Journal of Agroecology and Natural Resource Management
p-ISSN: 2394-0786, e-ISSN: 2394-0794, Volume 6, Issue 3; April-June, 2019, pp. 89-91

http://www.krishisanskriti.org/Publication.html

The Exigency of Soil Restoration and Remediation

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Abstract—*The misuse of soil and abandonment of agricultural area after intensive utilization has led to the degradation of soil; also the development and activity of essential microbes have been highly compromised. Nowadays there are many factors which cause severe soil degradation and desertification. It is clearly one of the most pressing problems and its continuation will eventually lead to a loss in crop productivity even though fertilizers and other inputs often result in increased yields in the short term. Considering the threat of global change and rapid growth in world population, soil degradation should be a matter of concern as it is the main substrate for agriculture and ecosystem services. The biggest apprehension associated with soil contamination is the harm it can cause to human health. There are significant health risks involved in direct contact with contaminated soil. To fight with soil degradation, restoration approaches have been proposed in order to recover soil fertility and improve soil quality. A process called soil remediation is used to treat soils contaminated by heavy metals or other pollutants by removing pollutants and decontaminating it. There are large number of different processes for soil remediation some of them are thermal soil remediation, encapsulation, air sparging and bioremediation each employing a distinct technique for removing contaminants. However, all the living beings directly or indirectly depend on the soil, so it's better to conserve it. The present study focuses on the various aspects by which soil restoration can be achieved in a significant way.*

Keywords*: Air sparging, Bioventing, restoration*

1. INTRODUCTION

The soil is a fundamental foundation of our agricultural resources & the support of our ecosystem. The human being thinks that soils possess an infinite assimilation capacity but that's not true. Thus by ignorance man throw all types of organic & inorganic matter into the soil which leads to soil contamination [1]. One main reason for its contamination is urbanization & industrialization. The soil is the uppermost layer of earth's crust containing minerals particles mixed with organic substances, water, air & microorganisms. It is an important basis for human being survival. The soil is formed as a result of the interaction of various processes- parent material, topography, climate, organisms, & time.The soil has many functions some of them is to sustain life & provide a habitat for animals, plants & microorganisms, provide protection to the groundwater, conserve mineral resources, for carrying out food production, & to support social & economic activities. Soil must be assumed as a non- renewable natural resource.

Due to the increasing population, it is difficult to fulfill the demands of food without the use of pesticides in agriculture [2]. The pesticides used in agriculture may be natural, synthetic. Pesticides are used because of its benefits in improving crop yield as well as fighting with certain diseases like Malaria, Yellow fever, & Dengue & also in the elimination of internal & external parasites. But the continuous use of pesticides contributes to a number of health risks for mankind because it leads to contamination of food & natural resources like river water, groundwater & thus endangering the survival of many species. The chemical compound used to control insects, mites, harmful grass, fungus & other forms of animals, that may be dangerous for farming, cattle & other product. Hence there is a great need for developing the effective technologies for the sustainable remediation, and restoration of contaminated soils.

Soil remediation is a technique to purify the contaminants of soil using various pathways. Healthy soil is better able to grow vegetation, as well as contributing to healthy air & groundwater [3]. Although soil itself is resilient natural resources cannot forever withstand the abuse we do to them. Therefore, soil remediation techniques have been evolved to face this serious issue. Soil remediation is a process used to treat soils contaminated by heavy metals or other pollutants by removing & converting them into less harmful products.

Soil Remediation

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2. METHODS

Soil remediation is done by two methods i.e. Biological treatment & chemical treatment

Chemical treatment

Chemical treatment involves the technologies that destroy or chemically transform the contaminants. There are two ways to do chemical treatment either in situ or ex-situ.In-situ involves the injection of chemical oxidants into the soil especially Hydrogen peroxide. Key site characteristics are high soil permeability & the presence of a confining soil layer to control migration away from the contaminated zone [4]. While in ex-situ treatment, includes techniques such as land farming, bio piling, & processing by bioreactor. Mechanical energy is used to separate pollutants from the soil. In this technique the soil is crushed & separated via grieving, the soil is then dispersed in a liquid (additive) to dissolve the pollutants [5]. The additive breaks the bond between the pollutants & the soil particles. Purified soil is then separated. This is the most effective method to remove heavy metals, VTEC, TPH, PAH & toxins. This is cost effective method due to excavation & transportation of soil so many people opt for biological methods and treatments.

