POTENTIAL USE OF GENETICALLY MODIFIED PLANTS IN CLEANUP OF CONTAMINATED SOILS.

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ABSTRACT
Bioremediation involves the use of living organisms to breakdown hazardous substances to less or nontoxic substances. The use of plants in bioremediation referred to as phytoremediation is gaining acceptance Some plants are able to bioaccumulate toxins in their parts body parts which are harvested to remove contaminant. The rate of bioaccumulation of most of these plants are slow hence the need for genetically modified plants with more efficient phytoremediation capacity. This paper attempts to elucidate the potentials of genetically modified plants for bioremediation of contaminated soils.

Keywords: bioremediation, phytoremediation, wetlands.

INTRODUCTION

The concept of using plants to clean up contaminated environment is quite an old one. About 300 years ago, plants were proposed for use in the treatment of wastewater (Hartman, 1975). In the last quarter of the last century, a lot of successful work and field trials were done on the use of plants to clean contaminants. Bioremediation involves the use of organisms to remove or neutralize pollutants from a contaminated site. During bioremediation, microbes utilize chemical contaminants in the soil as energy source and, through oxidation-reduction reactions, metabolize the target contaminant into useable energy. The metabolites released back into the environment are typically in less toxic form than the parent contaminants. The degradation of petroleum hydrocarbons by microorganisms is an example of such process. Great improvements have been made in the application of the technology and it is being effectively applied in such areas as metal extraction, decontamination of petroleum product polluted areas etc. Advances in combinatorial DNA techniques and genomics have further enhanced the potential application of microbes and plants in remediation of contaminated soils through the development of novel plants with better remediation ability. The increasing volume of data in gene banks consequent of increasing number of complete genome of organisms (microbes, plants and animals) will be able to help in the supply of 'missing links' with respects to gene functions which could improve proficiency in the development of genetically modified plants for use in phytoremediation.

The Problem of Contaminants:

Contaminated lands resulting from industrial activities, disposal of hazardous substances and the unintentional discharge of untreated waste or spillage of petroleum products is generating much concern today. Most of these environmental contaminations happened when awareness of the health and environmental effects connected with these activities was not a serious concern. The problem is worldwide and the estimated number of sites is significant. It is now widely recognized that contaminated land is a potential threat to human health, and its continual discovery over recent years has led to international effort to remedy most of these sites. Pollution and environmental contamination arising from oil spill and other pollutants is a multi-facet problem presently ravaging oil-producing communities and wetlands all-over the globe; it causes loss of species diversity, loss of habitat, destruction of breeding grounds of aquatic organisms and sometimes death of organisms including man (Ndimele, 2008). The environmental degradation caused by oil spill affects the social and economic lives of oil-producing communities; rivers and other water bodies can no longer sustain aquatic life hence they cannot practice aquaculture or capture fisheries. Considering that most of these communities are involved in artisanal fisheries, their primary source of livelihood is negatively affected. They also can't drink or swim in their rivers as they used to do before the pollution and so their social life is affected. Previously, use of high temperature incinerations and various chemical decomposition techniques have been the method in the remediation of contaminated sites (Vidali, 2001). But these methods did not solve the problem of detoxification of the contaminants and with time has become unacceptable to the society that is more environmental safety conscious. These processes also involve complex technology, which is expensive and require moving the contaminated soil to distances in order to get to treatment plants.

Bioremediation offers great potential to destroy or at least render harmless various contaminants using natural biological activity (Alum and Obuba, 2015). The technique is low cost and environmentally friendly involving the use of naturally occurring organisms. Bioremediation could be slow and might not be able to completely remove the contaminants from the environment. Living organisms, particularly microorganisms (Bryant, 1987; Avgustin, 1998; Wasay *et al*., 1998; Pokethiyook *et al*., 2002; Tsekova and Petrov, 2002) and higher plants (phytoremediation) have been used in cleansing of contaminated sites with impressive results.

