Phytoremediation and the Deserts towards a Sustainable Environmental Development

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Abstract: Desertification is fast spreading in North Africa and the northern Nigeria in particular which share border with the sahara desert of the north African countries. The leading causes of this desert encroachment has been identified as; overgrazing, conversion of rangelands into croplands, incessant deforestation and bush burning thus leaving the soil bare, barren, and the entire environment unprotected. Apart from windstorm that carries suspended particulate matter especially heavy metals in form of dust, urban environment suffer greatly from the negative effect of pollutants. Relentless effort has been made by various governments in many ways to check the problem but the effort has either been poorly implemented or not properly regulated. Desert encroachment is fast spreading in the northern part of Nigeria, thus leaving the environment open, the soils bare and barren with lots of contaminants owing to the overwhelming dependence on trees for fire wood in place of kerosene that is hard to get or not available at all. It therefore becomes necessary to find a means of covering the soil to check erosion , immobilized the pollutants, plant trees to replaced the lost ones, decontaminate the soils and check windstorms and sandstorms that comes from the neighbouring countries in the sahara. One of this means that is cheap and environmentally friendly is phytoremediation. This is therefore aimed at discussing the laudable in-situ techniques of phytoremediation and their potential abilities in decontaminating contaminated environment.
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Introduction

Environmental pollution by heavy metals is now a global issue that require considerable attention towards combating. Soils contaminated with heavy metals usually lack established vegetation cover either due to the toxic effects of the heavy metal or to the incessant physical disturbances. It has been observed that barren soils are much more expose to erosion of all kind and leaching which further distribute the pollutants in the environment(Salt, 1995). The transfer of contaminants to non-contaminated sites in the form of dust or leachate through the soil, spreading of sewage sludge is example of events that contribute to the contamination of the environment. Contamination with heavy metals is one of the main environmental problems. Heavy metal is general term describing a group of elements with a density of 6 g/cm^3(Gardea and Torresdey, 2005). Most heavy metals are essential nutrient required by plant and animals' consequently human being at low concentrations but they turn to be toxic when present in excess concentrations (Yoshida, 2006). Many countries therefore, due allocate certain percentage of their annual budgets to carry out ecogoechemical and geohygienic research into residential and its natural environment. These are usually the analysis of the soil for its chemical content (Jankaite 2005). Nigeria is entangled with ecological degradation, a problem that has reached a dreadful scale in recent years. Oil spillage in the south and desert encouragement in the entire northern part of the country. The earth has five main natural, warm desert regions, all of which lay primarily between latitudes 15^0 and 30^0 north and south of the equator. The greatest deserts region of them all is the deserts that extend from the Atlantic cost of north Africa (the sahara desert) eastward to the desert of Arabia, Iran, Russia, Pakistan, India and finally China (Grainger, 1982).

The northern part of Nigeria shares a border with this region (north-western Africa). Desert soils are mainly inorganic, that is coarse and typically sandy, and the plants that grow are too sparse and unproductive to create a soil rich in organic matter. Wind storm from this region usually carries along suspended particulate matter rich with heavy metals in the form of dust and settles in any settlement it came across. Dust in the urban environment are of great concern because of the presence of many toxic substances(heavy metals) and the potential exposure of children who often play in the streets, school yard,

parks etc. They may transfer dust particles onto their hands and consequently be ingested (Radojevic and Bashkin, 1999). The issue of environmental pollution and its consequence should be the greatest priority in this part of the world, if the objective of millennium Development goals is to be achieved. The term environment has been defined as the sum total of human surroundings consisting of the atmosphere, the lithosphere, the hydrosphere and the biota. Human beings are totally dependent on the environment for itself. The atmosphere provides the air we breath, the hydrosphere provides the water and the soil of the lithosphere provide us with the vegetables we eat (Radojevic and Bashkin, 1999). Fouling the environment by pollutants of all source can have many harmful consequences therefore comparatively cheaper and feasible sustainable methods of minimizing, combating, or removal if possible from the environment is imperative. One of such method is phytoremediation a term applied to a group of technologies that uses plant to reduce, remove, degrade or immobilize environmental toxins primarily those of anthropogenic origin with the of restoring area site to a condition useable for private and public applications(peer et al., 2003).

