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Use of Some Aquatic Plants as Bioindicator of Contamination with Hydrocarbons and Heavy Elements : A Review

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ABSTRACT

This study illustrates the importance of some aquatic plants as bioindicators of contamination with hydrocarbons and heavy elements. Aquatic plants have many applications in the treatment of contamination with hydrocarbons and heavy elements, due to much lower cost and higher efficiency. Aquatic plants have been proved in numerous studies to be sinks for heavy metals and hydrocarbons in aquatic ecosystems, and it is also used in the treatment process and to reduce or limit contamination (hydrocarbons and heavy metals).

Key words : Aquatic plants, hydrocarbons, heavy elements, bioindicator, contamination

INTRODUCTION

Contamination of the environment is currently one of the most pressing issues on the planet. Several technological tools are required to detect and treat pollutants. Living species, such as plants, animals, and/or microorganisms, are used as biological indicators to identify pollution in a specific ecosystem (Zaghloul *et al*., 2020). Contaminated water, along with a scarcity of water, has placed a significant strain on the ecology. As a result of climate change, food demand, fast urbanization, and uncontrolled usage of resources of nature, Water scarcity affects over 40% of the world's population (Connell, 2018; Ali *et al*., 2020).

Rapid urbanization, industrialization, agricultural operations, geothermal water discharge, and olive wastewater discharge, particularly in olive-growing regions, have all increased the contaminated water flows into the environment in recent decade's population (Goncalves *et al*., 2017; Connell, 2018; Ali *et al*., 2020). Wastewater with high levels of contaminants is extremely harmful to the aquatic ecology and human health (Ahmed *et al*., 2017; Ewane *et al*., 2021). The only remaining alternative for meeting the expanding demand for water in the agricultural and industrial sectors has been wastewater reclamation (Tee *et al*., 2016). Oils, pesticides, colors, cyanides, phenol, hazardous organics, suspended particles, phosphorus, and heavy metals (HMs) can all be found in untreated industrial and home wastewater (Pakdel and Peighambardoust, 2018). Among these harmful compounds, heavy metals can easily build in the environment. (An *et al*., 2015).

Heavy metals are difficult to remove from wastewater because they come in a variety of chemical forms. The majority of metals are not biodegradable, and they can easily transit through several trophic levels to accumulate in the biota (Zhu *et al*., 2016). Toxic pollutants must be removed as soon as possible to reduce the risk to the environment and human health. Heavy metals are removed using a variety of processes, including reverse osmosis (Al-Alawy and Salih, 2017), exchange of ions (Levchuk *et al*., 2018), precipitation of chemicals (Huang *et al*., 2017), solvent extraction, and adsorption (Burakov *et al*., 2018) include exorbitant running and maintenance expenses, and are frequently unfriendly to the environment (Huang *et al*., 2017; Burakov *et al*., 2018). As illustrated by the current study an environmentally favorable method for aquatic plants for contamination bioindicators with hydrocarbons, and heavy elements. In addition, this review article covers the prospective uses

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of aquatic plants as contamination bioindicators with hydrocarbons and heavy elements.

Use of Some Aquatic Plants as Contamination Bioindicators

Plant species that are abundant, such as lichens, planktons, and higher plants, usually contribute basic information about the health of an ecosystem. Plants are extremely sensitive tools for predicting and recognizing ecological stressors. Contamination of terrestrial and aquatic ecosystems has increased recently as a result of industrialization and urbanization (Zaghloul *et al.*, 2020). Because most plants are stationary and quickly strike a balance in their natural environment, they help to estimate the contaminated ecosystem status (Zaghloul *et al.*, 2020). Aquatic plants are the water's primary source of food and oxygen. They are critical for the preservation of biological equilibrium in the aquatic ecosystem. Aquatic plants are the water's primary source of food and oxygen. They are critical for the preservation of biological equilibrium in the aquatic ecosystem (Kumar and Arisdason, 2020).

For aquatic plant treatment of a broad contaminated region, the aquatic ecosystem is a resourceful and cost-effective cleanup method. Contaminants and heavy metals are naturally absorbed by aquatic plants (Pratas *et al.*, 2014). Aquatic plants are the most efficient and cost-effective method for eliminating various heavy metals and other pollutants (Guittonny-Philippe *et al.*, 2015). Constructed wetlands, as well as Aquatic plants, have long been utilized to remediate wastewater all around the world. (Gorito *et al.*, 2017).

