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A Review on Purification of Yamuna River Water by Native Plants and Trees

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Abstract: ***Yamuna River is the lifeline of Delhi as it caters all the domestic water supply, irrigation, industrial, agricultural and other requirements. However the water quality of Yamuna is continuously deteriorating due to the direct/ indirect discharge of domestic sewage, industrial and agricultural effluents. It was observed that among the other pollutants, river water has very little ability to deal with heavy metal ions by self purification process. In this paper, we review the natural and self purification of both organic and inorganic pollutants in Yamuna River by phytoremediation. The native plants and trees have a great potential in purification of polluted water. So we discuss about the potential of some locally available native plants, weeds, herbs, woody plants and trees for the phytoremediation of the heavy metals present in Yamuna River.***

Keywords: Phytoremediation, Yamuna River, Heavy metals, Aquatic plants, Trees

1. Introduction

Rivers are the lifeline of any civilization. They are prime factor controlling the global water cycle and in the hydrological cycle they are the most dynamic agents of transport. In developing countries, for their social and economic development the exploitation of water resources is intensifying which results into many pollution events in the rivers and lakes.

Yamuna River is one of the important rivers of India originating from Himalayas. It is the largest tributary (1376 Km) of river Ganga, originating from Yamunotri glaciers at Bandu Panch in the region of Simla at 6387m above mean sea level (msl), in the lower Himalayas. After flowing through Shivaliks , it emerges on the plains near Tajewala at 370m (msl). The river then flows southwest to southwards for 224 Km to enter the National Capital Region of Delhi at 215m (msl). After meandering through Delhi for about 22 Km to Okhla, the river continues southwards for 272 km to Agra (146m msl) and then turn southeast until it confluence with the river Ganga at Allahabad (100 m,msl) as shown in Figure [1]. Based on hydrological and ecological Information River Yamuna can be differentiated into 5 sub stretches (as CPCB, 2012). Delhi region stretch extending from (third no. sub stretch) Wazirabad barrage to Okhla barrage (of 22Km) is the most polluted stretch due to sewage wastes as well as industrial discharge. Due to large variation in climate and soil the natural vegetation is also highly variable in the Yamuna River basin. There are approximately 2500 native plant species identified which are suitable to be grown in the Yamuna River basin as compared to the present deteriorated number of 25-30 species of fauna [1].

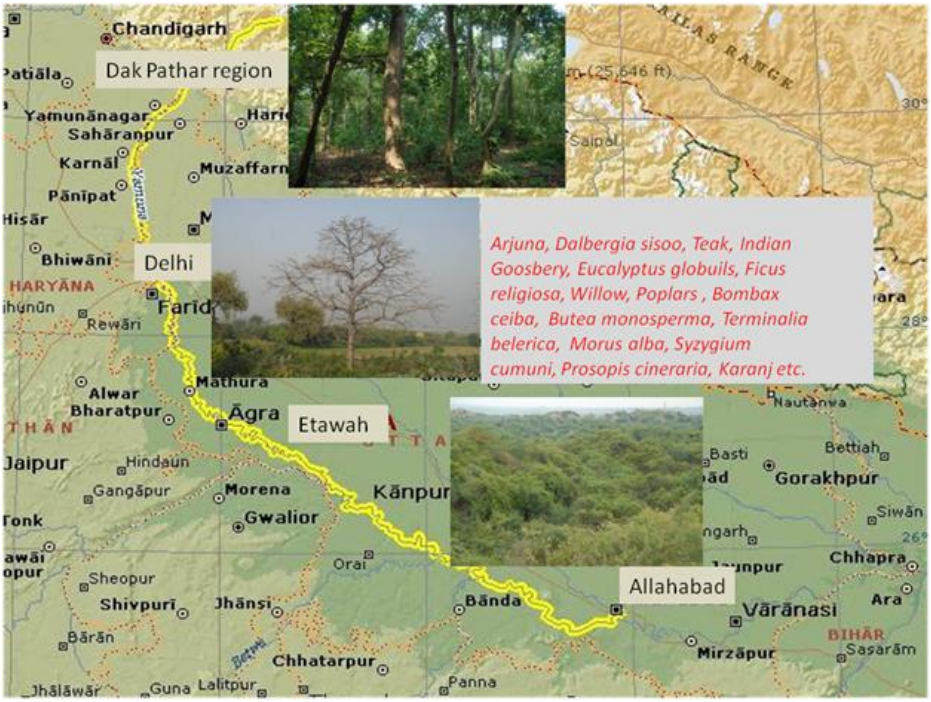

Figure 1

Nature plays essential role in the rivers self restoration via both the decomposition of total organic matter by fungi, bacteria and other micro organisms and utilization of several functional biological filters e.g. Rotifers, bryozones, Crustaceans (Removes phytoplankton and algae). The self purification of Natural water system is a complex process that often involves physical, chemical and biological processes working simultaneously. Among various stages involved in self purification phytoremediation is one of them in which the aquatic plant and vegetation on the River banks absorb Nitrates, Phosphates and other nutrients and removes pesticides and heavy metals. In this way quality of River water is largely improved. Filtering water by aquatic plants (duckweed, water hyacinth, azolla pinnata etc) communities also prevent the entry of pollution and biogenic elements.