Phytoremediation

Phytoremediation is a bio-mediation process that uses various types of plants to remove, transfer, stabilize, and/or destroy contaminants in the soil and groundwater. It is a promising technology that can deal with pollution cheaply, thoroughly and on-site using trees, crops and flowering plants (Germida and Carlson, 1999). The method used by green plants in the cleansing process is diverse but may involve the accumulation of contaminants into more stable, less toxic or inactive substance (*phytotransformation/phytodegredation)*; adsorption of leachates from contaminated soil - *phytostabilization* (Vidali, 2001); accumulation of contaminants within vegetative parts eg roots, stem, shoots, leaves- *phytoaccumulation* ; reduction of mobility and leachability of substances in the environment and water table by trapping (*Phytostabilization*); enhancement of soil microbial activity for the degradation of contaminants (*Phytostimulation),* typically by organisms that associate with roots; removal of substances from soil or water with release into the air(*Phytovolatilization*), sometimes as a result of phytotransformation to more volatile and/or less polluting substances. Aquatic plants can also support active populations of microbial degraders or may filter water through fluff of roots to remove toxic substances or excess nutrients by trapping them (*Rhizofiltration*). Aisien *et.al* (2010) that water hyacinth may be used in environment technology in constructed wetlands as a good hyperaccumulator of Zn, Pb and Cd with BCF values greater than 1000.

In general, the up take mechanism is selective; plants preferentially acquire some ions over others depending on the structure and properties of their membrane transporters (Lasat, 2001). Some plants are hyperaccmulators with super ability to adsorb high levels of contaminant.

Phytoremediating Plants: Many plants have been reported to naturally possess phytoremediation ability. The fibrous and extensive roots of grasses like the vertiva grass which in some cases may extends and penetrates over 2m into soils with an explains why grass inherent genetic diversity may enhance their phytoremediating potentials. Approximately 400 hyper-accumulating species of plants have been reported (Ni *et al*., 2002). Some plats have been found to have preference for metal soil contaminant.

One the best known phytoremediation plant for use in metal cleansing is *Thlaspi caerulenscens*. Other popular plants used for phytoremediation include *Sedum alfredi* (Ni, *et al*., 2002), *Brassica juncea*, *Eichornia crassipes* (Aisien *et al* 2010). The wide range of ecology that are able to support plants has further increased the variety of phytoremediation species and their ability to cope with diverse environmental conditions. Today biotechnology has taken advantage of these attributes in environmental management. Genomics is expected to play a major role here through compilation of list of important genes in bioremediation, accurate identifications of gene functions, and forecast of possible combinations (Alum and Obuba 2015)

Improving plants for Phytoremediation

Recombinant DNA technology, which has been used extensively with microorganisms, is an important tool for the direct manipulation of plants. This technique could be used to develop novel plants for phytoremediation. The ability of most plants to completely regenerate from a single cell (totipotency) has been an advantage to the process of genetic engineering of plants (Hadi, *et al*., 1996). Whole plant can be regenerated by tissue culture from a single cell that contains insert of the gene of interest encoding a desired

Table 1: Some Metal hyperaccumulator plant species and their bioaccumulation potentials (Modified After Lasat, 2001)

Plant species	Metal	Leaf content (PPM)
Thlaspi caerulenscens	Zn, Cd	39,600:1,800
Ipomea alpine	Cu	12,300
Haumaniastrum robertii	Co	10,200
Astragalus racemosus	Se	14,900
Sebertia acuminate	Ni	25% by wt. dried Sap

characteristics (Glick and Pasternak, 2003). The plant genome project has improved our understanding of such areas as multigene families, signal transduction, interaction between nuclear and organellar genomes and lots of other areas. Once a gene of interest has is identified and isolated, it could be applied for the transformation of plants. Some of the routes include; Ti plasmid of *Agrobacterium tumefaciens*, a plant pathogen which genetically transforms infected plant as part of its life cycle, micro projectile bombardment, viral vectors, microinjections and lisosomefussion.

Complete genome sequences has eliminated trial sampling biases, facilitating the identification of novel cell surface receptors, ion channels, and kinases (Bevan *et al*., 1998). The increasing availability of plant genome in databases is fuelling comparative genomics. It is expected that the opportunities presented by genomics particularly the increasing number of organisms (plants, animals and microorganisms) will not only aid in our understanding of physiology and evolution in plants but will provide the required information and insight needed for the utilization of the opportunities presented by plants and microbial diversity, for the better management of the environment and the development of novel plant especially for phytoremediation.

