IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

Phytoremediation of Soil and Water by Plants

Ragini Kapte[1], Rajshree Kamble[2], Achal Sawsakade[3], Pooja Choudhari[4], Pallavi Dashekar[5], Prof. Sandeep Ajmire[6]
Final Year students, Department of Civil engineering[1-5]
Project Guide, Departmentof Civil Engineering[6]
Rajiv Gandhi College of Engineering, Research & Technology, Chandrapur, Maharashtra, India.
Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad, India.

Abstract: *Phytoremediation is an eco-friendly and cost-effective biotechnological process that utilizes plants to remove, degrade, or stabilize pollutants from contaminated soil and water environments. This green technology harnesses the natural abilities of certain plant species to absorb, accumulate, or detoxify a wide range of environmental contaminants, including heavy metals, pesticides, hydrocarbons, and excess nutrients. Key mechanisms of phytoremediation include phytoextraction, phytostabilization, phytodegradation, rhizofiltration, and phytovolatilization, each involving different plant processes and pollutant interactions. Fast-growing plants with extensive root systems, such as Brassica juncea, Populus spp., and Vetiveria zizanioides, have demonstrated notable efficiency in remediation efforts. Phytoremediation not only restores ecological balance but also enhances soil fertility, promotes biodiversity, and integrates well with sustainable land management practices. Despite its advantages, the process can be limited by the type and concentration of pollutants, plant tolerance levels, and environmental conditions. Continued research and advancements in genetic engineering and microbial associations are expected to improve the effectiveness and applicability of phytoremediation in addressing global pollution challenges.*

Keywords: Phytoremediation, soil contamination, water pollution, heavy metals, phytoextraction, rhizofiltration, phytostabilization, environmental cleanup, sustainable remediation, pollutant degradation

I. INTRODUCTION

Environmental pollution caused by industrialization, agricultural activities, and urban development has led to the widespread contamination of soil and water resources with hazardous substances such as heavy metals, pesticides, hydrocarbons, and excess nutrients. Traditional remediation methods, while effective, are often expensive, energy-intensive, and disruptive to ecosystems. In recent years, **phytoremediation** has emerged as a promising, cost-effective, and environmentally sustainable alternative for mitigating soil and water pollution.

Phytoremediation is a biological process that utilizes the natural abilities of green plants to absorb, accumulate, degrade, or immobilize contaminants from the environment. This green technology leverages various plant-based mechanisms, including **phytoextraction, phytostabilization, phytodegradation, phytovolatilization,** and **rhizofiltration,** to remove or neutralize pollutants from the contaminated sites. Certain plant species, such as *Brassica juncea* (Indian mustard), *Populus* spp. (poplars), and *Vetiveria zizanioides* (vetiver grass), have shown remarkable potential in phytoremediation due to their fast growth, high biomass production, and tolerance to pollutants.

II. REVIEW OF LITERATURE

Sr. No	Project Title	Methodology	Conclusion
1.	Phytoremediation of samples extracted from wastewater plants and treatment of their socioeconomic impact 2020 Hayfa Rajhi, Anouar Bardi.	The physio-chemical and bacteriological quality was evaluated in wastewater samples before and after	Decrease in the quantity of mineral salts and phosphorus in the treated wastewater. These elements were assimilated by

