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***Review Article***

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# Phytoremediation: A Potential Tool for Waste Water Recycling

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## Abstract

Plants can be used in the cleanup and prevention of environmental pollution. This relatively new and green technology that uses natural processes to break down, stabilize, or accumulate pollutants. Phytoremediation-related processes might amend the situation or chemical makeup of contaminants. Multidisciplinary studies will help to develop a better understanding of the ecological interactions that contribute to phytoremediation, the effects of phytoremediation on ecological relationships, and the movement of pollutants through ecosystems. Phytoremediation, requires careful choice of plant species and management practices are key to promoting ecological restoration and preventing pollutant dispersal. Native/local plant species with effective remediation properties should be used that provide natural hydraulic control and soil stabilization should be selected.

## 1. Introduction

Approximately 70% of the Earth is covered by water and freshwater accounts for less than 3% of the total amount of water available (including ice caps) however, merely less than 1 percent of the world's fresh water (or 0.01 percent of all water) can be used in a renewable fashion. The cleanup of contaminated water and soil is necessary in order to maintain a strong and healthy ecosystem to defend the lives of people. Several physical and chemical ways has been devised to reuse the contaminated systems such as, incineration, landfilling, excavation, soil washing, soil flushing, etc. (Sheoran *et al*., 2011), which are labor intensive, time consuming, and require huge amounts of financial input. Further, they cause irreversible changes in soil properties, and even cause disturbances to the native microflora of soil and water and chemical methods can generate secondary pollutants (Gurjar *et al.,* 2017). Therefore, the need is to remove the pollutant in an acceptable and economical ways to clean up the environment. In this case, an extensive development of phytoremediation, a green technology (Prasad, 2004) can be helpful. However, it is often reorted that certain microbes, fungi, algae, and plants can live, grow, and flourish even in highly contaminated areas, including radioactively polluted environments, Chernobyl, (Beresford *et al.,* 2016). This indicated the possibility of utilizing biological processes in the remediation of contaminated areas (Lone *et al.*, 2008), known as bioremediation. Phytoremediation (green or botanical remediation) is a part of bioremediation, which is carried out with the help of plants. "Phyto" means plants and "remediation" means restoration. Chaney (1983) gave the concept of phytoremediation for the first time. It consists of technologies that are applied on plants and plantsmicrobe interactions, to reduce the concentration, or to transform, toxic inorganic and organic contaminants. These green plants not only accumulate or transform toxic metals by uptaking it from contaminated medium, but also help on improving that media's fertility with supply of organic matter in form of root exudates, enzymes and litter into that. Unlike physical and chemical methods, phytoremediation is suitable for extremely large contaminated sites, as low installation and maintenance costs are required (Pilon-Smits, 2005). Phytoremediation is driven, to a large by the discovery of hyperaccumulator. These plants show significantly high heavy metal accumulation beyond the threshold level for a given metal of up to 2% of the dry biomass of the fern *Pteris vittata* (Ma *et al.*, 2001). Phytoremediation has so many advantages however, some of them are: (1) phytostabilization and phytoimmobilization (prevent spreading of risk contaminants in polluted sites) (2) phytomining (high value metals extraction using plants having high economic value, like Ni and gold (Au) (3) restoration of land/water bodies (gradual improvement of soil/water quality

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with subsequent cropping cycles during phytomining and phytoextraction) (Vangronsveld *et al.*, 2009).

There are several methods employed for the treatment of waste water like reverse osmosis, ground injection, land application, constructed wetlands etc. The traditional physico-chemical processes for treatment requires high energy and huge investment, whereas aquatic plant based phytoremediation is highly cost effective technologies and eco-friendly, which can be easily adopted by developing countries for treatment of waste water, especially contaminated by organic pollutants, heavy metals and surfactants.

