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ORIGINAL ARTICLE

Role of Plant Species for Controlling Water Pollution

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ABSTRACT
Pollution has become the biggest problem for the survival of the biological species. There are various types of pollution e.g. air, water and soil. Earth was a beautiful landscape but man has ruthlessly exploited it from last several decades. Rapid industrialization and random urbanization are the key reasons for environmental as well as water pollution. There are various ways to avoid water pollution. Planting pollution- tolerant and dust scavenging trees and shrubs for abatement of pollution and improvement of an environment is an effective way. Plants play an essential role to clean the pollution in environment by accumulating toxic substances. In this paper thirty plants which are belonging to different families are selected for identification of heavy metal contaminants like cd, cr, Zn, Ni, Fe and Pb. Some plant species like Andrographis paniculata, Acacia nilotica, Acacia moniliformis, Ageratum conyzoides, Barleria terminalis, Celosia argentea, Calotropis gigantea, Caesulia axillaries, Cassia tora, Cassia auriculata, Cleome viscosa Capparis spinosa, Coccinea grandis, Eriocaulons edgewickii, Evolvulus alsinoides are found to have highest metal accumulating capacity planting these trees in water resources will reduce contamination in water and helps to solve problem of water pollution due to industrialization.
Keywords: *Water pollution, Phytoremidetion, plants, heavy metals.*

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INTRODUCTION

Nature is self sufficient to tolerate many changes, which otherwise may alter the nature's balances in biogeocycling. In this century careless anthropogenic activities have crossed their limits and have degraded the environment and have been damaging environmental ecological balance irreversibly. Soil pollution, water pollution, solid waste deposition, depletion of resources, scarcity of potable water, and dispersal of health hazards are the outcome of ever increasing industrial activities with negligence to its negative impact on life of humans and environment. These pollutants can be categorized broadly into two types; organic and inorganic. Organic pollutants include substances like detergents, fats, grease, insecticides, herbicides, organohalides and hydrocarbons of petroleum origin. Inorganic pollutants include industrial discharges containing sulfur dioxides, ammonia, nutrients like nitrates and phosphates and heavy metals. Heavy metal pollutants are of significant ecological/environmental concern because they are not biodegradable and have long half-lives in the soil. Phytoremediation is an environmentally friendly and environment cleanup strategy in which some of the green plants are used to remove environmentally toxic components. It is one of cheap and easy long term, environment friendly method of transferring and stabilizing contaminants such as pesticides, metals and chlorinated hydrocarbon. This paper presents the application of phytoremediation technology to the contaminated water of the Ekrukh Lake Solapur which focus on relevance of phytoremediation technology to cleanup of metals in water for sustainable development. The increasing discharge of industrial wastes in this river is posing serious danger to the water resources and the health of people in the area. The major problem of environmental concern, facing Solapur city, is that of wastewater discharge from industries located within the metropolis. High levels of some physico-chemical pollution indicators studied from textiles and tanneries in the area showed higher pH, temperature, conductivity, turbidity, colour, TSS, Oil and grease above the WHO recommended levels. The concentrations of Cu, Zn, Mn, Pb, Cr and Ni were also reported to be significantly higher than the levels recommended by FAO, FEPA and the WHO. This study was aimed at examining the phytoremediation potentials of *Andrographis paniculata, Acacia nilotica, Acacia moniliformis, Ageratum conyzoides, Barleria terminalis, Celosia argentea, Calotropis gigantea, Caesulia axillaries, Cassia tora, Cassia auriculata, Cleome viscosa Capparis spinosa, Coccinea grandis, Eriocaulons* *edgewickii, Evolvulus alsinoides* in removing Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn from industrially contaminated water from Ekrukh lake located in Solapur.

MATERIAL AND METHODS

Area of the study:

The agricultural fields around the Solapur city and fields irrigated with urban waste water were the sites selected for the study. Non agricultural sites contaminated with urban wasters and/or industrial waste waters were considered for assessing biodiversity. The study was carried out at Ekrukh Lake.

Collection of plants and preparation of Herbarium

Plant specimens were collected from heavy metal suspected areas with frequent excursions through the years 2017-19. Most of the plant materials were collected during rainy season. The plant specimens were collected by laying ten quadrates of 1 m × 1 m. The two quadrates were spaced 50 cm apart. Individuals of each species were counted in each quadrate. During the collection information like habit, period of flowering, fruiting were studied for all the species in the studied area. Correct botanical names are given to all the species according to International Code of Botanical Nomenclature (ICBN). The collected plant material specimens were processed for herbarium preparation as per the method of Rao and Sharma (1990). Specimens were preserved at the Department of Botany, Dayanand College, Solapur. Identification was confirmed by direct comparison with authentic specimens at BSI Herbarium, Western Circle, Pune.

