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RESEARCH PAPER

Investigation on Heavy Metals Absorption through Bamboo Plantation on Bank of Hindon River

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ABSTRACT
Rapid urbanization, industrialization and excessive use of pesticides in the catchment area of the Hindon River (a tributary of Yamuna River), in recent past, impacted the River by discharging harmful effluents, untreated domestic sewage, etc. Proliferation of such activities along the banks of River has contaminated the surface as well as ground water. Increased concentration of toxics in the River water deteriorated the water quality substantially making it unusable for any purpose. Despite institutional and regulatory framework in place, effective implementation of remedial measures remained a far cry owing to various factors such as cost intensive setups, poor awareness levels, etc. Therefore, with a view to explore the remedial measures to improve the water quality, the present study has been conceived to develop ecologically sustainable techniques to mitigate pollution levels of the River. The study envisages utilization and promotion of bamboo plantation along the bank of the River. Bamboo, the fastest growing plant of earth, can grow in varied types of edaphic conditions. Bamboo clumps act as effective soil binder and roots hairs from rhizome efficiently absorbs heavy metals along with other nutrients from the soil. So far, root based technology to mitigate the pollution and improve the water quality has remained underutilized in the country. Therefore, proposed study may prove a yardstick to combat the pollutions of River and develop ecologically viable methods for the water treatments.

Key words: *Heavy metals, Phytoremediation, Bamboo*

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INTRODUCTION
The Hindon River is considered to be one of the essential Rivers of Western Uttar Pradesh. River originates from Upper Shivalik region and flows through six major districts, viz., Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautambudh Nagar and joins River Yamuna downstream in Delhi. Human activities such as urbanization, deforestation, agriculture has deteriorated the water quality of Indian Rivers significantly. 96% of India's water is polluted due to indiscriminate discharge of municipal wastes (Chaudhary, 1981).
Almost 70% of country's water resources and ground water reserves are contaminated due to biological, toxic, organic and inorganic pollutants (Murthy & Kumar, 2011). River kali and the Krishni River are two main tributaries of the Hindon River together they have

60 industrial units associated with them which includes paper, sugar, distillery and many small-scale industries related to electroplating, paper board, food processing, milk products, chemicals and rubber etc. These industries consume large volume of water from the River for manufacturing purpose and release their untreated industrial effluents directly into the River. These industrial effluents mostly contain high concentrations of heavy metals. Various small-scale industries do not effluent treatment plant facilities as the profit margin is low. They release effluents openly which may lead to water contamination in water body and causing serious health hazards. The Indrapuram sewage treatment plant is the only such facility within the Hindon River catchment. However, this treatment plant does not have adequate volume capacity and efficiency to treat all domestic and municipal wastes in the catchment. There are 32 major paper industries out of which 24 are located on Kali River and rest 15 are sugar manufactures and alcohol distillation industries. They release effluents which gets stagnant for a longer duration causing low level of oxygen in water.

WATER QUALITY OF HINDON RIVER

After reviewing various literature sources, it was found that the water quality of Hindon River is severely polluted and hence not adequate for domestic and other life supporting purposes (Suthar, *et al.,* 2010), Sharma *et al.,* 2014). As per the Central Pollution Control Board report (CPCB) toxic pollutants coming from industries mainly contain heavy metals, pesticides and industrial xenobiotic pollutants and examples of such pollutants are drugs, food additives and other environmental pollutants. Presence of these heavy metals in water bodies causes severe toxicological effects on human health and also on aquatic life. Due to frequent accumulation and absorption, the concentration of metals in bottom is much higher than in the water above.

Hindon River drains a catchment of approximately 5,000 sq km of largely agricultural land and while also flowing through number of substantial sized towns and villages. Most people use open fields defecation, with few of them using pit latrines or septic tanks. Activities such as bathing, washing of clothes held in or near the water body causing in-situ diffuse pollution. As per the CPCB reports, estimated an average 15 g BOD per capita per day of the rural population reaching in the major River draining. There are no formalized domestic waste water drainage systems along the course of Hindon River. These untreated municipal wastes are known to contain a very high level of pollutants and suspended particulate matter, as well as heavy metals.

The CPCB has set up the standard for the levels of BOD acceptable for bathing water 3 mg/l. Levels of BOD acceptable within drinking water source without treatment is just 2 mg/l. A clean River with low organic pollution levels is also expected to have a BOD level of around 2 mg/l. The minimum levels of dissolved oxygen required for bathing water at 5 mg/l, and for drinking water before treatment at 6 mg/l.