The conventional methods of metal removal for soil remediation are highly expensive and may cause secondary pollution. A series of scientific discoveries has come up with this promising, low-cost and environmentally friendly technology termed as phytoremediation (Krmer, 2005). It is applicable to both organic and inorganic pollutants that may be present in soil, water and the air (Salt et al., 1998). This paper therefore is aimed at creating awareness to the use of in-situ techniques of phytoremediation and to stimulate all the stakeholders regards to desert encroachment and environmental pollution in developing the world with Northern Nigeria as a case study. Desert-like areas can be created anywhere by the poisoning of soils. Poisoning of soil can result from the persistent application and improper disposal of agricultural and sewage sludge waste product. Air borne pollutants, acidification and or oil or chemical spills can all lead to soil degradation. Preventing desertification begins with the monitoring of these factors. Environmental sanitation is defined as an intervention to break the cycles of disease towards human and animals (Simson-Hebert and Woods, 1998). Proper methods of soil conservation, forest management and irrigation can help prevent the spread of desert. The planting of trees that help slow down the wind to prevent sandstorms and erosion of the soil has become imperative. Phytoremediation offers the possibility of addressing an intractable global problem of this nature by providing a double purpose alternative, cheap and effective technology that could significantly improve the prospect of cleaning up metal contaminated soils and at the same time checking the excessive windstorms.

Remediation of soils contaminated by heavy metals

Different plants show different response to the presence of potentially toxic heavy metal ions in the soil. Although some of these metals are essential nutrients required at low concentration by plants and animals, it turns to be toxic when present in excess. Some plants however have developed resistance and the capacity to accumulate high levels of these metals (Tolra et al., 1996; Salt et al., 1998; Schat et al., 1999). This ability of accumulating and tolerating large concentration of heavy metals has opened the feasibility of using some plants species to clean up heavy metal contaminated soils and waters (Van der Lelie et al., 2001).

Plants response to heavy metals

The response of plants growing on a metal contaminated soil is categorised into the following: Hyperaccumulators: These are species of plants that absorb and concentrate high levels of heavy metals either in their roots, shoots and/or leaves (Cunningham, and Ow, 1996; Bert, et al., 2003). Baker and Brooks (1999) defined metal hyperaccumulators as plants that can contain more than or up to 1000mg/g of Cu, Cr, Cd, Pb, Ni and Co or greater than 10,000mg/g of Zn or Mn in the dry matter. Hyperaccumulators take up high amounts of a toxic substance, usually a metal or metalloids in their shoots during normal growth and reproduction (Baker and Whiting, 2002). The defined levels of these elements are at a concentration of one order of magnitude greater than those found in non-accumulator species (Salt and Kramer, 2000). Hyperaccumulators are found in 45 different families with the highest among the Brassicaceae (Reeves and Baker 2000). These plants vary from perennial shrubs and trees to a small annual herbs. These could therefore be used, when planted as wind breaks, soil cover etc. to checkmate erosion of all kind.

Metal excluders (tolerant): These categories of plant specie prevent metals from entering their aerial

parts and so maintain constant metal concentration in the soil around their roots (Ghosh and Singh, 2005). A specie that can grow on soil with concentration of a particular elements that are toxic to most other plants. They mainly restrict the metal in or around their roots. Example of such species that tolerate or excludes metals include Holcus lanatus (Meharg and Macnair 1992). Agratis capillaries, Mimulus guttatus, and Silene vulgaris (Pollard et al., 2002).

Metal Indicators: Plant species that absorp and translocate high levels of heavy metals to their aerial tissues. Such species resist the high concentration of the metals by the aids of metal binding compounds (Ghosh and Singh, 2005). Metal indicator and hyperaccumulating plants are also tolerant but experiment had shown the differences in the mechanism involved (Assunção et al., 2001; Bert et al. 2003).

Phytoremediation is a term applied to a group of technologies that include: phytoextraction, phytodegradetion, rhizosphere degradation, rhizofiltration, rhizostabilization, phytovolatilization and phytorestoration (Saxena et al., 1999).

Phytoextraction:- This is the use of plants for the removal of pollutants especially heavy metals and metalloids, by the of plants with subsequent translocation to aerial plant organs (Lombi et al., 2001).Fig.1.Plants species use for this purpose combine high accumulation in shoots and high biomass. Phytoextraction could be continuous or induced (Salt et al., 1998) continuous phytoextration involve the use of plants that can accumulate high levels of heavy metals naturally throughout their lifetime. At least 45 families have been identified to have hyperaccumulate plants. Some of these families are: Brassicaceae, Fabaceae, Laminaceae, scophulariaceae (Salt et al., 1998)

Phytodegradetion:- In this technique organic pollutants are converted by internal or secreted enzymes into compounds with reduced toxicity (Suresh and Ravishankar 2004). Trichloroethylene (TCE) was found to be taken up by hybrid poplar trees, Populus deltoids, x nigra, which breakdown the contaminants into its metabolic components (Newman et al. 1997).that are thought to be non hazardous.

