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Study Of Microbial Impact On Lead Remediation In Industrial Wastewater

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Abstract

Heavy metal burdens in wastewater have increased as a result of industrial and development activities, and their inadequate treatment before disposal poses serious environmental problems. Lead (Pb) is a highly toxic heavy metal that is commonly utilized in a variety of sectors, including paint, batteries, electroplating, tanneries, paper and pulp mills, textile mills, smelting, and mining. As a result, excessive amounts of lead are produced when disposing of effluent from these industries. Lead's potential for bioavailability poses a health risk to youngsters and results in mental retardation. This heavy metal must be removed from industrial effluents before they are released into the environment and natural land or water. Pb treatment in industrial wastewater is being done using a variety of conventional procedures. These techniques' primary limitations are their limited effectiveness and lack of technical proficiency. The widespread acceptance and low cost of microbial Pb treatment of industrial waste water has recently established as a feasible alternative. It is advised to use biotechnological methods to recover metals from the effluents (which are heavy metal-rich) that are dumped into ponds. Heavy metals will be removed by the microorganisms, who will then enclose them inside of their cell membranes. Hazardous metals can be degraded or converted into simple, harmless compounds through the process of bioremediation. In the present study, the role of Pb microbial remediation in industrial wastewater is comprehensively analyzed.

Keywords: lead, toxic Heavy metals, health risk, industrial waste water, microbial remediation.

INTRODUCTION:

On a worldwide scale, vast volumes of wastewater are being created as a result of the expansion of industry and the global urbanization trend. The industrial sector utilizes an average of 22% of the water used globally. A whopping 80% of all generated wastewater is discharged into rivers, harming aquatic life and degrading the environment. According to The Trade Council, Embassy of Denmark, India, 2015, India creates around 44 million m3/day of industrial effluent, of which approximately 6.2 billion liters are thrown into the nation's natural aquatic bodies without being treated (Dutta et al. 2021). Several industries can be considered to be the major sources of metals in wastewater, including chemical, distillery, sugar, food and dairy, paper and pulp, textile bleaching and dyeing, mining and quarries, battery manufacturing, nuclear power, organic chemical, leather/tannery, iron and steel, soap and detergent, electric power plant, metal refining, pesticide and biocide, petroleum and petrochemical, pharmaceutical, metal processing, and electroplating industries. Copper (Cu), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Mercury (Hg), Iron (Fe), Lead (Pb), Nickel (Ni), and Arsenic (As) are among the metals in the list (Awuchi et al. 2020). Due to insufficient wastewater treatment facilities, including electrical failure, poor maintenance, and a lack of competent and experienced labor, untreated wastewater effluents are routinely dumped into water bodies, harming typical aquatic life. These contaminated water sources, particularly groundwater, can endanger human health and contaminate the ecosystem (Bora and Dutta 2019). Thus, when more industries utilize resources like water more often, there is an increase in the amount of wastewater released into the environment, which contains a range of dangerous heavy metals. On a worldwide level, industrial wastewater management has become a significant problem. The treatment of wastewater using various techniques has been the subject of several research and investigations too far (Lee et al. 2019) (Alalwan et al. 2020) (Babincev et al. 2020) (Mustafa et al. 2020). All of these procedures still have substantial problems, though, such as low efficiency, the requirement for huge amounts of solvents and reagents, and the generation of secondary pollutants including waste residues, sludge, waste water, toxic chemicals, etc. (Gebretsadik et al. 2020). As a result, effective wastewater treatment at low cost and with little negative influence on the environment has become significantly necessary everywhere in the world (Dutta et al. 2021). Traditional approaches, like physical, chemical, and thermal treatments, have a number of significant drawbacks, including the creation of toxic intermediates, the transportation of contaminated soil or water for treatment, the expensive nature of treatment, and the inadequate restoration of natural habitats and fauna. Utilizing bioremediation techniques that call for organisms like microbes (bacteria, fungi, and Actinomycetes, etc.) or their byproducts can reduce and neutralize contaminants from industrial wastewater via regular biological processes, either by aerobic or anaerobic processes (Arora 2018) (Saxena et al. 2016).

MATERIALS AND METHODS:

By searching PubMed, PubMed Central, Google, and published research papers and review articles from around the world on the environmental pollutants produced by the leather industries and the microbial bioremediation strategy to remove the pollutants for a cleaner world, the relevant information for this review paper was found. We only took into account published data, and we removed speculative claims about exposure. These inclusion criteria include the use of data obtained from reliable publications on the subject. Other languages besides English were not included by the study.

RESULTS AND DISCUSSION:

Lead releasing industries via waste water: Approximately every nation in the world has Pb, and approximately 800 locations have been shown to have significant levels of Pb exposure. According to WHO 2018 elevated Pb pollution has put around 26 million individuals at danger and caused 540,000 deaths annually, with poorer nations bearing the brunt of this load (Rahman et al. 2019). The major sources of heavy metals especially lead in the wastewater can be attributed to the chemical, distillery, food and dairy, sugar, Pulp and paper, Petroleum industries, Soap, Detergents and leather/tannery industries during various industrial processes and operations (Dutta et al. 2021).