As per the study conducted by some foundation in 2007, BOD levels found to be exceeding 1000 mg/l at which River is said to be entirely devoid of oxygen which means devoid of aquatic life (samples taken in Krishni River). In Saharanpur district, Nauana sugar mills, UP Cooperative sugar factory federation distillery, Singh straw board factory, SMC food ltd, Nauna are located due to which effluent level in water body is too high, reported up to 9600 mg/l. Effluents discharged from sugar mills is known to have a BOD level in the range of 1,700 to 6,600 mg/l. Hindon River received high effluents from number of sugar mills, paper industries, ethanol distillation units which act as primary contributor to anaerobic conditions in the water body.

As per the report of Janhit Foundation, samples were collected from 22 sites of Hindon water to assess following parameters such as DO, Pb, Cd, Cr and pesticides concentration to get a good overview of general water quality. This study was done in 2007 to evaluate physical and chemical properties of Hindon River water, presence of toxic contaminants

such as heavy metals and pesticides in it. Out of 22 samples, only highest levels DO, Pb, Cd, Cr and pesticides concentration were shown in graph 1.

BIOCHEMICAL OXYGEN DEMAND

It is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organism to breakdown organic material present in water. Higher the BOD levels, the more rapidly oxygen will get depleted in the water body and there will be less availability of oxygen for aquatic life, hence River suffocates and dies. Higher the BOD, lower will be the levels of dissolved oxygen in water, therefore it is a reliable indicator of organic pollution in water body. BOD level in Hindon River water is reported to be too high. As per the standard level set by CPCB, BOD acceptable for bathing and drinking is 3 mg/l and 2 mg/l respectively. However, reports of Janhit foundation shows BOD ranging from 1000 mg/l to 6600 mg/l assessed after taking water samples from different locations.

