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UTILIZATION OF PLANT BIOMASS USED FOR PHYTOREMEDIATION TECHNOLOGY: A REVIEW

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ABSTRACT

In present time, one of the major problems faced by the industry is the pollution which can be soil, water pollution and air pollution. Phytoremediation is the direct use of living green plants for in situ, or in place, removal, degradation, or containment of contaminants in air, soils, sludge, sediments, surface water and groundwater. It can be used for the restoration of abandoned metal mine workings, and sites where polychlorinated biphenyls have been dumped during manufacture and mitigation of ongoing coal mine discharges reducing the impact of contaminants in soils, water, or air and for many other purposes. As there are problems associated with every process so the problem with the phytoremediation is the disposal of the waste plants after the process. The review papers discuss the various possibilities for the use of the waste product after the process of phytoremediation such as extraction of heavy metal, nano-particles formation, Bio-diesel formation and Bio-gas generation.

Keywords: Phytoremediation, Biogas, Biodiesel, Nanoparticles, Heavy Metal.

I. INTRODUCTION

The last 3-4 decades are the decades of industrial revolution. A lot many industries came up and there started the era of modernization and industrialization. But along with this it also bring some problems over the time. One of them is the pollution. Pollution became the major drawback of the industrialization and modernization. The world is growing very fast but we want not only growth, we want sustainable growth. The pollution is like a stone in the way of the sustainable growth. Pollution introduces the contaminants into the natural environment that cause adverse change. Pollution can be of many types such as water, air, soil, noise, thermal and many more. The soil will be polluted as a result of different human activities. Most of these pollutions are caused by vehicle accident which moves contaminants. The other pollutants, which cause soil pollution, include cars, trucks and airplanes that do not move the waste; rather, they carry materials like fuel which can cause soil pollution as a result of pouring and emitting them from the vehicle. The factors like human activities will also pollute the soil. Dumping of toxic substances like different types of solvents, colored materials and detergents will extend earth and soil pollution [1].The methods to overcome soil pollution is Using water to remove pollutants from the soil, using chemical and aerial solvents, eliminating pollutants with incineration, helping natural organisms for breaking down atoms of pollutants, adding materials to the soil for protecting it and preventing spread of pollution to the other regions [2].

Phytoremediation is a cost-effective plant-based approach to remediation that takes advantage of the ability of plants to concentrate elements and compounds from the environment and to metabolize various molecules in their tissues. Toxic heavy metals and organic pollutants are the major targets for phytoremediation. Knowledge of the physiological and molecular mechanisms of phytoremediation began to emerge in recent years together with biological and engineering strategies designed to optimize and improve phytoremediation. In addition, several field trials confirmed the feasibility of using plants for environmental cleanup. [3]

There are many ways to control soil and water pollution but many of them are ineffective or they are much costlier. Phytoremediation is one of the way by which soil as well as water pollution can be treated. Phytoremediation may be applied wherever the soil or static water environment has become polluted or is suffering ongoing chronic pollution. Examples where phytoremediation has been used successfully include the restoration of abandoned metal mine workings, and sites where polychlorinated biphenyls have been dumped during manufacture and mitigation of ongoing coal mine discharges reducing the impact of contaminants in soils, water, or air. Contaminants such as metals, pesticides, solvents, explosives [4] and crude oil and its derivatives, have been mitigated in phytoremediation projects worldwide. Many plants such as mustard plants, alpine pennycress, hemp, and pigweed have proven to be successful at hyper accumulating contaminants at toxic waste sites.

Table 1: List of plants with the type of pollution they control.

Plant name	Type of pollution treated	Reference
Amorpha Fruticosa	Accumulates lead	[5]
Azolla pinnata	Adsorbs metals	[6]
Bacopa monnieri	Accumulates metals	[7]
Hydrilla verticillata	Hyper accumulates metals	[8]
Myriophyllum aquaticum	Degrades a variety of contaminants	[9]
Phragmites australis	Used in reed bed system	[10]
Salvinia minima	Used in accumulating lead	[11]
Pistia stratiotes	Removes heavy metals	[12]
Lemma Minor	Purify wastewater	[12]
Salvinia natans	Accumulates Zinc	[13]
S. acmophylla	Accumulates metals	[14]

The cost of the phytoremediation is lower than that of traditional processes both in situ and ex situ, the plants can be easily monitored and the possibility of the recovery and re-use of valuable metals (by companies specializing in "phyto mining").It is potentially the least harmful method because it uses naturally occurring organisms and preserves the environment in a more natural state.

Phytoremediation is limited to the surface area and depth occupied by the roots. Slow growth and low biomass require a long-term commitment. Also with plant-based systems of remediation, it is not possible to completely prevent the leaching of contaminants into the groundwater (without the complete removal of the contaminated ground, which in itself does not resolve the problem of contamination).The survival of the plants is affected by the toxicity of the contaminated land and the general condition of the soil. Bio-accumulation of contaminants, especially metals, into the plants which then pass into the food chain, from primary level consumers upwards or requires the safe disposal of the affected plant material. There is another big disadvantage of phytoremediation which is the handling of the plant waste. There we have to find a solution to the plant waste handling as if we employ the phytoremediation in industries and will be taken on large scale then there will be a lot of plant waste which will arise a new problem.

So we will discuss some methods to effectively use the plant waste which are extraction of heavy metal, nano-particles formation, Bio-diesel formation and Bio-gas generation.