The selection of aquatic plant species for heavy metal buildup is a critical aspect of aquatic plant treatment (Galal *et al.*, 2018). Aquatic plants have built an enviable reputation over the years for their ability to clean up contaminated places all around the world (Gorito *et al.*, 2017). Aquatic plants grow a complex root system that aids them in accumulating pollutants in their roots and shoots and makes them the ideal alternative for this. Aquatic plant development and cultivation take time, which may limit the growing demand for the treatment of aquatic plants (Said *et al.*, 2015). Nonetheless, this flaw is outweighed by the numerous advantages that this technology offers in terms of wastewater treatment (Gunathilakae *et al.*, 2018).

These are the plants with floating leaves and submerged roots. Several aquatic plants have long been known for their ability to remove metals from contaminated environments: *Eichhornia crassipes* (water hyacinth; Gunathilakae *et al.*, 2018), *Salvinia minima* (water ferns) and *Lemna minor* or *Spirodela intermedia* (duckweeds; Iha and Bianchini, 2015), Pistia *stratoites* (water lettuce; Abbas *et al.*, 2019) and *Nasturtium officinale* (watercress; Shi *et al.*, 2020).

The most important advantage of aquatic plant treatment is that it is a green technology that promotes long-term growth. It makes use of plant and microbe natural resources, lowers degradation of the environment, safeguards ecosystems, and improves lives and health. Other benefits include the fact that both organic and inorganic pollutants are effectively treated by aquatic plants, making it suited for the treatment of mixed types of pollutants using multiple mechanisms (Phytoaccumulation, Phytodegradation, Phytotransformation, Phytovolatilization, and Phytoextraction) to clean up or detoxify pollutants; At low-to-moderate concentrations, it works well on soil that has been contaminated in large quantities and widely scattered pollutants. It can be done in situ while maintaining the soil's texture and structure. It is environmentally sustainable and aesthetically pleasant to the public, with a nice view of the surroundings. It is possible to restore contaminated soil for agricultural use after cleanup or additional development goals or treated wastewater can be reused for cleaning or landscaping purposes, reducing the ecosystem's negative impact. Furthermore, because phytotechnology is simple to install and maintain, it is less expensive and less expensive than additional technologies for chemical and physical treatment (Sheikh-Abdullah *et al.*, 2020).

Hydrocarbon Contamination

Hydrocarbons are organic compounds found in nature, such as crude oil, coal, and asphalt. Hydrocarbons are available as a gas (natural gas), a liquid (crude oil), or a solid (petroleum).

Hydrocarbons are mostly made up of hydrogen and carbon, although they can also contain nitrogen, sulfur, and oxygen (Sheikh-Abdullah *et al.*, 2020).

Aliphatic and aromatic hydrocarbons are separated into subcategories based on the chemical structure of their compound constituents. Hydrocarbons aromatic have one or more benzene rings bound together, whereas aliphatic hydrocarbons are made up of carbon atom chains that are bonded together (Hunt *et al.*, 2019). Alkanes, alkenes, and cycloalkanes are the three primary categories of aliphatic hydrocarbons. Bonding patterns between nearby compounds can be used to distinguish aliphatic and aromatic substances chemically (Abdullah *et al.*, 2020).

In industrialized countries, hydrocarbons constitute the most common type of environmental pollutants. Leakage, pipe breakage, and unintentional spills are all possibilities during the exploration, refining, production, transportation, and products and storage of petroleum. Hydrocarbons are a major pollutant in aquatic habitats and have an immediate impact on human health (Sheikh-Abdullah *et al.*, 2020). Because certain hydrocarbons, such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), are persistent, which can contribute to mutagenic, toxic, and carcinogenic effects, Hydrocarbons can be hazardous, particularly if they enter the food chain (Sheikh-Abdullah *et al.*, 2020).

Many studies have proven the negative impacts of hydrocarbons in the soil, water, and air on the health of people, including respiratory tract irritation, psychological issues, skin, and blood profile disturbances, and renal disorders (Jeevanantham *et al.*, 2019). Hydrocarbon toxicity has an impact not only on human health but also on plants, soil microbes, and ecosystem sustainability. Plants grown on oil-contaminated soil, such as beans, showed harmful consequences with an oil-content of 10,000 mg/kg (Sheikh-Abdullah *et al.*, 2020). Hydrocarbons cause slower development and decreased germination rates for seeds. These effects have been observed in several plants as a result of soil pollution with diesel oil (Sheikh-Abdullah *et al.*, 2020).

The success of short- and long-term treatments to accomplish rehabilitative goals, pollutant reduction effectiveness, pollutant toxicity reduction, and cost-effectiveness are some of the criteria for land treatment or technology selection (Sheikh-Abdullah *et al.*, 2020). The % of plant kinds employed in aquatic plant therapy is shown in Fig. 1 and Table 1. Terrestrial plants account for 62% of the total, with aquatic plants accounting for 33% and ornamental plant kinds accounting for 5%. Hydrocarbon contamination in soil was found to be the subject of more investigation than hydrocarbon pollution in water. Furthermore, Terrestrial plants with a dense root system have a denser rhizosphere, in the degradation of hydrocarbons, plant-soil microbial interactions are dominant, contributing to the improvement of pollutant breakdown and uptake (Sheikh-Abdullah *et al.*, 2020).