Water and soil sample collection

Waste water samples were collected from Ekrukh Lake. Water samples were collected in sterile plastic bags and carried to the laboratory. Soil sampling was conducted four times in a year beginning from January 2017 to December 2019. In total 16 soil samples were collected from each site. All soil samples were taken from the surface layer (0-25 cm) of cultivated soils. After thorough mixing, 200 g representative samples from each field were stored in polythene bags. The soils were air dried, homogenized with mortar and pestle and sieved through 1 mm mesh. Physicochemical parameters such as pH of soil, water holding capcity, soil texture, EC, CaCO, total organic carbon and sodium adsorption ratio (SAR) were studied as per the standard procedures.

Digestion method

In order to estimate the total metal content soil and dried plants samples were digested with aqua-regia (3:1, hydrochloric acid + nitric acid) at 150^{0}C for 2 h in the COD digester (Model: 2015M, Make: Spectralab Inst. Pvt Ltd., India). The digested samples were cooled and filtered through Whatman No.1 filter paper and then the volumes were made up to 50 ml using volumetric flasks.

Metal extraction

To estimate the available metal concentration, 10 g dried irrigated soil was mixed with 20 ml of diethylenetriamine pentaacetic acid (DTPA) extracting solution at pH 7.3 and kept on rotary shaker at 120 rpm for 2 h. The mixture was centrifuged at 5000 rpm for 5 min and supernatants were collected and acidified with 1:1 nitric acid for metal analysis.

Metal analysis

Metal analysis of all digested samples and acidified wastewaters were estimated by atomic absorption spectrometry (Model: S2, Make: Thermo, USA) using the 'SOLAAR' software. Analyses were performed using hollow cathode lamps for copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb), zinc (Zn) and nickel (Ni) at 324.8, 357.9, 228.8, 217.0, 213.9 and 232.0 nm, respectively. Air-acetylene flame was generated using a fuel flow rate of 0.8 to 1.1 l/min. All analyses were replicated three times. All the reagents used were analytical grade (Thermo Fischer Sci. India Pvt. Ltd., and HiMedia Lab. Pvt. Ltd., India).

Table 1: Physicochemical analysis of Ekrukh Lake water running peripheral to Solapur city.

Parameter	Samples collected in 2018 & 2019			
	Jan-Mar	Apr-June	July-Sept	Oct-Dec
pH	7.28 (0.58)[a]	7.38 (0.81)	7.81 (0.45)	6.98 (0.81)
EC (dS/m)	1.58 (0.42)	1.98 (0.51)	0.90 (0.44)	1.54 (0.28)
Cu (mg/l)	9.75 (2.24)	7.54 (1.82)	5.23 (1.05)	11.28 (2.88)
Cr (mg/l)	35.18 (6.12)	24.23 (5.98)	13.02 (6.32)	18.38 (8.44)
Cd (mg/l)	25.38 (6.92)	18.22 (5.19)	4.54 (4.24)	16.32 (8.12)
Pb (mg/l)	9.23 (5.83)	11.13 (6.88)	5.32 (6.24)	8.22 (5.09)
Zn (mg/l)	18.56 (8.43)	21.01 (6.44)	8.54 (7.32)	22.23 (6.18)
Ni (mg/l)	9.43 (6.05)	18.32 (8.22)	4.98 (4.72)	7.54 (6.42)

All values are mean values; a, Figures in parentheses are of standard deviation (n= 12 each quarter)

Table 2: Physicochemical analysis of soil receiving from Ekrukh water.

Parameter \ Site	Site-1	Site-2	Site-3	Site-4
Soil texture	Lome	Silt	Sludge	Lome
pH	7.8 (0.89)[a]	6.6 (0.66)	5.8 (0.57)	7.5 (0.83)
EC (S/m)	0.72 (0.65)	0.92 (0.58)	1.14 (1.12)	2.24 (1.72)
CaCO3 (%)	2.14 (1.65)	1.93 (0.94)	1.45 (1.06)	2.22 (1.84)
Total organic carbon, mg/l	28.18 (7.21)	42.32 (8.54)	55.14 (6.77)	24.97 (11.14)
Water holding capacity (%)	44.60 (12.06)	58.12 (10.22)	62.55 (14.14)	73.26 (8.96)
CEC, mEq/100g	16.41 (3.75)	27.18 (4.52)	13.23 (4.66)	23.96 (2.76)
SAR	5.66 (1.65)	5.24 (1.80)	3.41 (0.94)	6.68 (1.38)

All values are mean values; a, Figures in parentheses are of standard deviation (n= 16 at each site)

Table 3: Physicochemical analysis of soil at various locations around Solapur city