II. EXTRACTION OF HEAVY METAL

Induced Phytoextraction or Chelate assisted Phytoextraction Within the plant cell heavy metal may trigger the production of oligopeptide ligands known as phytochelatins (PCs) and metallothioneins (MTs) [15]. These peptides bind and form stable complex with the heavy metal and thus neutralise the toxicity of the metal ion [16]. Phytochelatin (PCs) is synthesised with glutathione as building blocks resulting in a peptide with structure Gly-(y-Glu-Cys-)n; {where, n = 2-11}. Appearance of phytochelating ligands has been reported in hundreds of plant species exposed to heavy metals [17]. Metallothioneins (MTs), are small gene encoded, Cys-rich polypeptides. PCs are functionally equivalent to MTs [16]. Chelators have been isolated from plants that are strongly involved in the uptake of heavy metals and their detoxification. Chelating agents like ethylenediamine tetra acetic acid (EDTA) are applied to Pb contaminated soils that increases the amount of bio available lead in the soil and a greater accumulation in plants is observed [18]. The addition of chelates to a lead contaminated soil (total soil Pb 2500 mg kg^{-1}) increased shoot lead concentration of Zea mays (corn) and Pisun sativum (pea) from less than 500 mg kg^{-1} to more than 10,000 mg kg^{-1}. This was achieved by adding synthetic chelate EDTA to the soil, similar results using citric acid to enhance uranium uptake have been documented. These results indicate that chelates enhanced or facilitated Pb transport into the xylem, and increased lead translocation from roots to shoots. For the chelates tested, the order of effectiveness in increasing Pb desorption from the soil was EDTA > Hydroxyethylethylene-diaminetriacetic acid (HEDTA) > Diethylenetriaminepentaacetic acid (DTPA) > Ethylenediamine di(o-hyroxyphenylacetic acid) EDDHA [18]. Vassil et al., [19] reported that Brassica juncea exposed to Pb and EDTA in hydroponic solution was able to accumulate up to 55 mM kg^{-1} Pb in dry shoot tissue (1.1% [w/w]). This represents a 75-fold concentration of lead in shoot over that in solution. A threshold conc. of EDTA (0.25 mM) was required to stimulate this dramatic accumulation of both lead and EDTA in shoots.

III. NANO PARTICLES FORMATION

Metal nanoparticles have many technological applications. Biological routes to the synthesis of these particles have been proposed including production by phytoextraction. While many studies have looked at metal uptake by plants, particularly with regard to phytoremediation and hyperaccumulation, few have distinguished between metal deposition and metal salt accumulation. It describes the uptake of $AgNO_3$, $Na_3Ag(S_2O_3)_2$, and $Ag(NH_3)_2NO_3$ solutions by hydroponically grown *Brassica juncea* and the quantitative measurement of the conversion of these salts to silver metal nanoparticles. Using X-ray absorption near edge spectroscopy (XANES) to determine the metal speciation within the plants, combined with atomic absorption spectroscopy (AAS) for total Ag, the quantity of reduction of Ag^I to Ag^0 is reported. Transmission electron microscopy (TEM) showed Ag particles of 2–35 nm [20]. Lead removal by Salvinia minima causes large accumulation of lead inside the cells in the form of nanoparticles (PbNPs)[11]. The Salvinia natans is capable of accumulating the zinc nanoparticles of average diameter 25nm[13].

IV. BIOGAS FORMATION

Water hyacinth (*Eichhornia crassipes*) and water chestnut (*Trapa bispinnosa*) employed for phytoremediation of toxic metal rich brass and electroplating industry effluent are potential to generate biogas. Inability of the plants to grow in undiluted effluent directed to select 20%, 40% and 60% effluent concentrations (with de-ionized water) for phytoremediation experiments. Slurry of both the plants used for phytoremediation produced significantly more biogas than that by the control plants grown in unpolluted water, the effect being more pronounced with plants used for phytoremediation of 20% effluent. Biogas production was quicker (maximum from 8–12 days) in water hyacinth than in water chestnut (maximum from 12–16 days) [21]. The main constituents of any biomass material are lignin, hemicellulose, cellulose, mineral matter and ash. It possesses high moisture and volatile matter constituents, low bulk density and calorific value. The percentage of these components varies from species to species. The dry weight of Brassica juncea for induced phytoextraction of lead amounts to 6 tonnes per hectare with 10,000 to 15,000 mg/kg of metal in dry weight [22]. Handling of huge quantity of this type of waste is a problem and hence need volume reduction [23].

V. BIODIESEL GENERATION

Scenedesmus obliquus, *Chlorella vulgaris*, *Chlorella kessleri* and a natural Bloom have capacity for nutrient removal, carbon dioxide biofixation, and generation of valuable biomass. They are used to generate the Bio-diesel after the phytoremediation. [24].The Jatropha (Jatropha curcas L.) can also be use to generate biodiesel[25]. Corn (Zea mays)[26], Miscanthus (Miscanthus _ giganteus)[27], Switch grass (Panicum virgatum L.)[28] can be used to produce bioethanol.

VI. CONCLUSION

Phytoremediation successfully removes the ill effects of toxic materials from water as well as soil. It will take time to become commercially viable in India as it is still in its evolving stage. Still we have to find more of its advantages as well as disadvantages. In future more scientists will evolve more ways to use the phytoremediation waste and the phytoremediation process will become one of the leading pollution control method in the near future.

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