-98%. Windrow compositing is cost-effective technology with modest equipment and monitoring requirements. Windrow compositing mixes soil with compost in long piles known as windrows. To facilitate the microbial growth, carbon sources as manure, straw alfalfa and agricultural products are added. To facilitate aeration and heat control, windrows are turned periodically using a compost tuner. Moisture content, window oxygen level and temperature are easily monitored,

Slurry Processes

Hazardous wastes in liquid solid contact are treated in a closed reactor or open pit or lagoon. The process is the conventional activated sludge process. Waste is taken in the reactor in form of slurry and mixed with micro-organisms organic or inorganic nutrients oxygen is supplied with spargers or floating aerators. Single batch reactor or sequence batch is used. The reactor may be mobile above ground or lined in situ lagoons or pits. Neutralizing agents, surfactants, dispersants are added to hasten the degradation process. After treatment solids are allowed to settle appropriately treated or disposed off. The liquid phase is discharged in environmentally safe manner. Materials most often treated by this method are wood - preserving and oil refinery waste containing phenol, benzene, tohuene, naphthalene, polychic aromatic hydrocarbons.

Soil slurry, orbioslurry technology is used for premeditating explosives-contaminated soils. For sites requiring greater process control, more complete degradation or where the cost of importing compose -amendments is prohibitive, bioslurry to allow contact between the micro organisms and the contaminants.

Because conditions are optimized for the micro-organisms, slurry processes are faster than many other biological processes. The treated slurry is suitable for direct land application similar to composted soils.

Bioslurry process has been demonstrated with a removal rate of over 99% for explosive chemicals and a high degree of mineralization. Disposition of the treated soil is an important part of bioslurry costs. Consideration of disposed soil placement is affected by risk base goals and future land use. If dewatering and this water treatment is required, cost will increase.

Windrow composit and biosluny process are found to have just half the cost of treatment when compared with incineration process. A slurry biocascade has been developed, in which simple face components like n-allcanes are biodegraded in first step while more recalcitrant contaminateds with multi rings PAHs are bioatttacked in reset step: this helps for proper optimization of conditions for different organisms.

Pump and Treat Types of Processes

Other ex-situ technology includes a wide variety of bioreactors ranging from small (l-smm3) portable units to large built specifically for polluted site. When contaminated soil is inaccessible (i.e. in prime location beneath the building or when buried pipes, cable, prevent or when ground water is to be treated this method is desirable. Soil leachate or ground water is pumped to this surface, treated under controlled conditions is the bioreactor and the cleaned water returned to the ground. The clean up of soils and sub-soils is totally dependent on permeabilies and dispersed status of pollutant

In Situ Technologies

Non-disruptive treatment of contaminated prime site (when excavation is not possible or advisable) is also possible with in situ treatment. In situ treatment, ground water may be extracted and supplemented with organism and nutrients and re-introduced or nutrient solution is added along with useful micro-organism by injections into the subsurface through wills and infiltration system. The entire are then like a bioreactor.

In situ bionicdiation provides a potentially significant benefit for volatile organic compounds (VOCs) and other contaminants that are held up in adsorptive soils or less permeable silts, sediments and clays that act as sinks or ground water which is contaminated with volatile organic compound pump and treat method is largely used. But is situ treatment for ground water will be more effective. in situ treatment, of ground water is faster and safer with worker exposure to chemical contaminated being minimum. It may stop or slow the movement of radionuclides in the ground water and acceptance of the technology by people is more. The method gives ultimate on-site solution to completely remove contaminant from the concerned environment. The main limitation of this technology when compared with base line method is the difficulty in designing and implementing an effective subsurface treatment system for highly heterogeneous media. Several key technical issues have prevented widespread used bioremediation for organic and inorganic subsurface contaminate. These are adequate nutrients delivering systems effective mixing for contacting micro-organisms nutrients contaminant, control of biojouling or excessive microbial growth and adequate tools for designing, predicting and monitoring the performance of in situ technology in heterogenous subsurface environment.

Bioremediation can destroy the VOCs in place and reduce the limitation of mass transport associated VOC adsorption/desorption to sediments and dissolution into the ground water that occur in pump and treat technology.

The time and cost of cleanup could be substantially reduced if bioremediation could effectively employed alone or in conjunction with other bulk contaminant removal technology styrene • spillage in sandy soil which had also reached ground water could be cleaned by in situ treatment in which ground water was extracted inorganic nutrients and oxygen were added and it was allowed to". reinfiltrate though contaminated soil within 14 weeks concentration of styrene was reduced to less than • 0.05 mg/kg.

The in situ treatment is carried out in fuel spills chlorinated solvents and pollutant mixtures. In bioscreening, porous walls are inserted into the ground and sucked with micro-organisms which screen out any contamination, effectively isolating and treating the area simultaneously.

Bioremediation of Subsurface Material

Undissolved chemicals exist when fuels, solvent spill or leak from tanks or pipes occurs. Undissolved material may be dense and more towards the bottom of aquifer in light and will concentrate in the capillary fruige above the water table. Plume is contaminate solute in ground water. It has little dispersion along the flow palts of aquifers. Contamination of subsurface may be plumes in ground water or fuiues in soil air both undissolved phases be pumped out-before in situ bioremediation is initiated.

