GREEN TECHNOLOGY: CHECKLIST OF MACROPHYTES FOR TREATMENT OF WASTEWATER IN CONSTRUCTED WETLANDS

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***ABSTRACT*:** The present paper attempts to provide an overview and summarise the role of the macrophytes in treatment of wastewater with respect to phytoremediation. Different macrophytes have different adsorption capacities for pollutants or heavy metals, so the efficiency of pollutant removal is also different. By combination of macrophytes, the removal efficiency of pollutants can be improved. Constructed wetlands are manmade systems that contain wastewater, media, and macrophytes. With respect to differential biological filtration ability of macrophytes, the inclusion of more than one type of macrophytes would seem more beneficial. In the present paper, commonly used 63 macrophytes belonging to different categories are listed. There is need to explore more plants which can be used for treatment of wastewater in constructed wetlands.

***KEYWORDS*:** macrophytes, phytoremediation, constructed wetlands

INTRODUCTION

Natural wetlands are ecosystems that are either permanently or temporarily saturated in water, providing a natural habitat for biotic organisms and supporting conditions. In natural wetlands the wastewater is purified by means of various chemical (adsorption, precipitation), physical (sedimentation) and biological processes (nitrification, denitrification, ammonification). Constructed wetlands (CW) are the artificially created man made systems in which wastewater treatment take place by utilizing natural processes by involving soil, vegetation, and microbial communities. Due to their cost- effectiveness, lower operational and maintenance costs, and green and sustainable character, by using different aquatic plant species; constructed wetlands is proven environment friendly alternative for the removal contaminants from wastewater. In Constructed Wetlands, the macrophytes grown have many assets relevant to the process of wastewater treatment. Physical effects, root release, plant uptake, and surface area for growth of microbes are the foremost important effects of the macrophytes in treatment process [27].

During past few decades, constructed wetlands have been increasingly applied as an eco-friendly, sustainable and green technology for wastewater treatment. Use of the green plants, particularly aquatic macrophytes, in constructed wetlands (CW) has gained much attention because of their ability to treat different types of contaminants [28, 29]. Phillips et al, [22] assessed the metal accumulating ability of emergent macrophytes.

Constructed wetlands, which use a variety of species or combinations of species, have proven to be a flexible treatment option for a variety of wastewaters. The uptake of heavy metals by plants using phytoremediation technologies appears to be a promising way to treat heavy metals-contaminated water [26]. Since 1990s the constructed wetlands have been extensively built and operated for treatment of all kind of wastewater such as Sewage water [23]; fish farm [20]; dairy farm [32]; ponds effluent [11]; domestic greywater [4] ; UASB reactor effluents [5]; greywater and septic tank effluent [25]; low-strength municipal wastewater [1] etc.

Plants are used in various sectors to remove heavy metals from contaminated soil, recover metal-contaminated habitats, and prevent ongoing environmentally harmful effects on living organisms [6]. Wetlands have been reported to successfully removal of metals from a tool industry [10]. Various wetlands exist for treating different types of industrial wastewater such as pulp and paper wastewater [14]. Aquatic macrophytes play variety of roles in reducing various EC and also help in reducing the greenhouse gases [24].

MATERIAL AND METHODS

In this review, the scattered information and data on plants suitable for phytoremediation are being compiled. Constructed wetlands have proved their efficiency and low-cost wastewater treatment processes. In the literature removal of heavy metals within wetlands is performed generally by plant uptake and by adsorption.

RESULT

In the present paper, commonly used 63 macrophytes belonging to different categories are listed. There is need to explore more plants which can be used in phytoremediation. With respect to differential biological filtration ability of macrophytes, the inclusion of more than one type of macrophytes would seem more beneficial.

Following checklist of macrophytes is proposed as bioremediants, which are useful plant species in phytoremediation studies due to their ability to accumulate pollutants and heavy metals in high concentration in the different plant parts.

Table 1: checklist of macrophytes

Sr. No.	Name of Plant	Removal/ absorption of	Sources
1	*Acorus calamus*	Metallic pollutants	[21] Paritosh Kumar et al. ,2019
2	*Apium nodiflorum*	As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. ,2017
3	*Arundo donax*	Metallic pollutants	[21] Paritosh Kumar et al. ,2019
		As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. ,2017
4	*Bacopa caroliniana*	Ca, Mg Fe and Mn	[3] Ang et al. ,2023
5	*Bambusa multiplex*	N	[16] Liu et al. ,2017
6	*Bolboschoenus maritimus*	Cd, Zn, Cu and Pb	[18] Maria et al. ,2020
7	*Brachiaria mutica*	N, P, B	[31] Vanitha et al. ,2023
8	*Butomus umbellatus*	Cd, Zn, Cu and Pb	[19] Maria et al. ,2020
9	*Canna indica*	N, P, B	[31]Vanitha et al. ,2023
		Cr, Cu, Fe, Pb, Zn, Al, Ni, and Cd	[7] Ghezali et al. ,2022
10	*Canna x generalis*	Ca, Mg Fe and Mn	[3] Ang et al. ,2023
11	*Carex acuta*	Cd, Zn, Cu and Pb	[18] Maria et al. ,2020
12	*Carex appressa*	Ca, Mg Fe and Mn	[3] Ang et al. ,2023
13	*Carex iparia*	Cd, Cu, Pb, and Zn.	[7] Emre Boynukisa et al. ,2023
14	*Carex pseudocyperus*	Cd, Zn, Cu and Pb	[19] Maria et al. ,2020
15	*Carex riparia*	Cd, Zn, Cu and Pb	[19] Maria et al. ,2020
16	*Carex rundinacea*	Cd, Cu, Pb, and Zn.	[7] Emre Boynukisa et al. ,2023
17	*Carex seudocyperus*	Cd, Cu, Pb, and Zn.	[7] Emre Boynukisa et al. , 2023
18	*Chrysopogon zizanioides*	Ca, Mg Fe and Mn	[3] Ang et al. ,2023
19	*Colocasia esculenta*	Ca, Mg Fe and Mn	[3] Ang et al. ,2023
20	*Cymodocea nodosa*	As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[8] Giuseppe et al. , 2017,
21	*Cyperus alternifolius*	Cu and Pb	[17] Mai Huong et al.,2020
22	*Dryopteris carthusiana*	Cd, Zn, Cu and Pb	[19] Maria et al. , 2020,
23	*Echinochloa colonum*	Cd, Co, Cu, Ni, Pb and Zn	[12] Nirmal Kumar et al., 2008
24	*Echinodorus palifolius*	Ca, Mg Fe and Mn	[3] Ang et al. , 2023
25	*Eichhornia crassipes*	Ca, Mg Fe and Mn	[3] Ang et al. , 2023
		P	[33] Xie et al. , 2016
		Cd, Co, Cu, Ni, Pb and Zn	[12] Nirmal Kumar et al. , 2008
26	*Eleocharis dulcis*	Ca, Mg Fe and Mn	[3] Ang et al. ,2023
27	*Eleocharis sphacelata*	Sewage water	[23] Pradeep et al. ,2019
28	*Elodea canadensis*	Sewage water	[23] Pradeep et al. , 2019
29	*Heliconia psittacorum*	Ca, Mg Fe and Mn	[3] Ang et al. , 2023
30	*Hydrilla verticillata*	Cd, Co, Cu, Ni, Pb and Zn	[12] Nirmal Kumar et al., 2008