CONCLUSION

Plant diversity provides great opportunity for their utilization in bioremediation. These potentials have been magnified by advances in biotechnology particularly functional and combinatorial genomics. These tools, have not only made it impossible for easier manipulation of plant genetic information for better gene targeting in novel traits development, but have also opened doors to unlimited application of plant diversity to environmental management. By integrating proper utilization of plant capabilities with appropriate engineering designs to provide suitable growth environment, field implementation of bioremediation can be more successful. However, successful application of genetically modified plants to bioremediation must address both the heterogeneous nature of contaminated sites and the complexity of using living organisms, particularly modified plants, This will throw more light on the potential environmental effects of introduction of novel plants into new environments. There is need for proper the implementation of laboratory study and observations in controlled environment of such new plants before field trials as required by the regulations in most countries. Field trials must be well monitored and approval for tests, secured from regulating agencies within such states before field trails commence. The release of transgenic plants for use must be certified and proven to be environmentally safe with no perceivable adverse effect on both humans and animals.

REFERENCES

Aisien, F. A.; Falaye, O. and Aisen E. T. (2010) Phytoremediation of Heavy Metals in Aqueous Solutions. *Leonardo Journal of Sciences*. 17, 37-46.

Alum O. U and Obuba L. E. (2015).Microbial Diversity: A key Driver of Environmental Biotechnology. *International Journal of Biotech Trends and Technology* (IJBTT), Vol11:31-37.

Avgustin, G. (1998). Microbial diversity and the modern approach to the investigation of complex microbial ecosystem. *Kmtijstvo Zootechnika*, 72, 69 – 75.

Bevan, M., Bancroft, I., Bent, E., Love, K., Piffanelli, P., Goodmand, H., Dean, C., Bergcanp, R., Dirkse, W. and Van Staveren, M. (1998). Analysis of 1.9 Mb of contiguous sequence from chromosome 4 of *Arabidopsis thaliana*. The EU genome project. *Nature*, 391, 485 – 488.

Bryant, S. R. (1987). Potential uses of microorganisms in petroleum recovery technology. *Proc. Okla. Sci*., 67, 97 – 104.

Germida, J. and Carlson, T. (1999). Phytoremediation: using plants to clean up pollution. *Agbiotech*, 44, 1 – 2.

Glick, B. R. and Pasternak, J. J. (2003). Molecular Biotechnology, 3rd Edn. ASM Press, Washington D.C.

Hadi, M. Z., McMullen, M. D. and Finer, J. J. (1996). Transformation of 12 different plasmids into soybean via particle bombardment. *Plant Cell Rep*., 15, 500 – 505.

Hartman, W. J. (1975). An evaluation of land treatment of municipal wastewater and physical siting of facility installations. Washington D.C. US Department of Army.

Lasat, M. M. (2001). The use of plants for the removal of toxic metals from contaminated soil. U.S. Environmental Protection Agency. Grant No. CX824823. 1 – 33.

Ndimele, P.E, (2008). Evaluation of Phytoremeditive Properties of Water Hyacinth and Biostimulants in Restoration of Oil Polluted Wetland in the Niger Delta. Ph.D. Thesis, University of Ibadan, Nigeria.

Ni, W. Z., Yang, X., Long, X. X., He, Z. L. and Calvert, D. V. (2002). Comparative study on Zn tolerance and accumulation between two ecotypes of Sedum alfredii. 17th WCSS symp., 42, 1773 (1) – 1773 (6).

Pokethitiyook, P., Sungpetch, A., Upathame, S. and Kruatrachue, M. (2002). Enhancement of *Acinetobactercalcoaceticus* in biodegradation of tapis crude oil. 17th WCSS symp., 42, 2309 (1) – 2309 (10).

Tsekova, K. and Petrov, G. (2002). Removal of heavy metals from aqueous solution using *Rhizopusdelemar* mycelia in free and polyurethane-bond form. Z. *Natuer forsch*. 57c, 629 – 633.

Vidali, M. (2001). Bioremediation: an overview. *Pure and Applied Chemistry*, 73(7), 1163 – 1172.

Wasay, S. A., Barrinton, S. F. and Tokunaga, S. (1998). Using *Aspergillusniger* to bioremediate soils contaminated by heavy metals. CRC Press, LLC. 183 – 190.