In situ treatment is not possible since electron acceptors and nutrients cannot be mixed easily with the contaminated ground water. The clean water is injected into plume and it displaces contaminated groundwater. This is taken then to above ground reactor, mixed with nutrients and returned. These are an infiltration well and recovery well. Water in the filtration wells is oxygenated and then it reached subsurface.

The recovery well collects it and brings it into bioreactor. Aromatic compounds alkyl-benzenes are degraded by this technique. Also vinyl chloride trichloroethylene, dichloroethylene are degraded using methane oxidizing bacteria.

Bioveuting: It is also called as soil vacuum extraction. It is used for removal of oily phase contaminants above the water table. A well is bored near point of contamination but above the water table. Vaccum is applied from the extraction well and volatile emissions are safely vented. Oxygenated air comes in contact with the undissolved contaminated subsurface material which gets biodegraded. Appearance of CO_2 in extraction well is indication of biodegradation activity. The slow removal of air and maintaining 5% oxygen in subsurface is the practice. Bioventing is cheaper than use of nitrates or hydrogen peroxides as the source of electron acceptors.

Hydrocarbon degradation of 2-2mg /km aquifer material I day is achieved. In the unsaturated surface, bioventing is done for petroleum - derived contaminant that are of fuel contaminated sites by at least 50%. Bioventing not required excavation of contaminated material nor will usually require further treatment. It is relatively non invasive and can be used where buildings, road-ways and runways overlay the contaminated soil. This technology can degrade non-volatile fuels not amenable to soil venting treatment technology.

Bioventing has the potential for accelerating the process of natural biodegradation and hydrocarbons will be degraded before they contaminate groundwater, Bioventing combines vacuum extraction with biodegradatin to mineralize jet fuel in the vadoes zone.

This technology works when air is moved through contaminated soil via a perforated pipe connected to a vacuum pump. Oxygen in the air hastens the breakdown or biodegradation of the hydrocarbons in petroleum fuels and promotes the growth of soil bacteria to contribute to biodegradation.

Contaminant like crude oil, benzene, toluene xylene, jet fuels, diesel fuels, gasoline waste oil can be treatment by bioventing but chlorinated organic compounds are not appropriate because they are resistant to biodegradation.

Bioremediation of oil spills

Oil during production, refining, transport and ultimate disposal are introduced in large amount in nature. It is estimated that 6 million metric tonnes of oil gets added into ocean annually through various sources. (Production sites wells, slipping routes deliberate or accidental leakage from tankers etc).

Floating oil is difficult to contain, is destructive to fishes, birds and causes economic and aesthetic damage. Oil slicks in ocean are handled by used of detergents for dispersal or sinking oil'by use of oil siliconized sand or chalk is done but it is costly. Oil spills can undergo auto-oxidation photochemical oxidation and biodegradation. Actual biodegradation rate for C - labeled hexadeane observed in experiments does not exceed 50mg of hydrocarbon degraded 1 m3 per day and 960mg per m3day is too optimistic. Susceptibility of oil to biodegrade varies due to complexity of oil. It has aliphatic aromatic, alicyclic, branched hydrocarbons. C30-12 alkanes are susceptible to degradation while branched aromatic condensed rings are difficult for degradation. Tarry lumps and stable emissions are also difficult for attack. Rate of biodegradation'through good laboratory is poor in natural conditions. Deficiency of carbon, nitrogen nutrients and of phosphorus and iron is responsible for low rate of degradation. Also low degrading micro-organism deficient in keeping organism in contact which oil and poor survival of externally added micro-organism in new environment are some of the problems. Inoculations of hydrocarbon degradation organism and addition of nitrogen and phosphorus fertilizer to support their growth is being explored for attack on oil slicks. Superbugs (psendomomas spp. Carrying simultaneously genes, cloned on plasmids for attack on camhor, octane, salicylate, naphthalene, toluene) have been constructed and tried. These multi-plasmid stain are found to be useful in closed systems but their effectively in ocean slick is questionable. Accidental oil spills on land are easier to contain gasoline and other low viscosity distillation products may seep into subsoils and persist due to anoxic conditions. Oil spills on land is also damaging and harm is caused to vegetation, anoxic conditions are produced by its see page in subsurface soils. For disposal of oil spills and oil sludges from oil refining operation on land. The three approaches are (i) slurry bioreactor (ii) Land farming and (iii) soil barking.

Conclusion

Many may not feel bioremediation of pollutants sites as an urgent need or a severe problem in Ogbaland. But it can reach an alarming state slowly and unknowingly. Many bioremediation technologies are available but success depends upon treat ability studies before applications. This piece of work has been able to evaluate the usefulness of this technology and there is a need for the oil companies operating in Niger Delta to use bioremediation technology now that their host communities are demanding for removal of contaminants from the surrounding soil and water.

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