

TRANSFORMING THE CONTAMINATED SOILS TO SUSTAINABLE SOILS THROUGH APPLICATIONS OF MODERN TECHNOLOGIES AND PRACTICES.

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ABSTRACT: The soil and land has been used interchangeably, though it's quite different in structure, shape, form, function, and in their properties. Land mass is presents on the earth, whereas soil is mixture of minerals, organic compounds, including water, air, and other elements of environment. Geological / Physical Weathering processes in time, under the certain environmental conditions. Soil plays pivotal role in human sustenance on the earth, provides food, shelter, and terrestrial ecosystems on the earth. Anthropogenic activities of man has destroyed the soil fertility and turned soil into highly contaminated form, and reduced ability of physical fertility and production in general. This deteriorated structure of soil compelled academicians / scientists to develop the techniques and scientific methods, and modern technologies to ameliorate the quality of soil from degraded to sustainable soil, as it could be productive, and play vital role in human sustenance, and survive on the earth.

Keywords: Physical, Weathering, Soil Structure, land forms, Contamination, Sustainability. Land Topography.

1. Introduction:

The soil is a principal medium (including certain other) for the human sustenance on the earth. Soil provides food and shelter to man, plants, animals, and other forms of life. Unfortunately, anthropogenic activities destroyed, damaged, and degraded soil's fundamental structure. The principal groups of contaminants are the chemicals, we use for development, exploration, and excavation of natural resources. This exploitation of natural resources ever increasing demand has made soil nothing but an unproductive rubble and dust to flow in the atmosphere, to make environment filthy, unclean, and unsuitable for living organisms to survival on the earth. However, to maintain the life for future on the earth, man has to take strenuous efforts to decontaminate the soil, make earth able to

provide essentials for human growth and development. In this context, various methods and procedures been developed and more in the pipe to be implemented in the future.

2. Methodology.

The research methodology is based upon the literature review, and physical surveys and other relevant information about the topic.

3. The Soil and Land.

The word soil and land remains unambiguous until not clarified, generally both words been used interchangeably that's not correct. **Land** is the part of world not covered by the oceans, while **soil** is a mixture of minerals, organic material, living organisms, air and water

that together support the growth of plant life. Thus the soil is a thin covering over the land. (Enger Smith. 1997).

3.1 The Process of Soil Formation.

The combination of physical and biological events forms soil. Soil building begins with the physical fragmentation of the **parent material**, which consists of ancient layers of **rock** or more recent **Geologic** deposits from lava flows or **glacial** activities. Generally, the kind of parent material and the climate determines the kind of soil formed. The factors which can bring about fragmentation or chemical change of the parent material are known as **Weathering**. Temperature changes and abrasion are two fundamental agents of **mechanical weathering**. Thus oxygen oxides the smaller rock fragments and further breakdown begins with the interaction that is called hydrolysis. In addition to that rain being slightly acidic in nature further destroys the rock even much smaller fragment to dissolve in the water to be a part of decaying organic matter the **humus** formation process. Thus humus supplies essential organic matter to plants and slightly acidic to dissolve the inorganic nutrients to make available for plants to utilize. An addition to that humus provides a loose soil texture to allow water to soak in and permit air to be inside the soil, while compact soils have no air spaces and percolation capacity to run off water.

Further, animals, soil bacteria, fungi, and debris of plants roots are also essential part of biological process of soil formation. About a rough estimate, that one hectare of soil may support a population of 500,000 earthworms, which play a primary role in the process of soil formation. (Enger Smith 1997). It is estimated that, under an ideal climatic conditions, soft parent material may develop a centimeter of a soil into 15 years, while under unfavorable climatic conditions (extreme drought and cold) takes hundreds of years to turn into soil, therefore, the soil formation process remains extremely slow and unproductive.

Principally, the process of soil formation formally depends upon five major processes, such as, Climate (precipitation & temperature), Topography (Shape of the land), Biota (Native vegetation, animals, and microbes), and Parent Materials (geologic weathering of rocks), Time (parent material subject to process of soil formation). Jenny. H (1941).