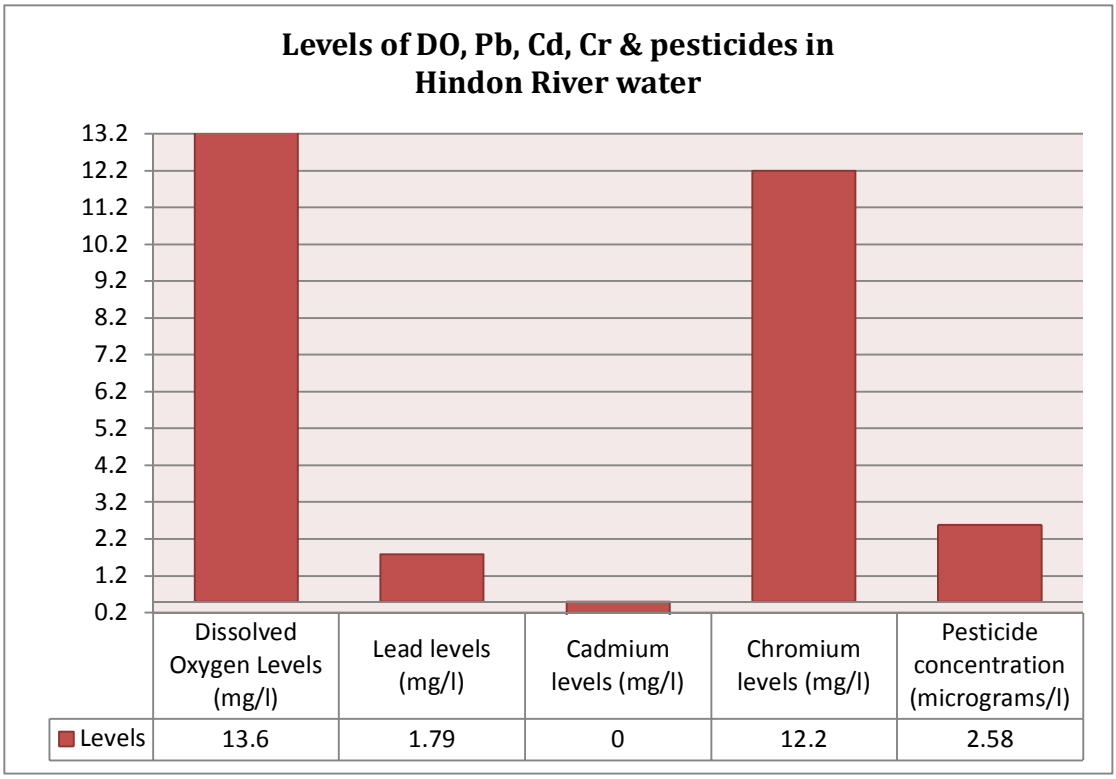
DISSOLVED OXYGEN LEVEL

The minimum levels of DO required at 5 mg/l and 6 mg/l for bathing and drinking as standardized by CPCB. The samples taken from Hindon water shows highest level of 13.8 mg/l and minimum is 0.8 mg/l. It is an important parameter to assess the water quality due to its influence on aquatic organisms and act as a good indicator of organic pollution levels. Dissolved oxygen levels in water body are influenced by many factors such as water temperature, rate of photosynthesis, degree of light penetration and the amount of oxygen used by aquatic animals for respiration and decay of organic matter. Excessive amounts of organic matter such as sewage, manure and effluents runoffs from industries are also responsible for reduce in level of dissolved oxygen concentration in water bodies. Erosion from any number of sources is another factor that lowers dissolved oxygen levels. Presence of organic matter in water such as sewage and food waste attract bacteria and other microorganisms due to its high nutrient content, and these microbes use DO to decompose organic material which reduces level of oxygen present for other aquatic organisms. The unremitting increase in nutrient content in water body, mainly nitrogen plays their role in algal growth and high phosphorous content cause eutrophication in water bodies. The levels of DO is produced by the process of photosynthesis takes place at the surface by shallow water plants algae and by seaweeds, phytoplanktons and sub water algae in under water. Due to frequent photosynthesis process during day time, the photosynthesis process is much more than respiration resulting in net addition of dissolved oxygen to water. However, during night time photosynthesis process is slow whereas respiration requirement continues at faster rate which leads to depletion of oxygen in water.

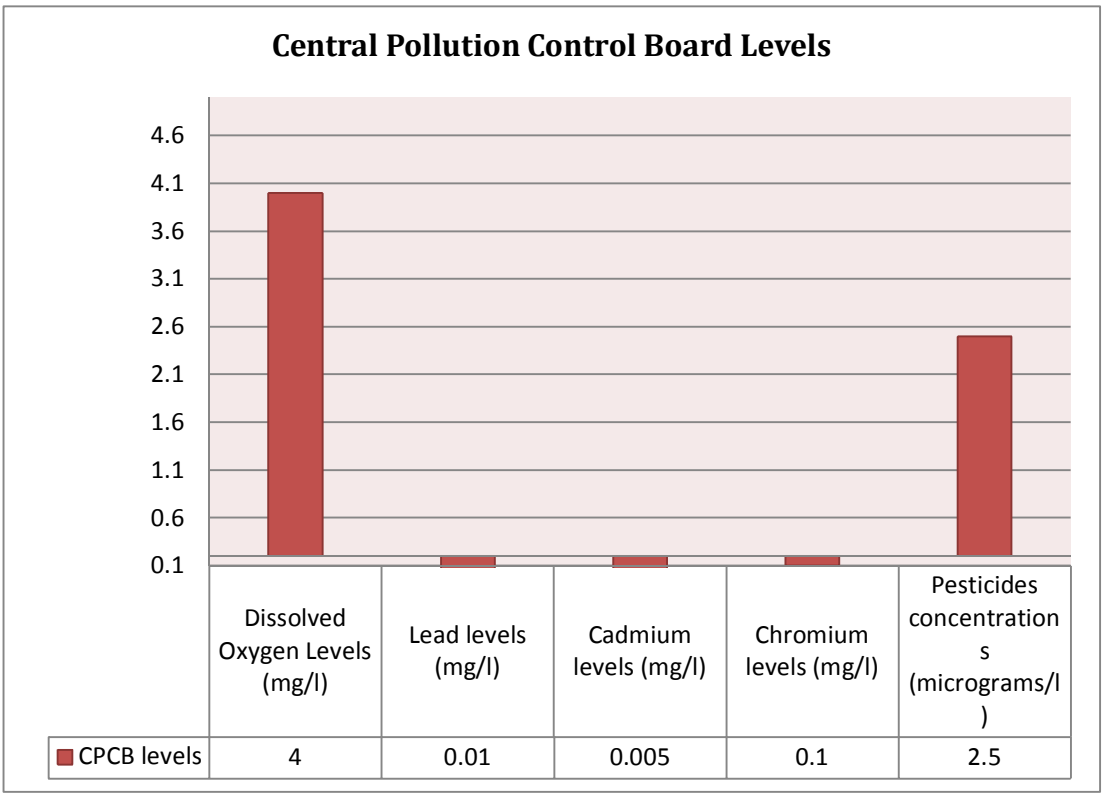
LEAD LEVELS

Heavy metals are introduced in environment through natural and anthropogenic sources. Natural sources are mineralization of parent rock, anthropogenic sources ranges from agriculture activities such as application of inorganic fertilizers, animal manures, pesticides etc, metal, minning and ceramic industries other than this gasoline, battery manufacture, power plants are other sources of heavy metals including lead. Effluent emissions from large industries can cause large scale contamination of land and water bodies.