Presence of heavy metals at a higher concentration then the permissible limit in the river water is one of the causes of water pollution which is toxic to aquatic flora, fauna and human beings. The average heavy metal concentration at different location of Yamuna river water and its catchment area in Delhi varies in the order of Fe > Cr >Mn > Zn > Cr > Pb > Cu > Ni > Hg > As > Cd and the average heavy metal concentration at different location in soil varies in the order of Fe > Mn > Zn > Cr > Pb > Ni > Hg > Cu > As > Cd. [2]

Phytoremediation is defined as the removal of pollutants from the environment or converts them into harmless using the plant species. It is classified into 5 subgroups.

Phyto-remediation involves growing plants in a contaminated matrix to remove environmental contaminants by facilitating sequestration and/or degradation (detoxification) of the pollutants

a) Phytoextraction: plants remove metals from the soil and concentrate them in the harvestable parts of plants
b) Phytodegradation: plants and associated microbes degrade organic pollutants.
c) Rhizofiltration: plants roots absorb metals from waste streams.
d) Phytostabilisation: plants reduce the mobility and bioavailability of pollutants in the environment either by immobilisation or by prevention of migration.
e) Phytovolatilisation: volatilisation of pollutants into the atmosphere via plants

Trees also play an important role not only in air purification but as natural filters to protect our streams, rivers and lakes. Stream (Riparian) buffer are the strips of trees and vegetation that also improve water and soil quality. Phytoremediation is cost effective alternative to high energy high cost conventional methods, have aesthetic advantage and long term applicability and is considered to be a Green Revolution in the field of innovative cleanup technologies. Hence the identification and selection of plants and trees that are suitable for successful remediation of water pollution is a matter of great concern. It is recommended that plants that have large and extensive root system should be planted at sites which are polluted due to industries and sewage.

Here we review the self purification of Yamuna River by phytoremediation process using the native plants and trees available in and around Delhi. We are focusing more on the purification of heavy metals present in the River bed and river water by both aquatic and terrestrial plants/ trees. Trees are considered to be more effective not only in controlling the water pollutants because of its advanced root system, but also it control air and noise pollution and helps the environment in wood production. In aquatic and herbs/ woody plants, the reduction of contaminant may be in small quantity and that is also present in the edible part.

In the natural settings, certain plants and trees have been identified which have the potential to purify River water (or to uptake heavy metal) and are native to the Yamuna river belt. In table [1] we have summarized the details of native plants and trees which have the potential to store the heavy metals preferably in their non-edible parts.

Table 1: Details of plants and trees native to Yamuna River and their role in bioremediation

S.N	*Name of Plants*	*Family*	*Storage Organs*	*Pollutant/Contaminant*	*Mechanism/Process*	*Ref.*
	Aquatic Plants					
1	Siprodelapolyrrhiz (Gaint Duckweed) Floating aquatic plant	Araceae higher classification Lemnaceae	In thallus	Reduce Cu-95%, Zn- 79%, Cr-73%, Hg-45%, Co-26%, Mn-20%,NO3-100% & Ni-7%, BOD-37&, COD-49%, PO4- 36%, SO4-16%, TDS-53%	Phytodegradation	[3]
2	Eichhornia crassipes (Hyacinth) Floating aquatic plant	Pontedericeae	Root plays important role	Removal of heavy metal Cd-82%, Cu-78%, As-74%, Al-73%, Zn-65%, Cr-62.8%Fe-61% and Hg. Also removes cyanides, reduces chloride, Iron, Copper, Manganese, lead (in root) fluoride, sulphate, nitrate and phosphorous.	Rhizofiltration	[4-12]
3	Pteris vittata L.	pteridaceae	In fronds	Fe, Cu, Zn, Ni, Al, Cr, Pb, Si, and As	phytoextraction	[13][14]
3	Azolla pinnata(feathered mosquito fern/ water velvet)Submerged plant	Salviniaceae	In roots and aerial parts	Domestic waste water Removes 70-90% of Cd & Hg	Phytoextraction	[15][16]
4	Arabidopis thaliana	Brassicaceaea	In shoots	Remove Hg, Cd and other heavy metals		[13][14]
5	**Lemna Minor (duckweed)**	**Lamiaceae**	In aerial parts andin roots	Ni, Cu, Cd, Pb, Co, Cr	phytodegradation	[17]
6	Typha Orientalis	Typhaceae	More in aerial part	Removes Pb	Phytoaccumulation	[18]