3.2 Soil Properties.

A scientific investigation provides remarkable details of soil properties. Soil properties include soil texture, structure, atmosphere, moisture, decayed organic matter, and chemical composition. Further **soil texture** is determined by the size of rock particles within the soil. The largest soil particles are **gravel**, which consists fragments, larger than 2.0 centimeter in a diameter. While particles between 0.05 and 2.0 millimeters are classified as **sand**. Particles ranging from 0.002 to 0.05 are classified as **silt**, and the smallest particles are **clay** less than 0.002 millimeters in diameters. The **loam** particle is an ideal for agriculture, combines with clay, having aeration capability, and to drain the water properly. (Enger Smith 1997).

Soil texture and sizes.

Soil Texture	Size. Cms / dms
Gravel	2.0
Sand	0.05 – 2.0
Silt	0.002 – 0.05
Clay	0.002 <

Table No: 1, Soil Textures. Enger Smith, 1997.

3.3 Soil Functions.

Basically the functions of soil / land are diverse in nature, and play key roles in maintaining our lives, environment, aesthetic beauty, food production, clean water and air, rangeland, wild life and landscaping.

A. Nutrient Cycling in Soil / Land.

The soil has capability to deposit and release, and recycling of the minerals and other elements. In the process of **biogeochemical cycling**, the water cycle transports these minerals and elements to the plant roots. Thus these roots absorb water including these minerals and other, certain quantity is held by the soil itself, and finally evaporates from trees / plants into the environment and lost.

B. Soil Controls Water Drainage Mechanism.

The soil controls water drainage and storage of water, including solutes in it. Thus the flow of water includes nitrogen, sulphur, phosphorus,

pesticides, and other compounds in the dissolved state in the water. Predominantly water has ability to accelerate all chemical reaction for further utility of minerals, elements, and compounds, to be used by the plants.

C. Soil Provides Biodiversity and Habitat for Living Organisms.

Soil provides growth and development of plants, animals, and soil microorganisms. Soil gives functional utility of the organisms by using physical, chemical and biological habitat to secure their next generations, with complete supplies of food and nourishment to animals, plants, and microbes.

D. Soil Plays Role of Buffering and Filtering of Materials.

Soil has performs a basic role in filtering and the water, air, and other essential resources in general. Soil degrades the toxic compounds otherwise to be available to plants, animals, and in environment particularly.

E. Soil Provides Physical Stability to Plants.

Soil gives extraordinary physical support to plant stability by fixing its roots in it. Other physical forces pressurizes plants to get destabilizes such velocity of air affects stability, whereas, the soil being porous and soft in structure provides storability to insert the plant root system on maximum extensive scale.

3.4 Nutrient Cycling of Soil and its Indicators.

Soil plays a series of vital functions one is these functions are storage and moderate release of nutrients, to support plants and animals to survive and maintain biodiversity in a given habitat in the environment. Soil stabilizes the biogeochemical reactions by moderate release of various chemicals through water cycling process. Again water decreases the abundance of toxic compounds and neutralizes their effects upon the flora and fauna of the ecosystem. Water reduces the toxicity of soil through its release in water and air, and smaller quantity is being held by it.

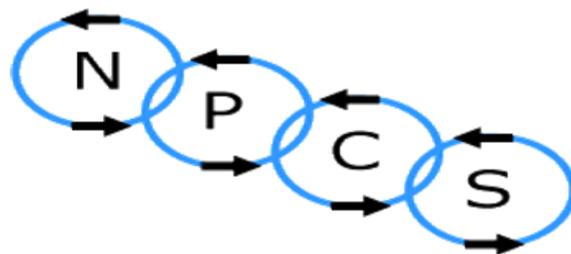


Fig No: 1. The process of assessment of nutrient indicators.

3.5 Soil Fertility Indicators.

The group of minerals and electrolytes plays a comprehensive role in maintaining the balance of its fertility factor. These include nitrogen (in soil nitrate form), potassium, sulphur, magnesium, calcium, boron, and zinc etc.