## 2. Phytoremediation Mechanisms for Water Bodies

Phytoremediation mechanisms for water bodies involve the use of plants for the removal of contaminants from aqueous solutions. Cyperaceae, Hydrocharitaceae, Lemnaceae, Pontederiaceae, Potamogetonaceae, Typhaceae, Haloragaceae, Najadaceae, Juncaceae, Zosterophyllaceae Ranunculaceae, are among the main aquatic plants that represent phytoremediators. These plants are either emergent (i.e their roots are attached to the substrate at the bottom of water bodies while the leaves grow to or above the surface of the water), submerged (their root system is attached to the substrate but their leaves do not reach the surface of the water), or free floating (i.e exclusively found on the surface of water bodies, usually found in standing or slow moving waters). Aquatic plants are extremely important components of an aquatic ecosystem for primary productivity and nutrient cycling. Furthermore, it assists varieties of several organisms by providing refuge, habitat and food for them. The aquatic plants have been reported for long to detoxify environmental pollutants. The notable environmental contaminants are inorganic and organic pollutants which can be phytoremediated in various ways. There are various forms of phytoremediation technology which are applicable in treatment of wastewater. Uptake mechanisms of plant help in remediating organic and inorganic contaminants from wastewater in Phytoremediation method (Chandekar and Godboley, 2015).

*2.1. Phytoextration*

In this mechanism, plants uptake the contaminants by the root and translocate it to the different tissues of the plants by absorbing and further precipitating the pollutant from contaminated zone.

*2.2. Phytodegradation*

In this metabolic mechanism breakdown the pollutants in the soil. Microorganisms consume nutrients from the organic substances.

*2.3. Phytovolatization*

Plants absorb pollutants from water similarly as soil then provide to the atmosphere as vapour at low concentrations through the leaves.

*2.4. Rhizofiltration*

Removal of the pollutants in water by surface assimilation/ adsorption and further, precipitation through plant roots (Figure 1).

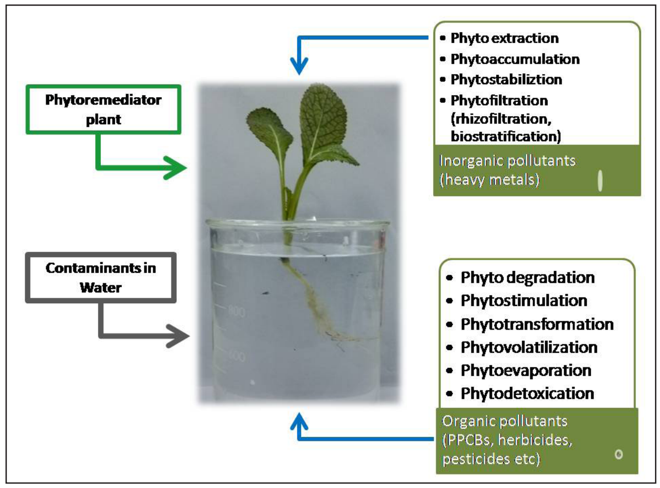


Figure 1: A schematic representation of Lai plant (*Brassica juncea*) as phytoremediator for contaminants removal in water

*2.5 Phytostabilization*

Plants immobilize or solidify the pollutants in the water and soil through accumulation and absorption in plant.

*2.6. Phytotransformation*

The employment of plants for uptake and transformation of contaminant from soil or water. The plant secrets natural enzymes that cause fast chemical reaction to less toxic forms

## 3. Phytoremediators

Research over the past decades has proved that some floating plants, such as water hyacinth (*E.crassipes*),

Table 1: Important plants used as phytoremediator (modified from Chandekar and Godboley, 2015)

| Sl. No. | Plant used as phyoremediator | Experimental conditions | Experimental findings | Reference |
|---|---|---|---|---|
| 1. | *Canna indica* | Plants were grown in sand & gravel medium with vertical sub surface flow | 1. Total P, COD & BOD is reduced to 90% as compared to control.<br>2. Ammonium-N and Total N reduced by 67 & 63%, respectively as compared to control.<br>3. Canna has good absorption capacity | Namratha et al. (2016) |

Table 1: Continue...