7	Hydrila verticillata	Hydrillas	In aerial parts and roots	Removes As (92.5%), Zn (93.7%), TSS (60%), BOD (37.5%), COD (37.5%), NO3- (33.41%) and P (46.01%)		[19]
	Plants					
	Brassica Juneceae (Indian mustard)	Brassicaceae	Root and shoot	Pb, Hg, Cd, Cr, Ni, Zn, Cu	Rhizofiltration	[15][16]
	Helianthus annuus(Sun flower)	Asteraceae	Root and shoot	Pb, Hg, Cd, Cr, Ni, Zn, Cuand radio nuclei Sr and Cs	Rhizofiltration	[20-22]
	Trees					
8	Dalbergia sissoo	Fabaceae	In woody part	Removes Pb, Co	Bioaccumulation	[23-25]
11	Queens flower (Arjuna)	Combretaceae		Remove Se and the organic pollutant in petroleum contaminated soil		[26][27]
12	Pongamia Pinnata [Pongam (Karanj)]	Leguminosae	Roots, shoots and stems and transport further to upper part of the tree	Cr, Cu and Cd	Phytoextraction	[28-31]
14	Teak tree (Tectona Grandis)	Lamiaceae	Bark, leaves	Fe, Cr, Cd, Cu, As Mn Zn Pb Hg		[32][33]
15	Salimax viminalis (Willow)	Salicaceae	Leaves, stems and roots	Remove inorganic nutrients and chlorinated solvents along with heavy metals such as Cd (83%) and Zn (71%)	Phytoextraction	[34][35]
16	Poplars (Populus spp.)(Cotton wood)	Salicaceae	More in roots than in shoots	Removes Cd, As,Ni, Pd tolerance	Phytoextraction	[36-40]
17	Sugar maple tree	Sapindaceae		Removes Cd, Cr, Ni, Pb		[41]
18	Butea monosperma (Flame of forest)	Fabaceae	Barks	Cr (VI), As Fe Cr Mn Cu Zn Cd Pb Hg	Phytoextraction	[32][33]
19	PHYLLANTHUS EMBLICA (Indian Gooseberry or Amla)		Barks and leaves	Remove Zn and Pb		[42]
20	Zea mays L			As and Cd accumulation		[43-45]
21	Eucalyptus globulus		Roots and barks	Remove As Fe Cr Mn Cu Zn Cd Pb Hg		[46-48]
22	Ficus religiosa	Moraceae	leaves	As Fe Cr Mn Cu Zn Cd Pb Hg	bioaccumulation	[32] [33]
23	*Prosopis cineraria/ Prosopis juliflora*		Roots	Floride	bioaccumulation	[49]
24	*Azadirachta indica*		Roots	Floride	bioaccumulation	[49]

2. Conclusion

The problem of water pollution as a result of contamination of ground water is constantly increasing especially in developing countries due to the fact that there are limited financial and technological resources to remediate polluted water sources. In this situation, the use of trees to remediate polluted water is considered as the new emerging technology which is relatively cheaper, sustainable and inexpensive alternatives to conventional remediation methods and will be most suitable for a developing country like India. The technology of Phytoremediation offers viable solution to water pollution. It offers restoration of sites, limited decontamination, preservation of the biological activity, and physical structure of the soil.

To breed plants having superior phytoremediation potential with high biomass production can be an alternative to improve bioremediation. Genetic engineering technique can also play an important role in this field by implanting more efficient accumulator genes into other plants as suggested by other authors. Implanting more efficient accumulator genes into other plants that are taller than natural plants increase the final biomass. Fast growing plants with high biomass and good metal uptake ability are needed to improve the quality of Yamuna River. Emphasis is to be given on the plantation of locally available native terrestrial plants and trees rather than aquatic plants due to their larger root system.

The importance of trees in urban environment is now widely recognized that they too cleanse the particulate air pollution and help to make cities and towns more agreeable places to dwell upon. India's rich biodiversity of both indigenous and exotic trees offers a wide range of choice to restore our sick and sultry towns. The present paper recommends various tree species for urban plantings, so that a wider usage of local as well as exotic tree species can be explored for controlling heavy metals and other organic pollutants in Yamuna. Much more research on urban trees is needed for effective control of air, water and soil pollution.

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