

Phytoremediation of heavy metals from industrial wastewater by using aquatic macrophytes

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Submitted By
Sangeeta Anand
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Under Supervision of

Dr. Narendra Kumar

Assistant Professor

Department of Environmental Science
Babasaheb Bhimrao Ambedkar University (A Central University,
NAAC Accreditation "A" Grade)
Vidya Vihar, Raebareli Road Lucknow-226025, India

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Summary

Contamination in freshwater system due to direct discharge of industrial wastewater loaded with inorganic and organic contaminants such as heavy metals, metalloids, oil and grease and other petrochemicals etc. causes serious threats to plants and animals health. Constrains associated with heavy metal pollution includes their non-biodegradability, persistence nature, bioaccumulation in food chains. Since metal pollution affects the quality of water thereby affecting human and plant lives directly. Over last two decades many efforts have been done by several researchers in order to reduce the heavy metal contamination. In recent years, due to water scarcity, industrial wastewater is used for irrigation purposes which lead to detrimental effect on plants growth and reduction in crops yield and quality. Therefore, it is necessary to study the effects of industrial wastewater on crop system before irrigation.

Many conventional methods like chemical precipitation, ion exchange, coagulation, reverse osmosis, adsorption, flocculation, nanofiltration etc., has been used for wastewater treatment, however certain limitations like expensiveness and sensitive to operate, toxic sludge generation, extra operational cost for sludge disposal etc., make these techniques unaffordable and unsustainable. Therefore, a cost effective, more cleaner and eco-friendly alternatives are required to sustainably remediate the industrial wastewater to minimize the health hazards. The efforts made in this area of wastewater treatment include the use of green technologies like bioremediation and phytoremediation. Most of the research work carried in this field has been conducted using hydroponic cultures with plant and most of which are invasive in character. For a successful phytoremediation technique it is recommended that the selected plants should be perennial in nature, have high biomass production, tolerance and survival rate under different biotic and abiotic stress conditions.

Present work was undertaken to evaluate the wastewater quality from petrochemical, chemical, battery manufacturing industries and thermal power plant, situated at, Auriaya Kanpur, Lucknow and Kanpur respectively. The present study were also demonstrated the potential of aquatic macrophytes *viz.* *E. crassipes*, *P. stratiotes* and *L. gibba* for remediation of industrial wastewater contaminated with heavy metals. Comparative studies of selected macrophytes for their remediation potential for different industrial effluent concentration were also examined. Phytotoxicity caused by industrial effluents was also assessed in terms of seed germination. The selected seeds used for phytotoxicity assessment were seeds of Rice (Basmati- 198, Pusa sugandh and sambhamsoori), pulse (Chick pea, Moong N-1, and Massor VL-1) and Oil seeds (Mustard BR-40, Alsi KL-43 and Sesame G. til-3) varieties. The following studies were combined from these analyses.

Analyse the physicochemical characteristics including heavy metals of different industrial wastewater

Physico-chemical characteristics of industrial wastewater showed presence of high level of heavy metals *viz.* Fe, Zn, Mn, Pb, Cu, Cr, Cd, Ni and Hg and other organic and inorganic pollutants like chloride, oil and grease etc. which can cause major public health concern. The objective of the study was to evaluate the status of pollution created by industrial effluent. pH of the effluents was slightly alkaline nature and EC was slightly higher than prescribed level of CPCB. Total Suspended Solid (TSS) composed of silt, decaying matter and suspended waste was three times higher than prescribed limit of CPCB in three industries i.e. petrochemical, chemical and battery manufacturing industry effluent. However, in case of thermal power plant effluent TSS was found to be slightly lower than other industrial effluent but higher than the prescribed limits of CPCB. Chloride concentration was found to be higher in battery and chemical manufacturing industries due to application of chlorine compound. Dissolve oxygen (DO) of effluent were low because of high microbial activities resulting high

level of biological oxygen demand (BOD). Oil and grease are important class of pollutant which is also toxic to aquatic plant and animals and carcinogenic to human beings. Effluent generated from petrochemical and chemical industries show high level of oil and grease. Nitrate and phosphate concentration were found under prescribed limits. Concentration of heavy metals *viz.* Hg, Mn, Pb, Cd in battery manufacturing Fe, Zn, Ni, Cr in petrochemical and Cu in chemical industry were found to be higher. Further, the thermal power plant effluent was found to be least polluted as compare to others effluent. The overall results showed that the presence of high level of heavy metals contamination and on prolong use of these effluent for irrigation purpose may leads irreparable ecological harm which could not be masked by short term economic prosperity. Therefore, the effluent generated from all selected industries should be treated prior to apply in agricultural field.