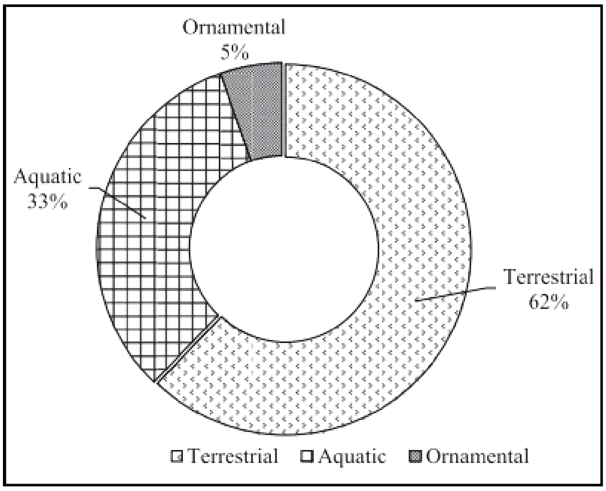

Fig. 1. Plants used in phytoremediation (Abdullah *et al.*, 2020).

A synopsis of the general mechanisms involved in aquatic plant pollution remediation is depicted in Fig. 2. The treatment procedures for aquatic plants can be split into three categories: (i) pollutant degradation, (ii) suppression, and (iii) extraction, or a mix of these three categories (Santos and Maranho, 2018). The processes used by aquatic plants to remove or detoxify contaminants can also be categorized. Contaminant extraction from groundwater or soil, contaminant levels in plant tissue, biotic and abiotic mechanisms that degrade contaminants, and evaporation or transpiration of volatile pollutants from the plant into the air and contaminant immobilization in the root zone are examples of these mechanisms (Abdullah *et al.*, 2020).

Table 1. Various aquatic plants utilized to degrade petroleum hydrocarbons (Abdullah *et al.*, 2020)

Aquatic plant		Reference
Common name	Scientific name	
Black rush/needle rush	*Juncus roemerianus*	Sheikh-Abdullah *et al.* (2020)
Perennial bunchgrass	*Vetiveria zizanioides* (L.) Nash	Sheikh-Abdullah *et al.* (2020)
Mangrove	*Rhizophora* sp., *Bruguiera* sp., *Avicennia* sp.	Hidayati *et al.* (2018)
Reed	*Phragmites australis* *Phragmites communis* Trin.	Sheikh-Abdullah *et al.* (2020)
Triangular club-rush	*Scirpus triqueter*	Zhang *et al.* (2020)
Seepweed	*Suaeda glauca*	Sheikh-Abdullah *et al.* (2020)
Sea lavender	*Limoniumbi color* Kuntze	Sheikh-Abdullah *et al.* (2020)
Central Asia saltbush	*Atriplex centralasiatica* Iljin	Sheikh-Abdullah *et al.* (2020)
Rice	*Oryza* sp.	Sheikh-Abdullah *et al.* (2020)
Grey sedge	*Lepironia articulate*	Al-Sbani *et al.* (2016) and Sharuddin *et al.* (2019)
Greater club-rush	*Scirpus grossus*	Sharuddin *et al.* (2019)

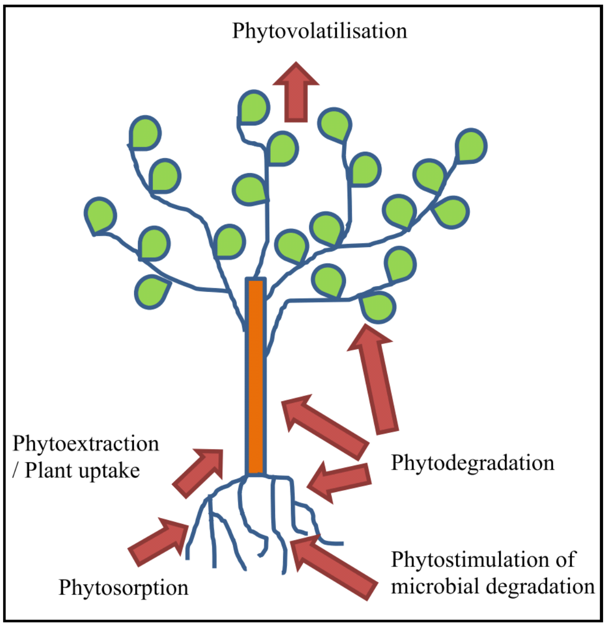

Fig. 2. Aquatic plant treatment mechanisms of hydrocarbons (Abdullah *et al.*, 2020).