Biological treatment

In biological treatment, there are two ways & these are Bioventing & Phytoremediation.

In bioventing, indigenous microorganisms are used to bio-degrade organic pollutants found in the unsaturated zone. It involves injecting of air into the soil which enhances the activity of microorganisms that are already present in the soil & it leads to an accelerated rate of degradation of pollutants present in the soil. Bioventing targets particularly benzene, acetone, toluene, phenol, gasoline, and diesel or kerosene fuels.

While in Phytoremediation soil contaminated with hydrocarbons, chlorinated solvents, pesticides, explosives, heavy metals, landfill leachate is takenand a layer of soil is placed over these pollutants. The plants that are capable of naturally extracting, degrading, mobilizing or volatilizing the pollutants are grown on it [6]. The ability of plants to uptake the contaminants are limited to an extent. Pollutants are absorbed & stored in roots, stems & shoots of the plants [7]. Also, there are plants that provide sugars, alcohols, acids, nutrients & their excretion products to the microorganisms to grow & destroy the pollutants [8].

These techniques thus may be applied by two ways: either*in situ* (curing the contamination area) or*ex-situ* (taking the soil from the contaminated area, making it go through a treatment complex and thus restoring it in its original place). The various decontamination techniques may be classified as per the nature of treatment; which may be biological, chemical or thermal or some other techniques.

1. Biological Techniques

Bioremediation is the actual principle of this technique where all types of microorganisms are made in use to remove the waste and purify the soil, sludge treatment and restoring underground water.

1.1 Bio piles and land farming

Bio piles and land farming (also known as Agrarian Technique) are the prime biological techniques in which the contaminated soil is removed and then the microbial activity is stimulated by manipulating the temperature, nutrients, minerals, and humidity in it. Airing the soil is an important part of both these processes. In bio piles, the airing is done by the pipes with the help of a compressor placed at the bottom and in case of land farming, the tractors are used.

1.2 Natural Attenuation

This process is controversial for the reason being considered it as 'do nothing' solution. The land is kept unaltered and a close watch is kept over it. Biodegradation occurs by natural processes and without human intervention. The only risk involved is not obtaining the desired soil after a very slow process of biokinetics.

1.3 Composting

This is a well-known process of degrading the complex substances into stable by-products under thermophilic conditions using either aerobic or anaerobic conditions. The pH, humidity and other physical conditions are kept constant to achieve the maximum degradation efficiency.

1.4 Phytoremediation

This process is in situ in nature and involves the using of some plant varieties to remove the contaminated soil without the use of any chemical or hazardous nature[9]. The only disadvantage it holds is the seasonal availability of the plants and the chances of bioaccumulation in animals.

1.5 Bio-Air sparging

To reduce the concentration of the contaminants in the soil and the absorbed volatile components, this biological technique of air sparging is used which involves the insertion of oxygen and other nutrients from time to time to maintain or increase the microbial activity in the soil. This in situ technique uses microorganisms which are native to the area (Table 1). This technique does not work for non-biodegradable contaminants.

1.6 Bioventing

Opposite to bio-air sparging, bio inventing involves the insertion of air and nutrients into the unsaturated zone. To maximize the in situ biodegradation and minimize the off-gassing of contaminants into the atmosphere, the air and

nutrients are injected into the contaminated media in this technology.