A. Organic Matter Indicators.

The principal organic matter indicators are; decomposes microbial biomass carbon, particulate organic matter, soil enzymes, soil organic matter, total organic carbon, and total organic matter.

B. Soil Reaction Indicators.

Included Soil PH.

C. Water Relation to Soil.

Generally, soil has the ability to regulate, the drainage, flow, storage of water and solutes, contain nitrogen, phosphorous, and pesticides, and other compounds in dissolved state present in the water. The proper tillage of soil, water recharges through it, and support extensively plants to grow, and animals have to use water as well as the grown plats on the soil.



Fig No: 2, The Water Runoff Process.

D. Soil Water Relation Assessment Indicators.**E. Physical Stability Indicator.**

Depends upon the multiple factors of sustaining water within it, such as; collective stability, erosion patterns, slaking, soil loss and soil depth.

F. Water Availability Indicators.

Includes available water capacity, infiltration, hydraulic conductivity, infiltration, soil moisture, water holding capacity, pores and spaces.

G. Salinity and Sodicity Indicators.

This includes electrical conductivity, exchangeable sodium percentage, and sodium absorption ratio.

H. Toxicity Indicators.

Including arsenic, copper, pesticides, and zinc.

I. Biological Activity and Diversity Indicators.

Including active fungi, earthworms, potentially mineralizable nitrogen, respiration, soil enzymes, and diversity indices for organisms such as bacteria, macro and microarthropods, nematodes, and plants.

J. Soil Structure Indicators.

Including bulk density, penetration resistance, porosity, or root growth pattern.

K. Alternative Soil Function categorization.

No doubt the soil is a fundamental media to provide life to the nature. Whether its rich highly mineralized or poor in minerals has positive support to life in one way or the other. The most essential services provided by the soil are given by the various internationally known researchers listed below.

- ✓ Provide a medium for plant growth and biological activity.
- ✓ Regulate and partition water flow and storage in the environment.
- ✓ Serve as an environmental filter and buffer in the immobilization and degradation of environmentally hazardous compounds.

Larson and Pierce, 1991

- ✓ Buffering & moderation of hydrological cycle.
- ✓ Disposal of wastes and dead organic matter.
- ✓ Physical support.
- ✓ Retention and delivery of nutrients.
- ✓ Renewal of soil fertility.
- ✓ Regulation of elemental cycles.

Dailey, 1997

- ✓ Sustain plant & animal productivity.
- ✓ Maintain or enhance water & air quality.
- ✓ Support human health & habitation.

Doran & Parkin, 1994

- ✓ Sustain biological activity, diversity, & productivity.
- ✓ Providing support for socioeconomic structures.
- ✓ Protection of archeological treasures associated with human habitation.
- ✓ Water and solute flow.
- ✓ Filtering & buffering of contaminants.
- ✓ Nutrient cycling.

Seybold et al., 1997**4. Common Sources of Soil Contamination.**

A wider quantity of soil contaminants present ubiquitously in our society. The degree and the intensity of soil contaminants depends the activity on the site is taking place. However, the intensity of contaminants decreases with the time due to changing environmental conditions in a specific site, and the weather conditions around the site. The weather has ability to remove the soil contaminants with passage of the time. The nature of pervasiveness of chemicals has direct link with the air and water and directly affects the physical state of purity of both. The chemical which has huge impact on soil shown in the table.

Hazardous Chemicals with Heath Effects.

S/N	Heavy Metal	Source	Health Effects
1.	Lead	Paint, Glazes, Pesticides.	Violence lowered IQ, ADD, ADHD and many neurological problems. Lead is a widely distributed toxic metal due to its many uses in industry.
2.	Mercury	Fish and seafood is universally contaminated with mercury.	
3.	Cadmium	Air, Butter, Margarines, M/Female Sexual Fluid.	
4.	Copper	Zinc deficiency tends to copper accumulate copper. Mineral deficiencies. Deficiencies of manganese, iron, selenium, chromium and other minerals can contribute to copper accumulation.	Nervous system alone, copper toxicity is associated with migraine headaches, premenstrual syndrome, depression, anxiety, panic attacks, some schizophrenias, seizures, impair the conversion of T4 to T3, contributing to thyroid imbalances.
5.	Aluminum	Salts	Memory loss and dementias.