| Sl. No. | Plant used as phyoremediator | Experimental conditions | Experimental findings | Reference |
|---|---|---|---|---|
| 2. | *Typha spp.* | Plants were grown in sand & gravel medium with vertical & horizontal flow | TDS, TN BOD and COD reduced by 15%, 40%, 65% and 60%, respectively as compared to control. | Chopra et al. (2016) |
| 3. | *Phragmites austrails* and *Canna indica* | Plants were grown in sand & gravel medium with horizontal sub surface flow | pH-6.4-7.6 and 6.7-8.1,<br>COD 84 & 76%<br>BOD 71 & 67%<br>Total solid 80 & 81% Dissolved solids 79 & 75%, Suspended solids 76 & 74%<br>respectively for Phragmites austrails and Canna indica bed | Kallimani and Virupakshi (2015) |
| 4. | *Lepironia articulata* | Plants were grown in sand & gravel medium with horizontal sub surface flow | BOD -81.42%, COD - 84.57 %, AN- 39.83 %, SS- 54.70 % and Turbidity- 45.01 % were reduced as compared to control. | Wuruchekkea et al. (2014) |
| 5. | *Pharamites austrails* | Plants were grown in sand & gravel medium with sub surface flow | BOD-90% and Nitrogen -63% were reduced as compared to control. | Ramprasad (2012) |
| 6. | *Eichhornia crassipes* | Plants were grown in sand & gravel medium with Vertical flow | BOD-95.89%, COD-97%, TSS-82% and Phosphate-50% was reduced as compared to control. | Yadav et al. (2011) |
| 7. | *Pharamites austrails* | Plants were grown in sand & gravel medium with vertical and horizontal flow | TSS 41%, TDS 76%, TP 77%, BOD 75% and COD 36% were reduced as compared to control. | Baskar and. Deeptha 2009 |
| 8. | *Typha lotifolia* and *Canna sieamensis* | Plants were grown in sand & gravel medium with vertical flow | Removal rate of Typha lotifolia and Canna sieamensis were reduced in case of SS- 90%-93%, TN- 85%- 88%, Phosphate-85%-90% as compared to control, respectively. | Suntud Sirianuntapiboon (2007) |
| 9. | *Reed* spp. | Plants were grown in sand & gravel medium with vertical flow | COD -99.5% and TN -93.8% were reduced as compared to control. | Luederitz et al. (2001) |
| 10. | *Typha augustifolia* | Plants were grown in sand & gravel medium with vertical flow | TDS- 84.66% Turbidity-92.90%, COD- 80.53%, BOD5 -75.49% were reduced as compared to control. | Arivoli and Mohanraj (2013) |
| 11. | *Phragmites australis and Typha* spp. | Surface flow wetland Infiltration | Removed 99% of bacterial pollution, 80–90% of COD and BOD and 30–40% of N and P as compared to control. | Verhoeven and Meuleman (1999) |

water lettuce (*Pistia stratiotes*), pennywort (*Hydrocotyle umbellate*), duckweed (*Lemna minor*), water peanut (*Alternanthera philoxeroides*) and lidded cleistocalyx (*Cleistocalyx operculatus*), are one of the best and effective in purifying contminated water. Therefore, water hyacinth and duckweed were applied in the treatment of wastewater. The potential of Water hyacinth on the nutrient regime of a lake ecosystem for sewage treatment has been found out by many researchers.

## 4. Conclusion

Phytoremediation is a green technology which can be used in water resource management and removal of contamination. Many aquatic plants (emerging, submerged or free flowing) have been applied extensively to establish the effectiveness in remediating organic pollutants & heavy metals and improving other water quality parameters by aquatic plants. The phytoremediator plants must be of ubiquitous nature, invasive mechanism, sporadic reproductive capacity, bioaccumulation potentials and resilience in polluted environment might be a new answer to waste water treatment. However, the effectiveness of phytoremediation process needs more experimentation in the future to optimize the removal rates of contaminant by plant.

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