Industries	**Heavy metals**
Chemical industry	Cd, Cu, Cr, **Pb**, Zn, Hg, As, Fe, Ni
Distillery	Cd, Cr, Cu, **Pb**, Zn
Food and Dairy	Cd, Fe, Cu, **Pb**, Zn
Sugar industry	As, Cd, Cu, Cr, **Pb**, Hg
Pulp and paper	Cd, Cu, Cr, **Pb**, Zn
Tannery/leather industry	Cd, Cu, Cr, **Pb**, Zn, As
Petroleum industries	Cd, Cr, Cu, **Pb,** Zn
Soap and Detergents	Na, K, Ca, Mg, Cd, Cu, Cr, Fe, Zn, **Pb**, Mn, Cl

Table. 1. Showing heavy metal especially lead (Pb) releasing industries via waste water (Dutta et al. 2021)

Environmental and health Impacts of lead release via industrial waste water: The second-most harmful heavy metal found on earth as a contaminant is lead (Pb) (Pratush et al. 2018). All morphological, physiological, and biochemical systems are severely impacted if the quantity of Pb surpasses that critical limit (Kushwaha et al. 2018). Pb toxicity at various trophic levels in the food chain is now estimated using various quantitative indicators. Pb may collect in the soil or move to aerial plant parts (APP) after it enters the soil from any source and enters the root system of the plant (Kumar et al. 2020). Its pollution of soil has a number of detrimental effects on plants, including impairment of nutrient absorption, changes in plant water relations, and the production of ROS, among others, which inhibit photosynthesis and cause cell death, resulting in a significant decrease in crop output (Zulfiqar et al. 2019). According to some reports, Pb interferes with germination-related enzymes including amylase and protease and has negative effects on radical and hypocotyl development. Furthermore, lower mobilization of food that has been stored results in decreased radical production, degradation of proteolytic activities, and disruption of cellular osmoregulation, all of which impede germination and seedling growth when Pb is present. Pb pollution has negative effects on both the morphology and physiology of seeds and hinders early crop development and germination. Most commonly, ingestion and inhalation are the two ways that lead may enter the human body. Regardless of the method it is exposed, Pb is hazardous to practically all organs. Comparatively speaking, acute disorders for Pb poisoning are far less frequent than chronic illnesses. Children suffer the same impact at lower levels of exposure to Pb, despite the harmful consequences of the substance being the same for both adults and children (Rahman et al. 2019) (Gidlow 2015) (Kumar et al. 2020). Peripheral and central neural systems are also susceptible to Pb manifestations (Flora et al. 2012). Hemolytic anemia, hypertension, and cardiovascular disease are all results of Pb exposure, whether it be acute or chronic (Gidlow 2015). Acute Pb exposure in the renal system causes Fanconi syndrome, whereas chronic Pb exposure causes nephropathy. Long-term Pb poisoning affects the reproductive system in both men and women, impairing libido, causing aberrant spermatogenesis and infertility in males, and miscarriage and early birth in women (Rahman et al. 2019) (Flora et al. 2011).

Heavy metal	Toxicity	Health impacts
Lead (Pb)	Acute	Hemolytic anemia, hypertension, cardiovascular disease, Fanconi's syndrome
	Chronic	Encephalopathy, hemolytic anemia, hypertension, and cardiovascular disease

Table. 2. Effects of lead on individuals and its worldwide influence (Rahman et al. 2019) (Gidlow 2015)

Green approach for lead extenuation: The frequency of environmental degradation, the anticipated number of contaminated places, and its ongoing discovery have led to intensified global efforts to clean up many of these settings in recent years. This is either done to lessen the possibility of negative health effects or environmental effects caused by pollution or to prepare the region for rebuilding or restoration for usage (Luka et al. 2018) (Arora 2018). Due to its financial feasibility and environmental friendliness, bioremediation is a green approach with the potential to address environmental degradation. The technique of bioremediation involves using biological processes to remove or reduce pollutants from the air, soil, and water. The method uses an organism that was either brought in from another system or acquired from the relevant environment in order to lessen or eliminate the hazardous component. (Sher et al. 2019) (Luka et al. 2018) (Arora 2018) (Ashraf et al. 2018) (Saravanan 2022). Microorganisms that assault contaminants with enzymes to convert them into harmless compounds are essential to the bulk of the bioremediation process. Applying bioremediation frequently necessitates altering environmental conditions to accelerate microbial growth and breakdown since bioremediation can only take place in situations that support microbial growth and activity (Karigar et al. 2011). It is essential that isolated microorganisms can be produced under almost any environmental condition. Extreme cold, great heat, the desert, water, too much oxygen, anaerobic conditions, the presence of toxic substances, and on any waste stream are just a few of the environmental variables that microbes will adapt to and proliferate in. The two necessary components are an energy source and a carbon supply (Luka et al. 2018). This method relies on the environment and inputs like nutrients, oxygen, and other modifications to encourage microbial activity for Pb cleanup (Gong et al. 2018). Various microbial strains use immobilization methods to carry out lead bioremediation. The bacteria evolved a number of defense mechanisms that enable or aid them in withstanding the poisonous effects of lead (Pratush et al. 2018).