6.	Hydrocarbon	Crude Oil, Volatile Gases	TPH compounds, particularly the smaller compounds such as benzene, toluene, and xylene (which are present in gasoline), can affect the human central nervous system. If exposures are high enough, death can occur.
7.	Hydrochloric Acid	fluoridate drinking water	Contains lead, mercury, cadmium, arsenic, aluminum, benzene and radioactive waste material.
8.	Fluorides	Drinking water supplies.	Cancer mineral
9.	Arsenic	Wines, beers, fruits, vegetables, rice and other foods.	
10.	Nickel	Metal crowns and dental wires used in bridges and elsewhere in dentistry.	Contribute to cancer and other horrible problems.
11.	Uranium	Nuclear Radiation from Nuclear Plants.	Deformity, Genetic mutations, Carcinogenic.
12.	Iron	Food. Liver, sunflower, nuts, spinach, beef, whole grains, dark chocolate etc.	Irritating and pro-inflammatory.
13.	Chlorine	Common water purifier.	Heart disease and dementia, etc.

Table No: 2, Dr. Wilson Chemical Contamination.

Risk Management of Contaminants:

4.1 The Risk Management.

The issue health risk is predominantly essential to everything, and should be priorities than anything else. If the health risk remains highly it might have effects upon the overall situation of population / urban centers in general. There must be proper, accurate, and timely measures must be applied to reduce the dangers of if any situation exists. Therefore, its primary concern for public health. The effects may be documented well throughout the world. (Soil – Plant – Animal / Soil – Plant – Animal – Man).

4.2 Decontaminating Soil from Hazardous Chemicals.

The process of decontamination is highly risky due to degree of contamination and its exposure to top soil, man, and environment. The process of decontamination is stepwise from decontamination to monitoring, regular check and balance system requires if any exposure may take place should be capped / removed abruptly to avoid further damage. Its handling, operation, and monitoring involves many agencies / departments for permission, monitoring and if any risk in future on the affected soil (on / off site development or construction).

4.3 Various Remedies to Decontamination of Soil.

Generally, various options been applied for decontaminations of various contaminated soils.

4.4 Covering option.

It is necessary to decontaminate through onsite consolidation and covering of the affected soil. Contaminated topsoil may not be removed due to its properties, albeit affected soil may be covered by grasses to decrease the exposure to the environment.

4.5 Capping option.

Contaminated topsoil may be covered or capped with clean soil; it may be one foot or even more to reduce the chances of exposure to affect the surrounding environment in general. In this process a sufficient quantity of clean soil is required.

4.6 Blending with clean soil option.

Contaminated soil can be blended with clean soil of the area or outside of the area. This strategy cannot be applied in the areas, which have high level of contamination concentration; however, moderate level of contaminated concentration shall be considered to manage to topsoil to clean it. (Highest arsenic level is not permitted).

4.7 Outside (within area) blending option.

The process of decontamination through blending of affected soil may be applied within the area in an affected region. The blending of contaminated soil, within or outside of the boundaries for physical mixing, if there are underground water resources, need a greater quantity to decontamination, and to avoid any impact of these resources. If there is even highest level of contamination, then there is no need of decontamination of affected area.

4.8 Topsoil cleanup option.

Under this process to decontamination can be achieved through complete removal / replacement of the contaminated soil from the affected area. The option requires additional cost and the site for disposal is another matter of concern.

4.9 The treatment of soil option.

The process has multiple effects due to increased cost and the unavailability of technologies to decontaminate the soils. An additional cost may produce extra burden to afford is not feasible at all. Thus the treatment option is highly cost effective, and not possible to imply as a last option.