32	*Imperata cylindrica*	P	[33] Xie et al. , 2016
33	*Ipomoea aquatica*	Ca, Mg Fe and Mn	[3] Ang et al. , 2023
		P	[33] Xie et al. , 2016
		Cd, Co, Cu, Ni, Pb and Zn	[12] Nirmal Kumar et al. , 2008
34	*Iris kashmiriana*	greywater and septic tank effluent	[25] Raja Zubair et al. , 2021
35	*Iris sp.*	IBU and iohexol (IOH)	[35] Zhang et al. , 2016
36	*Juncus sp.*	IBU and iohexol (IOH)	[35] Zhang et al. , 2016
37	*Lemna minor*	heavy metal	[2] Ali et al. , 2020
38	*Limnocharis flava*	Hg	[13] Jose et al., 2017
39	*Morus alba*	P	[34] Yao et al. , 2005
40	*Myriophyllum speculum*	Sewage water	[23] Pradeep et al., 2019
41	*Nasturtium officinale.*	As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. ,2017
42	*Nelumbo nucifera*	Cd, Co, Cu, Ni, Pb and Zn	[12] Nirmal Kumar et al., 2008
43	*Neptunia oleracea*	Ca, Mg Fe and Mn	[3] Ang et al. , 2023
44	*Phalaris arundinacea*	Cd, Cu, Pb, and Zn.	[7] Emre Boynukisa et al. , 2023
45	*Phragmites australis*	Cu and Pb	[17] Mai Huong et al. , 2020
		heavy metal removal from wastewater	[15] Kumari & Tripathi , 2016
		low-strength municipal wastewater	[1] Aalam et al. , 2022
		As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. , 2017
		Sewage water	[23] Pradeep et al. , 2019
46	*Phragmites karka*	Metallic pollutants	[21] Paritosh Kumar et al. , 2019
		greywater and septic tank effluent	[25] Raja Zubair et al. , 2021
47	*Phragmites sp.*	N, P, B	[31] Vanitha et al. , 2023
		IBU and iohexol (IOH)	[35] Zhang et al. , 2016
48	*Posidonia oceanica*	As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. , 2017
49	*Potamogeton pectinatus*	Sewage water	[23] Pradeep et al. , 2019
50	*Sagittaria latifolia*	greywater and septic tank effluent	[26] Raja Zubair et al. , 2021
		Sewage water	[23] Pradeep et al. , 2019
51	*Sagittaria sagittifolia*	low-strength municipal wastewater	[1] Aalam et al. , 2022
52	*Salvinia molesta*	Ca, Mg Fe and Mn	[2] Ang et al. , 2023
53	*Scirpus tubernaemontani*	Sewage water	[23] Pradeep et al. , 2019
54	*Spartina maritima*	heavy metal	[22] Phillips et al. , 2015
55	*Thalia geniculata*	Ca, Mg Fe and Mn	[3] Ang et al. , 2023
56	*Typha angustata*	Cd, Co, Cu, Ni, Pb and Zn	[12] Nirmal Kumar et al. , 2008
		Ca, Mg Fe and Mn	[3] Ang et al. , 2023
57	*Typha capensis*	heavy metal	[22] Phillips et al. , 2015
58	*Typha domingensis*	Cu, Zn and Mn	[30] Sreenath et al. , 2017
		As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. , 2017
59	*Typha latifolia*	Metallic pollutants	[21] Paritosh Kumar et al. , 2019
		N, P, B	[31] Vanitha et al. , 2023
		heavy metal removal from wastewater	[15] Kumari & Tripathi , 2015
60	*Typha sp.*	As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn	[9] Giuseppe et al. , 2017
		IBU and iohexol (IOH)	[35] Zhang et al. ,2016
61	*Vallisneria Americana*	Sewage water	[23] Pradeep et al. , 2019

63	*Vetiver zizaniodes*	Metallic pollutants	[21] Paritosh Kumar et al. , 2019

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