Heavy Elements Contamination

Heavy metals have been extensively investigated in aquatic environments such as lakes and rivers due to their persistence, toxicity, and bioaccumulation tendency. Several investigations have shown that aquatic plants act as heavy metal sinks in aquatic ecosystems, with different types of aquatic plants accumulating varying quantities of various heavy metals (Bai *et al.*, 2018). The ability of these aquatic plants to remove heavy metals has been thoroughly investigated in some research (Ali *et al.*, 2020). Heavy metals are actively transported in aquatic plants through the roots, from where they are transmitted to other sections of the plant. Passive transfer is associated with direct contact of the plant body with the polluted medium. Heavy metals primarily amass in the higher portions of the plant's main body during passive transport (Ali *et al.*, 2020). The most commonly employed free-floating plants for heavy metal cleanup from wastewater are water hyacinth, duckweed, and water lettuce (Anaokar *et al.*, 2018). Table 2 lists a variety of aquatic plants' abilities to mitigate certain heavy metals (Ali *et al.*, 2020).

Bioaccumulation Factor (BAF)

Bioaccumulation Factor of different elements rooted aquatic plants to sediment, and aquatic plants to water (dissolved phase) was determined by Wilson's and Pyatt's equation (Al-Atbee *et al.*, 2019) :

$$\text{BAF}\,(\%) = \frac{C_{pt}}{C_{(s/w)}} \times 100$$

Where,

C_{pt} = the elements concentrated in the tissue of a plant (µg/g dry weight).

$C_{(s/w)}$ = the elements concentrated in sediment (µg/g dry weight) or water (mg/l).

CONCLUSION

Recently, Aquatic plants provide a wide range of benefits to humans, with many new applications still to be identified. However, the introduction of aquatic plant species that

Table 2. Various aquatic plants are used to reduce the effects of various heavy metals (Ali *et al.*, 2020)

Aquatic plant		Heavy metals	Reference
Common name	Scientific name		
Water Hyacinth	*Eichhornia crassipes*	Pb, Hg, Cu, Cr, Ni, Zn	Ali *et al.* (2020)
Water Lettuce	*Pistia stratiotes*	Cr, Zn, Fe, Mn, Cu	Ali *et al.* (2020)
Water Spangles	*Salvinia minima*	As, Ni, Cr, Cd	Ali *et al.* (2020)
Water Fern	*Salvinia herzogii*	Cd, Cr	Ali *et al.* (2020)
Lesser Duckweed	*Lemna minor*	As, Cr, Cu, Ni, Pb	Ali *et al.* (2020)
Duckweed	*Spirodela intermedia*	Zn, Fe, Mn, Cr, Cu, Pb	Ali *et al.* (2020)
Water Cress	*Nasturtium officinale*	Cr, Ni, Zn, Cu	Ali *et al.* (2020)
Parrot Feathers	*Myriophyllum spicatum*	Pb, Cd, Fe, Cu	Ali *et al.* (2020)
Hornwort	*Ceratophyllum demersum*	As, Cd, Cr, Pb	Ali *et al.* (2020) and El-Khatib *et al.* (2014)
Pondweed	*Potamogeton crispus*	Ni, Cu, Zn, Fe, Mn	Borisova *et al.* (2014)
American Pondweed	*Potamogeton pectinatus*	Cd, Pb, Cu, Zn	Ali *et al.* (2020)
Common Cattail	*Typha latifolia*	Zn, Mn, Ni, Fe, Pb, Cu	Hejna *et al.* (2020) and Ali *et al.* (2020)
Water Mint	*Mentha aquatica*	Pb, Cd, Fe, Cu	Ali *et al.* (2020)
Tape Grass	*Vallisneria spiralis*	Ar	Giri, 2019
Cordgrass	*spartina alterniflora*	As, Cu, Cr, Ni, Zn, Cd, Mn, Pb	Ali *et al.* (2020)
Common Reed	*Phragmites australis*	Fe, Cu, Cd, Pb, Zn	Ganjali *et al.* (2014) and Ha and Anh (2017)
Bulrush	*Scirpus* sp.	Cd, Fe, Al	Kutty and Al-Mahaqeri (2016)
Smartweed	*Polygonum hydropiperoides*	Cu, Pb, Zn	Rudin *et al.* (2017)

become problematic under specific conditions is putting both marine and freshwater environments at risk right now. These plant species are frequently imported from other regions of the world for medicinal or horticultural purposes, but they eventually escape domestication and establish natural populations. Aquatic plants have been proved in numerous studies to be sinks for heavy metals and hydrocarbons in aquatic ecosystems, and it is also used in the treatment process to reduce or limit contamination (hydrocarbons and heavy metals).

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