4.10 Vacuum Extraction.

This is the one of the most extensively used techniques in soil decontamination. This technique is cost-effective albeit much time consuming acts to decontaminate the contaminated soil in situ technique. By this process contaminated water extracted from the limited subsurface depth, thus extracted water is chemically and biologically treated for reuse. Vacuum extraction treatment is applied, where volatile organic compounds (VOC) being part of the soil. This technique is known as **Air Sparging**

or **Biosparging**. The technique is applied in vadoze zone, and further depends upon the accumulation of volatile organic compounds to be ejected out from the soil, exerting pressure of air (oxygen) inside the affected soil. However, technique is highly useful if the soil is granular, with spaces to exist out the VOCs in the state of liquid or vapors, whereas, the clay or organic compounds high retention and impeding capacity, high density and water content reduce the transmission of VOCs. Further VOCs properties, such as; sorption, solubility, vapor pressure and concentration have much influence on extraction. This process is also known as **Aerobic Biodegradation**.

4.11 The Method of Solidification and Stabilization.

This a process by which contaminated soil can be solidified, it's due to no immediate danger of pollutant to be spread, and that's why the best option is to solidify rather than to decontaminate or top soil removal. The process involves one or two step activities. In first step the polluted soil is mixed with binder to solidify which resultantly provides stability to the soil in situ. Whereas, in the second step first soil is made insoluble and nonreactive finally mixed with binder to reduce the chances of solubility and get stabilized. Solidification and stabilization is best suited the soils, which are highly transmitted soil, compacted, whereas, the soils with high clay and organic content do not favors ss method in situ.

On the other hand, ex situ method, the contaminated soil first grinded, dispersed then mixed with the binding material, thus it should be confirmed that bonded soil should not be leached, otherwise, it would be disastrous. The common binders used are cement, zeolites, fly ash, clay, pozzolonic materials and other binders. Organic binders include polythene, resins, epoxy, and bitumen etc.

4.12 The Chemical Decontaminations.

The process of chemical decontamination can be applied to those soils which are highly sorbed concentration of inorganic heavy metals, (IHM). At the first stage, in this method should fully understand the nature between the binding material and the soil surface. A suitable extractant should be selected for selected sequential extraction (SSE) of (IHM) of the soil mass. The

extractants includes weak acids, strong acids, electrolytes, oxidizing and reducing agents etc. in situ application, the poring of water through pumping, would help to extract contaminants from the soil. While pumped water treated on the ground to remove the contaminants.

Another method is to pore water into contaminants, but it needs barrier first to maintain the water pressure and accumulation inside the permeable soil. Thus barrier stops spreading water far and wide, thus inorganic heavy metals (IHM) shall be removed.

4.13 Biological Method.

Normally, fungi, bacteria, and viruses play a pivotal role in **biodegradation** of living organisms. The process is known as **Bioremediation**. Sometimes these microorganisms capacity is hampered or ineligible to breakdown the organic material, thus there must be use of **genetically engineered organisms (GMOs)** for biodegradation of organic materials. These organisms have capacity to produce certain enzymes to degrade the organic materials; however, there must be proper check and balance of introduction of GMOs if any toxicity is produced in the soil or **Geo-environment**. The process of bioremediation produces certain reactions such as; hydrolysis, redox reaction, volatilization etc. **Asquith, E. A. and Geary, P. (2011)**.

4.14 Electro - Kinetic Method.

Most commonly used method to decontamination of heavy metals from the soil. The method initiated through the use of two metallic electrodes such as; anode and cathode against one another around the contaminated soil, to introduce low intensity direct currents to move the passively and negatively charged ions produces electro-osmosis resultantly ion migration take place desorbed contaminants move towards the soil surface and being trapped and finally collected through recovery system. The recovery of uranium and mercury takes place through this method. **Asante-Duah, (1966)**.