		treatment by microalgae enrichment.	microalgae during their growth. In addition, the heavy metal contents were completely eliminated after the enrichment of the microalgae culture. Very significant fall in coliforms, faecal streptococci and Pseudomonas.
2.	Verm filtration as a natural, sustainable and green technology for environmental remediation: A new paradigm for wastewater treatment process 2021 Sudipta Arora, Sakshi Saraswati	Verm filtration is an extension of soil filtration or a biofilter with earthworms to speed up the decomposition of processes, to utilize organics to produce fresh manure which can be utilized in agriculture to support healthy plant production.	Earthworms change the properties of biofilm present in the active layer by their burrowing activity and ingestion. They also help in the degradation of organic matter by symbiotic and synergistic reactions into reactions with the indigenous microbes. It has been successfully applied for the treatment of municipal and industrial sewage.
3.	Phytoremediation Potential of Macrophytes of Urban Wate	A field sampling-based study was conducted to analyse water quality, heavy metals and	The present study examined naturally growing vegetation in a domestic wastewater.
4.	Performance Evaluation of Three Different Grasses for Use as Willows in Greywater Treatment in Semi-arid Ghana ADONADAGA TAKRAMAH - 2020-M-G,	The grasses were watered daily with 1.5L of greywater collected from a hall of residence on the university campus	The results indicated that only the effluent from lemon grass met the WHO guideline value of 50 mg/l for wastewater. Removal efficiency for TDS was between 70% and 84% while that for the nutrients ranged between 8% and 81%. Overall, lemon grass had the highest removal efficiency followed by elephant grass and then giant blue stem.
5.	Sustainable wastewater treatment via phytoremediation: Current status, challenges, and future perspectives - 2020: Hao Huu, Xiang Li	Comparing traditional and latest advances in the development of phytoremediation methods by characteristics of several types of wastewater and hazards.	Phytoremediation of wastewater is a remarkable and sustainable management approach.
6.	Recent studies of applications of aquatic weed in phytoremediation of wastewater: A review - 2020, article Hauwa N Mustafa, Gasim Hayder	Phytoremediation of wastewater using aquatic plants is reviewed. Employs the application of	Phytoremediation is a promising technique to remove excess nutrients from polluted sites. The application of

		aquatic weed for the treatment of polluted wastewater.	aquatic weed for the remediation of wastewater is beneficial because the aquatic plants have the capacity to absorb and degrade pollutants such as phosphate, heavy metals and inorganic, heavy metals, and pharmaceutical pollutants present in domestic, agricultural, and industrial wastewater.

III. METHODOLOGY

3.1 Selection of Plant Species :

Plant Selection Ceriteria : Pteris vittata, Grasses, Mexican petunia, Indian mustard, Curry plant, Water spinach, Water Lettuce.

Pteris vittata

Grasses

Mexican Petunia

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

Indian mustard

Curry plant

WATER SPINACH

WATER LETTUCE

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

3.2 Design of experimental setup for Water :-

Design: Tank with the following dimensions are used:

Length:2ft 7in, **Breadth:** 1ft 1in, **Height:** 1ft 4.5in

Fig 3.2 Phytoremediation of water setup

3.3 Working of Remediation Unit:

To improve the original remediation process, incorporating an initial screening step for coarse solids and updating the sedimentation tank setup, along with a more comprehensive filtration system, is an excellent adjustment . Here is an updated version of the process:

1. Phytoremediation Process: In the water tank plants such as water lettuce and water spinach are planted. This plant play a role in the phytoremediation process, absorbing nutrients, breaking down contaminants, and providing additional filtration through their roots and leaves system.

2. **Supervivsion and Rotation:** The phytoremediation process involves a cycle of supervision and plant growth. In this setup, plants are monitored for 30 days. This cycle ensures optimal plant growth and nutrient absorption, and it allows for efficient maintenance of the system

Design of experimental setup for Soil :-

Collected 3 soil sample from different location.

Weigth of planter :- **69** g ,

Weight of soil :- **801** g

Weight of soil with planter :- **870** g.

DOI: 10.48175/IJARSCT-28473

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

After the equal measurement of each planter the petris vitata, grasses and Mexican petunia were planted.
Those planter were kept for 1 month under the observation.

3.4 Standard method for the examination of Soil and waste water:

Published by the American Public Health Association (APHA), is a comprehensive guide for testing and analyzing various water quality parameters. Here's a simplified explanation of the process for each of the test methods mentioned, focusing on their typical procedures and key steps:

1. Calcium and Magnesium:

Complexometric Titration with EDTA: This process involves adding EDTA to the water sample, which is complex with calcium and magnesium ions. An indicator like Eriochrome Black T is used to detect the endpoint, where a color change occurs, indicating that all calcium and magnesium have reacted. The titration results determine the concentration of these ions, used to calculate water hardness.

2. Chloride:

Argentometric Titration: In this method, silver nitrate ($AgNO_3$) is used to titrate chloride ions in the water sample. Potassium chromate serves as the indicator. When all chloride is precipitated, the endpoint is indicated by a color change from yellow to reddish-brown, indicating the amount of chloride in the sample.

3. Colour:

Platinum-Cobalt Scale: Colour in water can be assessed visually or with a spectrophotometer. The intensity of color is compared against the Pt-Co scale, which measures color units based on a platinum-cobalt solution standard.