Evaluation of phytotoxicity of different industrial wastewater through seed germination test on different varieties of crop seeds

Presence of inorganic and organic contaminants has potential to reduce growth of microorganism, seed germination and can cause other environmental problems. Phytotoxic effects of different industrial wastewater were examined in terms of germination rate of rice, pulse and oil seeds. Seed germination rate is considered as an important parameter for evaluation of toxicity caused by wastewater. Seeds showed different sensitivities to toxic nature of effluents. Maximum seed germination was observed in control seed which are moisten by tap water. In the case of treatment of 50% effluent concentration a high percentage of seed germination was observed in compare to treatment of 100% effluent concentration. Result also indicated that the rice was more the susceptible crop while oilseeds were more tolerant crops towards toxicity caused by effluents. Salt (high TDS and TSS) concentration also reduced the seed germination rate. Rice, pulses and oil seeds varieties show maximum germination in petrochemical effluent except Moong and Alsi. Further, Moong and Alsi showed high

percentage of seed germination in thermal power plant effluent. In case of battery manufacturing industry effluent all seeds showed lowest seed germination percentage. The results also indicated that 50% dilution of effluent was appropriate for irrigation of crops. On increasing the effluent concentration resulted decrease in seed germination rate, tolerance index, seedling vigor index. The obtained results also help in screening of seeds which was able to tolerate the toxic effects of various industrial effluents. Among all selected industries, effluent of petrochemical industry was found to be more toxic to chick pea and Sambha masuri while chemical industry effluent was more toxic for Pusa Sugandh and Sambha masuri. Similarly, thermal power plant effluent was found to be more toxic for Alsi while battery manufacturing industry showed its high toxicity potential to Basmati, Pusa sugandh, moong and Chick pea.

To study the partitioning of metals within different aquatic weeds exposed to different industrial wastewater.

Accumulation of Fe, Zn, Mn, Pb, Cu, Cr, Cd, Ni and Hg were investigated in three aquatic macrophytes *E. crassipes*, *L. gibba* and *P. stratiotes*. On the basis of obtained results, all the selected aquatic macrophytes can be considered good accumulators for all the tested heavy metals. Accumulations of metals were found to be higher in roots than shoots. Although, variations in level of heavy metal accumulation among selected macrophytes were observed. Metal concentration in tissue increased gradually with increase in the metal concentration in growing medium along with duration of treatment. Zinc (Zn) was the most accumulated metal among all metals because Zn is essential for plants requires for carbon dioxide utilization, carbohydrate and phosphorus metabolism and synthesis of RNA and auxin. Mercury (Hg) was least accumulated metal which was found to be highly toxic for plants. Study also concluded that *E. crassipes* was most effective in accumulating Fe, Mn, Zn and Pb while *L. gibba* was effective in accumulating Cr and Hg only. Similarly, *P. stratiotes* was found to be effective for

accumulation of Cu, Cd and Ni. Further, *E. crassipes* can be considered as a most suitable species for phytoremediation due to their higher biomass, well developed fibrous root system and ability to absorb high amount of heavy metals from contaminated growing medium.

Comparative study on the phytoremediation potential of various aquatic weeds to remediate heavy metals from different industrial wastewater

The results shown that application of *E. crassipes*, *P. stratiotes* and *L. gibba* for treatment of wastewater can be considered as an effective method. Due to their high accumulation potential, these macrophytes can be suitable candidates for the remediation of industrial wastewater contaminated with heavy metals viz. Zn, Mn, Cd, Cu, Cr, Fe, Ni, Pb and Hg. The sequence of heavy metal removal by *E. crassipes* was found as follows: Mn>Fe>Pb>Hg>Zn>Ni>Cd>Cr>Cu. The sequence of heavy metal removal by *P. stratiotes* was Pb>Ni>Mn>Fe>Cd>Hg>Cr>Zn>Cu while in case of *L. gibba* trend of metal removal efficiency was Cd>Cu>Pb>Fe>Zn>Cr>Ni>Mn>Hg in all industrial effluent. Result also revealed that the *E. crassipes* was highly efficient for removal of Fe, Mn, Zn, Cr, Pb; *P. stratiotes* for Cu, Cd, Ni, Pb and *L. gibba* for Hg. Enrichment coefficient factors were calculated for the roots and shoots separately. The results revealed that the accumulation of metals in roots was higher than the shoots. Among the examined metals, the highest accumulation was exhibited for Cd in battery effluent treatment with *E. crassipes*. Translocation factor demonstrated that heavy metals were highly accumulated in roots of all the macrophytes indicated the less mobilization of metal from roots to shoots.

Identification and application of suitable aquatic macrophytes for the removal of heavy metals from different industrial wastewater

In the present study, all the macrophytes were found suitable for removal of heavy metal from different industrial wastewater. Applicability of macrophytes for wastewater treatment

may be different for different industrial wastewater. It was also found that the *E. crassipes* were suitable for chemical industry and thermal power plant effluent while *P. stratiotes* for petrochemical industry and *L. gibba* for battery manufacturing industry. Furthermore, accumulation of metals were much higher in roots than shoots indicating that these aquatic macrophytes may be a better option for the phytoremediation of heavy metals from industrial wastewater.