4.15 Thermal methods of Decontamination.

Generally thermal methods included using high temperature (>500C) and low temperature (<500C) methods and proved useful for

contaminants with high volatilization potential (**Evangeleu 1998**) high temperature consists on **incineration, electro pyrolysis** and in situ **vitrification**. Low temperature treatments consist on low temperature incineration, thermal aeration, infrared furnace treatment, and thermal stripping. High temperature completely destroys contaminations through oxidations. Low temperature increases rate of transfer of contaminations from liquids to gaseous state and compels contaminants to be isolated from soil. Radio frequency (RF) heating process is used for in situ thermal decontamination of soil having volatile and semi-volatile organic contaminants. Another process of decontamination is steam stripping or thermal stripping process which is highly useful process for soil decontamination for volatile and semi-volatile organic contaminants. In situ, this process steam or hot water injected into ground resultantly increased volatilization contaminants. In certain situations vacuum is applied to extract steam or air back to surface for further treatment. Using chemical agents enhance the effectiveness of volatility of the contaminants. Due to high costs and ineffectiveness the thermal processes are less attractive and incineration produces more toxic gases.

4.16 Bioremediation Method.

Historically, the process of bioremediation dates back to 6000. BC, and in 1891 first biological sewage plant was introduced in Sussex England, UK. Bioremediation is a process by which transformation and degradation of contaminants into non-hazardous or less hazardous chemicals. (**Hornung, U 1997**).

4.17 Fundamental classifications to clarify the process bioremediation.

- **Biotransformation.** The alteration of contaminant molecules into less or non-hazardous molecules.
- **Biodegradation.** The breakdown of the organic substances in smaller organic or inorganic molecule.
- **Mineralization.** The complete biodegradation of organic materials into inorganic constituents such as CO₂ or H₂O.

All three classifications of bioremediation can be applied *in-situ* or *ex-situ* conditions and both

have certain advantages as well as disadvantages in general. However, ex-situ applications to decontaminate take huge time, risky for exposure, and much costly in comparison in-situ treatment. Therefore, the in-situ treatment is given the priority always. While ex-situ process applied to dig up the contaminated soil and transported to bioreactor for decontamination, **Soil washing** with water and **soil venting** with the air is flushed into contaminated region, and contaminant may be liquid or gas. Thus contaminants transferred to bioreactor, these may be liquids, gases, or solids, there chemical properties and there toxicity.

Further, in-situ treatment does not require the removal of soil, albeit soil treated through the process of bio-stimulation or bio-augmentation by addition of certain other things or chemicals.

- **Bio-stimulation.**

Bio-stimulation is a process by which addition of nutrients, oxygen, and other electron donor and acceptors to the coordinated site to increase the population of microorganisms for biodegradation of chemical compounds, organic or inorganic compounds for bioremediation.

- **Bio-augmentation.**

Bio-augmentation is a process by which addition of microorganisms that can **bio-transform** or **biodegrade** the contaminants in-situ. By this technique a large number of new strains of microorganisms or already existing species introduced in an affected region to biodegrade organic or inorganic compounds. In-situ method is highly recommended due to its advantages, in this process, there is no need of the removal of contaminated soil, no exposure of hazardous chemical, and less costly in nature.

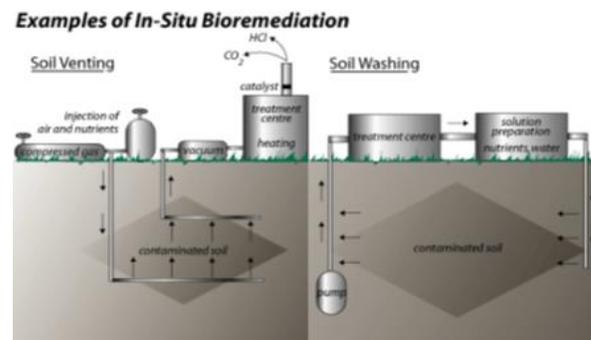


Fig No: 3, Geo-environment USGS. 1997.

4.18 Disadvantages of Bioremediation.

However, there are certain disadvantages of bioremediation in-situ strategy.