Parameter \ Site	Kamber lake	Degaon	Rupa Bhawani	Mulegaon
Soil texture	Lome	Sludge	Silt	Lome
Ph	7.55 (1.25)[a]	6.8 (0.78)	7.27 (0.94)	7.3 (0.46)
EC (S/m)	0.51 (0.37)	1.21 (0.39)	0.82 (1.35)	0.65 (0.93)
CaCO3 (%)	1.65 (0.82)	2.14 (0.71)	1.93 (0.66)	2.35 (0.94)
Total organic carbon, mg/l	32.18 (6.44)	56.36 (8.33)	48.21 (7.09)	28.12 (9.47)
Water holding capacity (%)	48.12 (7.15)	70.16 (8.81)	62.37 (11.55)	52.17 (6.48)
CEC, mEq/100g	18.20 (2.49)	28.08 (3.77)	19.21 (2.31)	21.48 (4.06)
SAR	5.37 (1.22)	6.28 (0.93)	4.27 (0.67)	5.78 (1.02)

All values are mean values; a, Figures in parentheses are of standard deviation (n= 12 at each site)

Table 4: Phenological features of plants

Sr.No.	**Botanical Name**	**Family**	GH	FS	CL	S	AB
1)	*Acacia moniliformis*	*Mimosaceae*	TR	Sep	YL	M	c
2)	*Ageratum conyzoides*	*Asteraceae*	HB	Mar	WH	R	0
3)	*Barleria terminalis,*	*Acanthaceae*	SH	Nov	BL	M	0
4)	*Celosia argentea*	*Amaranthaceae*	HB	Aug	PK	R,M	C
5)	*Calotropis gigantean*	*Asclepiadaceae*	SH	All	BL	AL	C
6)	*Caesulia axillaries,*	*Asteraceae*	HB	Oct	PK	AL	C
7)	*Cassia tora,*	*Caesalpiniaceae l*	HB	Oct	YL	D	C
8)	*Cassia auriculata*	*Caesalpiniaceae*	SH	Aug	YL	D	C
9)	*Cleome viscose*	*Cleomaceae*	H	Aug	YL	M	C
10)	*Capparis spinosa*	*Cappardaceae*	SH	Oct	YL	M	0
11)	*Coccinea grandis,*	*Cucurbitaceae*	CL	Aug	WH	D	C
12)	*Eriocaulons edgewickii*	*Eriocaulaceae*	HB	Aug	WH	M	0
13)	*Evolvulus alsinoides*	*Convolvulaceae*	HB	Aug	BL	AL	0
14)	*Acacia nilotica*	*Mimoceae*	T	Aug	YL	M	C
15)	*Andrographis paniculata*	*Acanthaceae*	HB	Dec	PK	M	0

GH, Growth habitat (TR, Trees; SH, Shrubs; CL, Climbers; HB, herbs; AH, Aquatic herb); FS, Flowering season; CL, colour (WH, White; PK, Pink; BL, Blue; YL, Yellow; RD, Red; GR, Green); S, Site (K, Kamber lake; D, Degaon; R, Rupa Bhawani; M, Mulegaon; AL, All sites); AB, Abundance (C, Common; O, Occasional; R, Rare)

Table 5: Heavy metal accumulation in selected plants

Plant and Family	Part	Metal concentration (mg/kg dry weight)					
		Cd	Cr	Ni	Zn	Pb	Cu
Acacia nilotica	L	8.54	4.08	6.61	26.89	73.78	9.87
	S	15.44	13.56	14.4	58.22	57.55	7.44
	R	18.40	15.21	15.12	45.81	75.80	13.87
Acacia moniliformis	L	4.12	5.00	2.67	25.28	78.34	2.18
	S	3.58	3.56	4.66	19.72	68.99	2.65
	R	12.45	9.76	8.56	25.10	59.74	9.76
Andrographis paniculata	L	5.89	4.23	2.67	24.76	63.95	3.21
	S	4.33	6.11	2.48	18.11	58.64	3.06
	R	11.27	5.01	4.52	12.45	75.12	12.78
Ageratum conyzoides	L	8.32	1.9	2.13	25.25	53.59	3.65
	S	6.43	2.87	5.33	16.27	46.23	2.65
	R	12.43	3.20	8.60	38.95	51.45	6.23
Barleria terminalis	L	7.12	2.21	4.77	25.12	89.12	1.87
	S	13.3	3.12	2.56	35.47	92.45	1.28
	R	23.45	1.55	3.15	52.46	76.19	5.23
Celosia argentea	L	3.56	3.18	5.98	25.45	67.91	3.12
	S	2.47	4.23	11.56	29.23	75.45	4.45
	R	8.96	8.78	13.45	26.77	65.44	6.44
Calotropis gigantean	L	4.13	2.42	5.85	28.87	38.23	2.76
	S	5.45	2.66	4.56	14.78	31.56	2.23
	R	6.70	4.62	11.49	48.44	28.75	8.56
Caesulia axillaries	L	1.46	3.60	4.35	12.45	48.44	3.23
	S	1.37	3.07	3.69	10.23	35.59	6.54
	R	2.78	5.98	8.56	20.96	58.21	12.80
Cassia tora,	L	1.03	2.12	8.10	14.89	56.30	3.98
	S	3.09	2.20	6.78	22.08	59.33	3.56
	R	5.52	3.45	13.56	31.45	65.21	4.88
Cassia auriculata	L	4.49	4.08	5.18	26.35	53.22	6.34
	S	8.23	6.45	3.54	19.25	65.41	8.58
	R	8.44	8.56	5.89	48.11	58.36	15.78
Cleome viscose	L	5.59	3.99	1.34	21.45	64.42	4.22
	S	5.28	4.88	3.23	27.23	48.54	4.23
	R	8.12	5.66	13.96	45.27	77.85	8.28
Capparis spinosa	L	4.12	3.03	2.98	26.91	97.56	4.89
	S	9.70	2.44	5.65	15.89	86.89	3.45
	R	13.21	3.89	12.21	41.08	79.28	3.47
Coccinea grandis	L	3.21	3.87	1.65	26.10	56.34	2.12
	S	5.20	3.63	4.23	32.42	62.45	5.23
	R	9.49	5.34	6.65	24.10	59.75	8.56
Eriocaulons edgewickii	L	5.08	2.34	2.23	10.23	52.05	3.12
	S	5.22	5.33	8.21	12.55	36.22	3.88
	R	9.12	4.37	8.32	15.11	61.78	11.33
Evolvulus alsinoides	L	4.30	2.24	3.98	27.19	65.34	4.03
	S	4.11	3.44	2.23	35.77	75.11	6.40
	R	7.87	5.49	6.52	26.22	56.44	6.55