Remediation of lead using bacterial species: By employing indigenous/exotic bacteria, microbial remediation refers to reducing the amount of Pb in the environment. *Alcaligenes sp., Bacillus firmus, Bacillus licheniformis, Enterobacter cloacae, Escherichia coli, Micrococcus luteus, Pseudomonas fluorescens, Aspergillus niger, Aspergillus terrus, Aspergillus versicolor, Neurospora crassa, Penicillium canescens, Penicillium chrysogenum, Penicillium decumbens, Penicillium simplicissimum, and Saccharomyces cerevisiae* and

Salmonella typhi are examples of biotransforming bacterial species that have the ability to bind lead from polluted sources (Kumar et al. 2020) (Pratush et al. 2018). The *Bacillus subtilis* mutant strain B38 has the enormous potential to remove heavy metals, especially lead, from China (Wang et al. 2014). Through bioleaching, Aspergillus niger strain SY1 successfully removed Pb (99.5%) from polluted sediment (Zeng et al. 2015). Major Pb biotransforming organisms are

Heavy metal	Bacterial species
Lead (Pb)	*Alcaligenes sp.*
	Bacillus firmus
	Bacillus licheniformis
	Enterobacter cloacae
	Penicillium chrysogenum
	Penicillium decumbens
	Escherichia coli
	Penicillium simplicissimum
	Saccharomyces cerevisiae
	Micrococcus luteus
	Penicillium canescens
	Neurospora crassa
	Pseudomonas fluorescens
	Salmonella typhi
	Aspergillus niger
	Aspergillus terrus
	Aspergillus versicolor
	Bacillus subtilis strain B38
	Aspergillus niger strain SY1
	Pseudomonas aeruginosa ASU6a
	Synecochoccus sp.
	Klebsiella michiganensis R19
	Providencia rettgeri L2
	Raoultella planticola R3
	Serratia sp. L30

Table. 3. Bacterial species that has the capability to remediate lead (Pb) (Kumar et al. 2020).

Pseudomonas aeruginosa ASU6a, *Synecochoccus sp., E. coli* can remediate Pb by biosorption process where Pb2+ is bound to molecules with carbonyl, phosphate, hydroxyl, and amino groups in the cell wall of *Pseudomonas aeruginosa* ASU6a and with amide, amino, hydroxyl, or carboxyl groups in the cell wall of *Synecochoccus sp.* Nearly 97% of the Pb2+ in E. coli is bound in the cell membrane. *Klebsiella michiganensis* R19*, Providencia rettgeri* L2*, Raoultella planticola* R3*, and Serratia sp.* L30 are known to absorb lead in mono- and mixed metal solutions by the biosorption method of metals by secreting extracellular polymeric substances (EPS) (Arashiro et al. 2018).

Remediation of lead using fungal species: Potential bio-sorbents include the fungal biomass of Lepiotahystrix, Aspergillus niger, Aspergillus terreus, and Trichoderma longibrachiatum (Kumar et al. 2020).

CONCLUSION:

A detailed analysis shows that several sectors' massive releases of lead through waste water have a major impact on the ecosystem as a whole. Industries' detrimental effects have highlighted the necessity for green technology. The physio-chemical therapy techniques involve a lot of chemicals yet are environmentally friendly. To safely breakdown and eliminate the solid wastes and wastewater produced by the industries that include heavy metals, bioremediation technologies may be a useful solution. These technologies are affordable, ecologically benign, and offer a promising technique to enhance environmental quality. This research presents a number of microorganisms that have been demonstrated to be able to eliminate or remediate harmful concerns present in waste materials generated by industry. Despite the abundance of microorganisms and great eco-friendly and cost-effective methods, industrial wastes and wastewater continue to often cause environmental pollution and toxicity issues. On that note, this study acts as a social massage to increase the population's goodwill. must take proper action, manage heavy metals, particularly lead, in an environmentally friendly way, lessen the use of hazardous chemicals, and draw the government's and other companies' attention to this serious issue.

FUTURE SCOPE:

Finding more potent microbes for the decontamination and degradation of lead, which affects soil ecology, marine ecology, and human health, is crucial before its final disposal into the environment. Building effective bioremediation solutions requires a thorough understanding of their genetic makeup and biochemistry. In the long term, natural ecosystems on land and in the sea will have a higher chance of survival. Waste-treatment techniques that are more affordable and ecologically beneficial must be used by every sector that releases lead through wastewater.

Conflict of Interest: There is no conflict of interest related to the study.

Author contributions: Acquisition and interpretation of data is done by Rupesh Dutta Banik. Conception, design and revising of the article are done by Dr. Pritha Pal.

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