- If the site bioremediation is not contained in timely fashion, it's difficult to control and monitor in a proper way, and its progress shall not be assess too accurately, especially microbes applied to oil spill site.
- In case of nutrients supplied to the site, are reduced or end up, due diffusion with water, and contaminated site concentration reduced to previous level affects severely the bioremediation. **(NABIR, 2003).**
- In-situ contaminated soil or another media is heterogeneous in structure or composition, resulting the uneven flow of liquid or gas contained microbes or nutrients, the rate of remediation would be changed. **(US Geological Survey, 1997 - 2004).**

Although the multiple levels of complications, still bioremediation is highly recommendable to treat the various contamination sites, such as; crude oil spill, sewage effluents, chlorinated solvents, pesticides, gasoline contaminations, wood processing, radioactive metals, and toxic metals. Despite of the several difficulties, there is no alternative of bioremediation to deactivate the various chemicals and radioactive materials except allow these metals to decay in specific sites under strict observation, check and balance system, and effective monitoring. Unfortunately, many radionuclides have very long half lives in the environment.

Radionuclide	Half-life
Sr-90	28 years
Cs-137	30 years
Pu-239	24,100 years
Tc-97	2.6 million years
U-238	4.5 billion years
U-235	7.13 million years

Table No: 4. BioTeach Journal | Vol. 2 | Fall 2004

Bacterial Species Reduce Radiation Effects.

Resistant Species of Microorganisms.

Bacteria	Resistance to
<i>Deinococcus Radiodurans</i>	Resistant to radiation damages.
<i>Bacillus Infernos</i>	High Temperature
<i>Methanococcus Jannaschii</i>	High Pressure. Up to 230 atm.
<i>Dehalococcoides</i>	Natural ability to Dechlorinate tri-, tetra- and penta-chloro dioxins.

Table No: 5, BioTeach Journal | Vol. 2 | Fall 2004.

4.19 Phytoremediation.

A process of bioremediation with the help of green plants is known as **Phytoremediation**. Arsenic is one target of phytoremediation. **(NABIR, 2003).**

Arabidopsis Thaliana has been genetically modified to overexpress two bacterial genes, arsC and g-ECS1. The gene arsC codes for arsenate reductase, an enzyme, which allows the plant to modify arsenate into arsenite, and g-ECS codes for gglutamylcysteine synthase, which makes a thiol that can detoxify arsenite by forming arsenic-protein thiates that are then stored in vacuoles. **(NABIR, 2003).**

Phytoremediation can also be used to destroy high-energy compounds such as TNT, GTN, RDX, TETRYL and HMX. Tobacco plants have been genetically modified to express bacterial pentaerythritol tetranite (PETN) reductase allowing these plants to take up high-energy compounds and reduce them to non-explosive substances. Another genetically modified plant possesses a bacterial mercuric reductase gene allowing it to take up mercury (Hg) out of the soil and store it safely. **(Molly Leung, 2004).**

Contamination Removal Cost Options.

Remedial Options	Cost Per Acre.
Consolidation and covering contaminated soil on-site (i.e., under roads and structures)	\$1,000 - \$2,000
Cap contaminated soil with clean soil	\$7,000 - \$12,000
Blending with clean soil from on-site	\$1,000 - \$2,000
Blending with clean soil from off-site	\$8,000 - \$15,000
Excavation and removal of contaminated soil	\$32,000 - \$ 80,000
Proven and innovative soil treatment technologies	\$50,000- \$100,000

Table No: 6, US Pesticide contamination report 1999, current expenditures have been increased.

5. Conclusion.

The soil structures, compositions, functions are diverse in nature, earth's physical environmental conditions play rudiment rule in its characteristics. The process of soil formation takes a long time, whereas, the degradation is abrupt. Anthropogenic activities has severely not only affected the soil's basic functionality and performance but also heavily degraded and turned its fertility to toxic level. Increased toxic level has a dual impact on soil's basic role in reduced production effects, and soil degradation is another impact. In larger context the soil degradation ultimately leads to soil erosion, loss of vegetation, and a pretext to the devastation of micro and macro ecosystem in particular. This whole scenario leads to major catastrophe of environmental damage which is final destination of climatic change directed towards global warming. However, new technologies are comparatively better to serve the cause of soil sustainability such as bioremediation, bio-stimulation, bio-augmentation, and phytoremediation. These processes are simple to complex, and much closer to Mother Nature in comparison to other techniques. Bioremediation play pivotal role to produce sustainable soil. If the object is soil sustainability, it could be achieved; currently no other techniques are as promising as these methods.

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