4. Electrical Conductivity:

Conductivity Meter: This device measures the electrical conductivity of the water, which indicates the concentration of dissolved ions or salts. The higher the conductivity, the more dissolved salts are present in the sample.

5. Fluoride:

Ion-Selective Electrode or Colorimetric Method: The ion-selective electrode allows for direct measurement of fluoride ions in the water. The colorimetric method uses a reagent that forms a colored complex with fluoride, and the intensity of the color indicates the fluoride concentration.

6. Nitrate:

Cadmium Reduction Method: This method involves reducing nitrate to nitrite using cadmium. The nitrite then reacts with specific colorimetric reagents, resulting in a colored compound. The intensity of the color correlates with the nitrate concentration.

7. pH:

pH Meter or Indicator Strips: A pH meter measures the hydrogen ion concentration in the water, indicating its acidity or alkalinity. pH indicator strips provide a less precise, color-based estimate of pH.

8. Total Dissolved Solids (TDS):

Evaporation and Gravimetric Analysis: This method involves evaporating a known volume of water and weighing the residue left after evaporation. The mass of the residue is used to determine the TDS level.

9. Total Alkalinity:

Acid Titration: Alkalinity is measured by titrating the sample with an acid (like sulfuric or hydrochloric acid) until a specific endpoint is reached. The endpoint is detected with a pH meter or an indicator like phenolphthalein, indicating the sample's alkalinity.

10. Total Hardness:

Titration with EDTA: This method combines the calcium and magnesium hardness determination. It involves complexing these ions with EDTA and detecting the endpoint with an appropriate indicator, similar to the process for calcium and magnesium hardness.

11. Turbidity:

Turbidimeter: This instrument measures the scattering of light by suspended particles in the water. Turbidity is quantified in Nephelometric Turbidity Units (NTU). Higher turbidity indicates more suspended particles.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

12. Iron:

Colorimetric Method: Iron concentration is determined by adding reagents that form a colored complex with iron ions. The intensity of the color indicates the iron concentration in the water.

13. Sulphate:

Turbidimetric or Gravimetric Method: The Turbidimetric method involves adding a reagent to form a turbid solution, measuring turbidity, and correlating it with sulfate concentration. The Gravimetric method involves precipitating sulfate, filtering, and weighing the residue to calculate sulfate content.

Observation :

Phytoremediation using Pteris Vittata(Chinese Braker Fern) :

Root Uptake:The roots of P. vittata absorb arsenic from the soil (primarily arsenate, As[V]).

Inside the plant, arsenate is often reduced to arsenite (As[III]), a more mobile form.

Translocation: Arsenic is transported from roots to the fronds through the xylem.

Accumulation: Arsenic accumulates in the fronds, where it is stored in vacuoles, minimizing toxicity.

Harvesting: The fronds are periodically harvested and safely disposed of or incinerated, removing arsenic from the contaminated site.

Petris vittata Observation :

SR.NO	CONSTITUENT / PROPERTIES	INSPECTION (BEFORE)	INSPECTION (AFTER)	IDEAL VALUES
1.	PH	6.7	6.6	6.0 – 7.5
2	Alkalinity etc. C.S. ml/cm (EC)	0.632	0.629	0.5 - 2.4ml/cm
3.	Organic carbon percentage (OC)	0.37%	0.40%	0.5% - 3.0%
4.	Availibility phosphorus kg/ha. (P2O5)	18.0 kg/ha	18.2kg/ha	11 – 22 kg/ha
5.	Available potassium (K2O)	265 kg/ha	262kg/ha	100 – 280 kg/ha

Fig:- Petris vittata

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

Possible Reason For Poor Plant Growth

*Soil Conditions:*Extremely acidic or alkaline soil (ideal pH: 6.5–8).Low organic matter or poor nutrient availability.Soil compaction preventing proper root development.

*High Contaminant Load:*Excessively high arsenic or other heavy metal concentrations can be toxic.Presence of other toxic elements like lead, cadmium, or chromium.

*Water Stress:*Overwatering may lead to root rot or oxygen deficiency.Drought or low water availability stunts growth.

*Climate and Light:*Pteris vittata prefers warm and humid environments with partial sunlight.Poor light or extreme cold reduces photosynthesis and slows growth.

*Competition and Pests:*Weeds competing for nutrients.Attack by pests or fungal diseases in roots and leaves.