Rhizosphre degradation:- This technique involve the microbial enzymatic breakdown of organic pollutants. The plant growing in the contaminated area influence the amount, diversity and activity of the microbial populations (Kirk et al. 2005). Grasses with high root diversity , legumes that fixes nitrogen and alfalfa fix nitrogen and have high rates of evapotranspiration are associated with different microbial populations, these plants enhances the oxidation of organic chemical residues in the soil (Jones et al. 2004).

Phytovolatilization:- This type of phytoremediation technology is mainly used to remove contaminants that are highly volatile. Mercury and selenium for instance can be taken up by plants roots, sequestered and converted into non-toxic form and volatilize into the atmosphere form the roots, shoots or the leaves.

Phytostabilization:- This technique is used to established vegetative cover in areas that lacks natural vegetation due to high levels of contaminants, physical disturbances and artificial materials. Phytostabilization reduces the mobility of contaminants; prevent their migration into the groundwater and possible aeration into the atmosphere and subsequently reducing the possibility of entering the food chain. The urban environment is highly contaminated with all sort of anthropogenic pollutants, phytostabilization be used to safe the children in the streets, school yards and lawns from the negative effect of these pollutants.

Rhizofiltration:- This refers to the use of plants roots to absorb, concentrate, and precipitate contaminants , specially heavy metals from surface or groundwater. Most rural dwellers in the north depend on some shallow streams or ponds dug out to supply animals with water, and for human domestic water requirements. These sources of water are exposed to all sort of toxic contaminants from all sources and are therefore dangerous to health. Phytoremediation provides the solution by the use of one of the in-situ technique: rhizofiltration which employ the use of plants to clean contaminated surface waters or wastewaters.

Phytorestoration:- This technique involves the complete remediation of contaminated soil to its fully functioning soils (Bradshaw, 1997). It is the complete restoring of land from its contaminated state to an environmentally friendly uncontaminated state.

Role of Phytoremediation in Sustaining Environmental Development

Plants growing on contaminated soils have been reported to grow without any symptoms or serious damage. This indicates that such plants could be used to detoxify harmful contaminants in the environment. Higher plants posses pronounced capacity and ability for the metabolism and degradation of many

contaminants and are regarded as " green livers" acting as a sink for environmentally harmful contaminants(Schwitzguébelm, 2000). City phytostructure refers to a green space that is within a city and more meaningful to the plants distribution in addition to the green space areas (Samudro and Mangkoedihardjo, 2006). It has been reported that green space programmes are conducted in most countries to check the increasing levels of carbondioxide which causes global warming (Mangkoedihardjo, 2007). But when properly managed and handled through the use of some plants that have phytoremediation property, green space would not only clean the atmosphere of its excess carbondioxide but also the soils from its contaminants. Greening of the top soil would maximize rainfall interception into the soil; minimize surface runoffs reducing the rate of flood, erosion and the distribution of contaminants.

Contaminated soils in the urban environments, waters in the rural areas and generally the atmosphere posed a major environmental and human health problem in the world and the entire northern part of Nigeria as a case study. In this part of world, almost all the soils in the cities, towns and most of the developing villages lacks proper vegetations cover and are therefore exposed to all sort of dangers. Desert encroachment, periodical heavy annual rainfall, erosion of all kind and subsequent deposition and distribution of contaminants especially heavy metals has been the basic environmental problem. The Millennium Development Goals-MDGs agreed by the international community in 2000 comprises of eight goals, eighteen targets, and forty eight indicators, environmental basic sanitation was added to the list at the 2002 world summit on sustainable environmental development in Johannesburg (IRC- International Water and Sanitation Centre, 2004). These aforementioned goals could be achieved through the phenomenon known as phytoremediation. A cheap, environmentally friendly, anaesthetically pleasing, method of removing pollutants, and most suitable for developing countries. This system of soil decontamination and protection is beneficial in terms of lesser financial commitment by both the government and every individual to its development and utilization.

Conclusion:

The necessity in decontaminating polluted sites recognised worldwide, both socially and politically, because of the increasing importance placed on environmental protection and human health. Based on the success recorded by the various studies on phytoremediation in the developed countries some of which are highlighted in this paper, it is the authors view that researches related to this cheap, environmentally friendly technology should be intensified and applied in the world of the desert regions especially North Africa and Northern Nigeria in particular. This is to reduce the pollutants stress, on the heavily contaminated urban soils, and the possible protection of the entire environment from strong windbreak and sandstorms.

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