2. PHYSICAL-CHEMICAL TECHNIQUES

2.1 Air Sparging

The process is to inject uncontaminated air into the saturated zone thus to enable the transfer of hydrocarbons from a dissolved state to the vapor state. This is also known as 'in situ air stripping' or 'in situ volatisation'. This air is then extracted out after the process (Table 1).

2.2 Dechlorination

The process by which the more toxic halogen compounds are converted into less toxic halogen compounds by the loss of halogen atoms from it via nucleophilic substitution reaction of compounds. This technology has two variants: Base Catalyzed Decomposition (BCD) and Glycolate Polyethylene Glycol (APEG).

2.3 Soil Flushing or Chemical Leaching

This is the *in situ* washing of the contaminated soil having heavy metals which involves the washing away of contaminants by dissolution, suspension or through chemical reactions carried out with the liquid that passes through the contaminated soil. This technique is often used as a pre technique just to lessen the amount of contamination in the unworthy soil.

Table 1: Techniques for various contaminants

TYPE	CONTAMINAMTS	TECHNIQUE
Biological	Volatiles (non halogenated) or semi volatiles and fuel hydrocarbons.	Biopiles and landfarming
Biological	Hydrocarbons, BTEX, PAHs	Natural Attenuation
Biological	PAHs and explosives	Composting
Biological	Radio-nuclides, BTEX, PAHs, heavy metals	Phytoremediation
Biological	Various fuels, oils and greases, BTEX and chlorinated solvents	Bio-airsparging
Biological	Petroleum products, non halogenated compounds, pesticides	Bioventing
Physical-chemical	VOCs, BTEX, MBTE	Air-sparging
Physical-chemical	Halogenated compounds and pesticides	Dechlorination
Physical-chemical	Inorganic compounds, radioactive contaminants, heavy metals, fuels, pesticides	Soil Flushing or Chemical Leaching
Physical-chemical	Sediments, sludge and soils having organic contaminants	Solvent Extraction
Thermal	Inorganic compunds including radio-nuclides, explosives, semi-volatiles and pesticides	Thermal Incineration
Thermal	Pesticides, dioxins and many organic and inorganic compounds, PAHs	Vitrification

2.4 Solvent Extraction

No use of water or water additives is done in this process. Instead, a chemical which is organic is used. The ultimate success of this process depends on the type of Solvent used for a certain type of pollutant to be extracted from the soil. This technique is often used as associated with certain other remedying techniques.

3. THERMAL TECHNIQUES

3.1 Thermal Incineration

It is probably one of the most used technologies which involve the combustion of halogenated or nonhalogenated, pesticide or any other type of contaminated substance to produce a high amount of carbon dioxide and water in the presence of excess oxygen under high pressure and temperature. Temperatures, Turbulence, Residence Time are the three **T's** which are the influencing factors for these incinerators. They are of different types and further produce three types of residues: Water used by the system, fuel gases given out at the last and the solid waste left at the end by the incinerating machine.

3.2 Vitrification

It is another thermal process in which the product is stabilized by changing into a vitreous product. It may be both in situ or ex-situ (Table 1). It is formed in amorphous materials and results in the fusion of soil matrix due to the heat provocation. The ex-situ process is the same except for the fact that the soil is excavated for its verification process.

Though the choices for the remediation are many but it depends upon the nature of the contaminants such as heavy metals, organics, radionuclides etc. and the condition of the soil. Composting may be attributed to be the most reliable technique to remove the contamination of the soil without any hazardous effects on it. Though it is a bit of time consuming technique but it is cost effective and involves no use of chemical substances.

CONCLUSION

Restoration is actually a type of farming that is based on the understanding of restoring the soil to its original actual purpose.Also, preventing the soil erosion and restoring the soil is being done by examining the organic soil amendments continuously. Though we have studied above various remediation techniques but no single technique is enough to de-contaminate the exploited soil back to its original

value.The selection of the technique is one of the most difficult steps to cure the contaminated site. The future developmental techniques have to be more eco-friendly, in situ, green technology and quick in nature.

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