Water Spinach (Ipomoea aquatica)

*Mechanism of Action:*Capable of rhizofiltration and phytoaccumulation.

Absorbs mercury (Hg), lead (Pb), arsenic (As), cadmium (Cd), and chromium (Cr).Also effective for removal of nitrates and phosphates in wastewater.

*Possible Reasons for Poor Growth:*Sensitive to salinity and stagnant or polluted water.Needs sunlight and warm temperatures to grow well.

Prone to leaf rot or yellowing under nutrient-deficient conditions.

Fig: Water Spinach

Recommendations for Improvement:

- Grow in controlled wetland tanks or canals with steady water flow.
- Apply low-dose organic fertilizer to boost biomass.
- Ensure adequate light exposure and prevent algal growth.
- Harvest periodically to maintain uptake efficiency.

Merits of Using Water Spinachin Phytoremediation:

- Fast-growing aquatic vine, producing large biomass.
- Excellent for wastewater treatment systems.
- High uptake rate for multiple pollutants.

Demerits of Using Water Spinach in Phytoremediation:

- Invasive in slow-moving waterways.
- Must be kept away from food chains if grown in polluted water.
- Regular harvesting needed to avoid decay and release of contaminants.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, July 2025
Impact Factor: 7.67

Observation:

Fastest-growing among the plants studied. Water remained clearer with visible decline in phosphate levels. Some root blackening noted in stagnant zones.

Phytoremediation Of Water By Plants

Sr. No	Test Parameter	Unit	Test Method	Test Results (Before)	Desirable Limit	Permissible Limit	Test results (After)
1.	Calcium	mg/L	APHA 24RD EDN, METHOD 3500C-B	57.6	75	200	58.0
2.	Chloride	mg/L	APHA 24RD EDN, METHOD 4500Cl-B	120	250	1000	123
3.	Colour	Hazen	APHA 24RD EDN, METHOD 2120C	Clear	5	15	-
4.	Fluoride	mg/L	APHA 24RD EDN, METHOD 4500F-B	0.82	1.0	1.5	0.85
5.	Magnesium	mg/L	APHA 24RD EDN, METHOD 4500	80.28	30	100	80.0
6.	Nitrate	mg/L	APHA 24RD EDN, METHOD 4500 No.1-B	45	45	100	45
7.	Odour	-	IS 3025 (PART 5)	Not specific	Agreeable	_	_
8.	pH	-	APHA 24RD EDN, METHOD 4500	7.2	6.5-8.5	No relaxation	7.0
9.	Taste	-	IS 3025 (PART 7)	Agreeable	Agreeable	_	Agreeable
10.	TDS	mg/L	APHA 24RD EDN, METHOD 2540C	550	500	2000	525
11.	Alkalinity	mg/L	APHA 24RD EDN, METHOD 2130B	300	200	600	250
12.	Total Hardness	mg/L	APHA 24RD EDN, METHOD 2340C	384	200	600	320
13.	Turbidity	NTU	APHA 24RD EDN, METHOD 2320B	1.3	1	5	1.1
14.	Electrical Conductivity	µS/cm	APHA 24RD EDN, METHOD 2510B	874	_	_	874
15.	Sulphate	mg/L	APHA 24RD EDN, METHOD 4500 SO4B	14	200	400	20
16.	Iron		APHA 24RD EDN, METHOD 3500 Fe B	0.01	0.03	1.00	0.1

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, July 2025 Impact Factor: 7.67

IV. CONCLUSION

This project evaluated the effectiveness of various plants, including Pteris vittata, Indian mustard, Curry plant, Mexican petunia, Water spinach, and Water lettuce, in phytoremediation of greywater. The findings are summarized below:

4.1 Pteris Vittata: Pteris vittata demonstrated good potential in phytoremediation, especially for heavy metal uptake, over the 30-day observation period. The plant exhibited healthy frond development and good root establishment in the greywater environment. Results showed a measurable reduction in contaminants, especially metals, total dissolved solids (TDS), and turbidity in the treated samples. These findings validate the use of Pteris vittata in greywater treatment, particularly for areas with elevated metal contamination.

4.2 IndianMustard: Indian mustard showed moderate phytoremediation performance. While initial growth was satisfactory, the plant exhibited signs of stress due to salinity and nutrient imbalance in the greywater. Although some reduction in pollutants such as nitrates and TDS was observed, the overall water quality improvement was limited. To improve its phytoremediation capacity, future efforts should focus on optimizing nutrient supply, managing salinity, and ensuring proper aeration of the root zone.