RESULT AND DISCUSSION

In this study we examined the Analysis of soils receiving Ekrukh water and other sites around Solapur city was performed to study the effect of soil properties on availability thus mobility of metals. The data of soil analysis are presented shows that soils of sampling silt belonged to loam, silt and sludge types. It can be seen that silt and sludge soils showed acidic pH against alkaline pH of loamy soils. Soil pH gets affected to a certain extent due the application of various amendments. Whereas, the pH of soils near urban areas was near neutrality. Electrical conductivity of soils was <1.5 with the exception of Site-4 having loamy soil. Total organic carbon is another important parameter plays a major role in nutrient cycling and also indicates the quality of soil. The data on metal analysis of soils near Kamber Lake, Degaon, Rupa Bhawani and Mulega sites located around Solapur city are presented in Table3 Among the six metals tested, cadmium was lowest in concentration while zinc was found to be highest at all the sites. Concentrations of soils ranged from 5.33 - 13.67, 23.12 - 87.21, 43.67 - 89.67, 47.78 - 98.04, 47.54-132.34 and 165.21 - 287.45 mg/kg of cadmium, nickel, chromium, copper, lead and zinc, respectively. Percent extraction metals with DTPA was lowest (<39%) for lead and highest (66.35) for nickel. Results of heavy metal analysis performed for the soils irrigated with Ekrukh lake water shows that Among the six metals tested lead, copper and zinc belonged to loam, silt and sludge types. It can be seen that silt and sludge soils showed acidic pH against alkaline pH of loamy soils. Soil pH gets affected to a certain extent due the application of various amendments. Whereas, the pH of soils near urban areas was near neutrality (Table 2). Electrical conductivity of soils was <1.5 with the exception of Site-4 having loamy soil. Total organic carbon is another important parameter plays a major role in nutrient cycling and also indicates the quality of soil. Electrical conductivity of Ekrukh water has ranged from 0.90 to 1.98 dS/m. EC values <2 have indicated less salt contents which will not add salts to the soils. Heavy metal analysis of Ekrukh water was done to check the suitability for agricultural use. Heavy metal concentration (mg/l) in Ekrukh waters at different locations ranged from 5.23 to 11.28 for copper, 13.02 to 35.18 for chromium, 4.54 to 25.38 for cadmium, 5.32 to 11.13 for lead, 8.54 to 22.23 for zinc and 4.98 to 18.32 for nickel. Highest accumulation of copper, chromium, cadmium, lead, zinc and nickel was found to 15.78, 92.45, 58.22, 15.12, 15.22, 23.45 mg/kg in *Cassia auriculata, Barleria terminalis, Acacia nilotica, Acacia nilotica, Barleria terminalis* respectively. These highest metal accumulations were found in roots. Lowest metal accumulation found in leaves than root and leaves in reaming species. A general trend has been observed that the metal accumulation was higher in roots than in shoot (leaves or stem). These plants can therefore be considered suitable for growing in the Industrially contaminated regions. Amassive plantation of these plants in and around the industrial state and irrigated contaminated water samples to check the mobility of heavy metals into the ground.

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