Lead is the most significant heavy metals causing toxicity, and it is being absorbed by humans and animals through ingestion by food, water and inhalation. Lead contamination poses a serious threat to the safety of drinking water in India. Agriculture soil, household dust, paints, gasoline, glass ware, automobile and ceramic industries are the major sources of lead exposure in water bodies. Lead gets into water bodies due to application of inorganic fertilizers and pesticides, water run-off enters into water bodies.



Graph 1: Levels of Dissolved Oxygen Level, Lead, Cadmium, Chromium and Pesticides in Hindon River Water



Graph 2: Levels of Dissolved Oxygen Level, Lead, Cadmium, Chromium and Pesticides standardized by CPCB

ABSORPTION OF TOXICITY BY BAMBOO PLANTS

Bamboo species have shallow root system and serves efficiently in preventing soil erosion, soil moisture conservation, establishment of embankments and drainage channels. *Dendrocalamus strictus,* is a hardy species and can grow in wide range of soil conditions particularly in porous, coarse grained dry soils *having* low moisture content and optimum pH 5.5-7.6 (Yadav, 1963). In a study (Singh and singh, 1999), growth and impact of bamboo species (*Dendrocalamus strictus*) was observed in a soil conditions deteriorated by minning. Bamboo plantation developed on mine site accumulate higher biomass i.e. 30-49 t per ha when compared with other studies in bamboo forests and plantations recorded biomass production of 0.8 to 24 t per ha (Veblen, *et al.*, 1980; Taylo & Zisheng, 1987; Rao & Ramakrishnan, 1989; Tripathi & Singh, 1996). *Dendrocalamus strictus* plantation shows higher values for net primary production of range between 20.7 to 32.0 t/ha in this study (Singh & singh, 1999) when compared with other native dry tropical forest species (Singh & Singh, 1991).

BAMBOO ROOT SYSTEM

Bamboo is a very shallow rooted plant and develops a profuse root mat of highly efficient fine root and root hairs. Root and rhizome system is confined to upper most soil horizon which is found to be well aerated and mineralization of nutrients is at faster rate than in deeper layers. Hence, available plant ions in soil are effectively absorbed by the dense root system of bamboo in upper soil layer. Therefore, absorption rate is high and leaching of nutrients is very low in bamboo species (Toky & Ramakrishnan, 1981; Toky & Ramakrishnan, 1982).

The absorption level of water and nutrient by bamboo depends on the growth and functions of roots and rhizomes. Similar to any other plant species, the fine root s and root hairs of the bamboo root system plays significant role in nutrient absorption and high productivity (Tripathy & Singh, 1996).

PHYTOREMEDIATION POTENTIAL OF BAMBOO SPECIES

Phytoremediation is a term used to clean up contaminants using plants, or remediate sites by removing pollutants from soil and water (Rao & Ramakrishnan, 1989). It is one of the most organic, cost effective method to remove contamination especially heavy metals from the environment and can be conducted with five mechanism including; Rhizospehere bioremediation, Phytostabilization, Phytotransformation, Phytoextraction and Rhizofiltration. These five mechanisms occur in most of the plants but plants with high root biomass production such as bamboo can be appropriate option for phytoremediation (Gerhardt, *et al*., 2009). Fast growing rate, high biomass production along with other characteristics such as wide root system, early harvest, tolerance to abiotic stresses are remarkable for phytoremediation process which makes bamboo as suitable option for phytoremediation (Rajkumar & Hasegawa, 2011).

MECHANISM OF PHYTOREMEDIATION

Bamboo species have shallow but wider root system which helps in absorbing, accumulating hence removing contaminants from soil by mechanisms of phytosorption, phytovolatization and hydraulic pumping system in plants and transfer them to plant organs (Nagendra, *et al*., 2006). Bamboo plays essential role in accumulation of heavy metals as they bind to peptide and anionic groups in vacuoles of root cells and prevent transfer of heavy metals to areal organs and protect plant photosynthesis and metabolism (Rascio & Navari, 2011).

CONCLUSION

Bamboo is the fastest growing plant and it grows in different types of types of climatic conditions. It can be utilized for plantation along the bank of the River. The clumps of

bamboo bind the soil rhizome absorb heavy metals along with other nutrients from the soil. So far, root-based technology to mitigate the pollution and improve the water quality has remained underutilized in the country. The proposed study may prove a yardstick to combat the pollutions of River and develop ecologically viable methods for the water treatments.

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