4.3 Curry Plant: The curry plant struggled in the greywater setting, showing limited vegetative growth and poor adaptation. Its low biomass and shallow root system resulted in minimal contaminant uptake. Despite its known aromatic and medicinal properties, its phytoremediation ability was not significant in this study. The curry plant may be better suited as a secondary or complementary species in combination with more effective primary remediators.

4.4 Mexican Petunia: Mexican petunia adapted well to greywater conditions, displaying vibrant growth and consistent flowering. The plant showed efficient uptake of nutrients and a noticeable reduction in turbidity and TDS. Its dense root system contributed to effective filtration and absorption. These results suggest that Mexican petunia is a viable candidate for sustainable phytoremediation systems in ornamental or urban treatment setups.

4.5 Water Spinach: Water spinach exhibited rapid growth and robust vegetative propagation throughout the 30-day study. It significantly reduced suspended solids and improved overall clarity of greywater. The plant's tolerance to waterlogged conditions and high nutrient loads made it an effective choice for continuous-flow or standing greywater systems. Its edible nature also offers dual benefits in urban agriculture-integrated treatment systems.

4.6 Water Lettuce: Water lettuce performed well in floating greywater treatment setups, with its large root mass helping to trap suspended particles and absorb nutrients. A clear reduction in turbidity and organic content was observed. However, care must be taken to manage its growth rate to prevent overcrowding. Water lettuce holds promise in low-maintenance, passive treatment units where space allows for surface coverage.

REFERENCES

[1]. Treatment Of Grey Water Using Technique of Phytoremediation. Randhir Bute1, Ekta Waghmare2, Ajay Sarode IRJET e-ISSN: 2395-0056
[2]. WasteWater Treatment by Phyto-Remediation Technique. Aditya Vikram Chopra, Umang K Shah Andjs Sudarsanat SRM University, Chennai, Tamil Nadu, INDIA ISSN 0974-5904, Volume 09, No. 03, June 2016, P.P.393-3
[3]. Phytoremediation and phytostabilization potential of water hyacinth in a tropical wetland. Renuka, C., Prasad, M. N. V., Vithanage, M., & Seneviratne, M. 39(4), 847-859.
[4]. Phytoremediation of industrial mines wastewater using Water hyacinth. Priyanka Saha, Omkar Shinde, Supriya Sarkar 19:1, 87-96

ISSN: 2581-9429
Impact Factor: 7.67

[5]. Application of aquatic plant–microbial reactors in wastewater treatment. Tiwari, S., & Gupta, A. Journal of Environmental Management, 112, 230-245.
[6]. Effectiveness of typha latifolia for phytoremediation of cadmium in acid my drainage. Maharani Permata Putriand Setyo Sarwanto Moersidik Conf.Ser.1811 012025.
[7]. Low-cost treatment of sewage using root zone technology-2014. Vame Ashok L. and Wagh KK
[8]. Ecological and Economic Potential of Major Halophones and Salk Tolman Vegetation in India-2020. TV. Vineeth, Shrvan Kumar
[9]. Purslane Weed (Portulaca oleracea): A Prospective Plant Society of Narration, Omega3 Fatty Acid, and Antionidant Attributes-2013 Md. Kamal Uddin, Abdul Shuker Jursimi
[10]. Potential of Helanthus annuus for phytoremediation of multiple pollutants in the environment. A Review-2018 Priti Chauhan and Jyoti Mathur
[11]. Application of Wetland System for Treatment of Industrial Wam-2017 Prof SwanPatili, Suraj P. Ahira
[12]. Performance Evaluation of Three Differ Grasses Jos Use as Willows in Grzywater Treatment in Semi-arid Ghana -2020, Adenanaga, M.-, rakamah
[13]. Phytoremediation of urban wastewater by model wetlands with ornamental hydrophysis-2006 ZHANG Xiao-bin LII Peng
[14]. Phytoremediation. An ecological solution to organic chemical contamination-2002 Seidhur Susarla a Vicar F. Medina
[15]. Phytoremediation of lead from water wing squame plans-2012: Doya Singh, Archana Tiwari and Richa Gupta
[16]. Perspectives of phytoremediation using water hyacinth for removal of busy