Environment and Ecology 36 (1A) : 316—320, January—March 2018
Website: environmentandecology.com ISSN 0970-0420

Relative Comparison for Phytoremediation Potential of Canna and Pistia for Wastewater Recycling

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Received 19 October 2017; Accepted 21 November 2017; Published on 14 December 2017

Abstract At present the water crises is one of the higgest threat to the entire Global ecosystem. Due to rapid growth of industrialization and urbanization, available water resources are decreasing and simultaneously wastewater generation is boosting up. Hence, it is necessary to develop most efficient low-cost-eco-friendly-plant based technology for wastewater recycling. Present experiment focused on phytoremediation of wastewater using Canna and Pistia, in which parameters viz. EC, pH, BOD, COD, TS, TDS, TSS, TN, TP, TK and Na were analyzed. The result shows that, most of the pollutants were removed by 20-50% in 5-15 days HRTs and Canna was observed more efficient for phytoremediation of above said parameters as compared to Pistia.

Keywords Phytoremediation, Canna, Pistia, Wastewater, Hydraulic Retention Time (HRTs).

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Introduction

Recently in the modern era of rapid urbanization, industrialization and population exploitation, it is more observing that the wastewater generation is growing in unmanageable quantity and simultaneously degrading the quality of fresh water. The Central Pollution Control Board [1], realized the big gap between sewage generation and treatment capacity for urban India in 2015 and reported that only a small fraction of about 23277 MLD (37.54% of total wastewater) out of 62000 MLD (million liters per day) is only treated through 816STPs across the country. Hence, there is urgent need to reduce this gap between generated and treated quantity of wastewater by using low-cost-ecofriendly method of wastewater treatment and recycling.

Phytoremediation is a plant-based technology [2], viz. phytoextraction, rhizofiltration, rhizodegradation, phytovolatilization, phytostabilization, which is relatively inexpensive since they are performed *in-situ* and are natural-driven [3]. Since low-tech, low-cost and eco-friendly in nature, phytoremediation is the most emerging clean-up method for contaminated wastewater. The selection and indigenous availability of suitable plant species according to types and concentration of the pollutants to be removed is very crucial [4]. The eco-friendly management of wastewater by the process called phytoremediation; in which wastewater is used as irrigation source, and up to some extent it is also called as fertigation [5] as it contains several essential nutrients as well as organic matter which are required for healthy plant growth [6, 7]. Most part of available freshwater, approximately

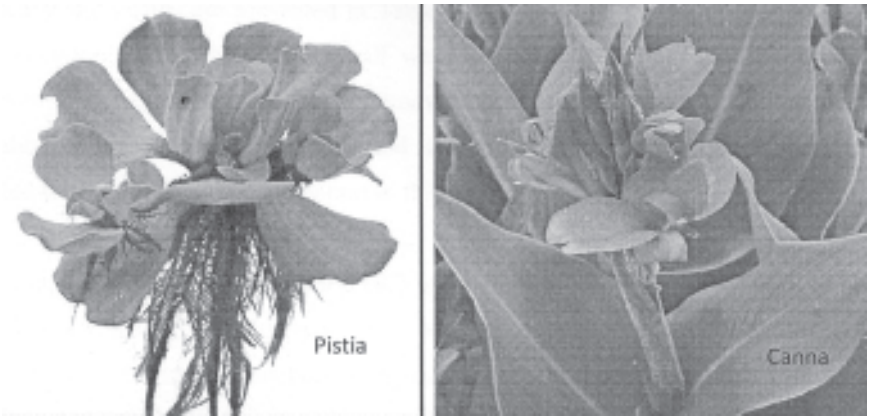

Fig. 1. Selected plant species Pistia and Canna.

79% is used in irrigation, hence for sustainable use of water resources and to reduce extreme water scarcity in future, it is very necessary to reuse the domestic and industrial wastewater for irrigation or fertigation purpose after certain treatment [8].

This experiment mainly focused on phytoremediation efficiency of Canna and Pistia for domestic wastewater. Furthermore, the study also shows that, wastewater can be safely used as irrigation for non-edible crops like flower crops.

(Authors thank to University Grant Commission (UGC) and G.B Pant University of Agriculture and Technology (GBPUA&T), Pantnagar for providing an academic platform to do this work. This experiment is a part of project entitled "Integrated Technology System for Phytoremediation of Domestic. Wastewater with Floating Rafts (Floating Wetland) : R&D and Pilot Testing" at Pantnagar University funded by IIT-Delhi).

Materials and Methods

Sampling site

Wastewater samples were collected from domestic wastewater discharge drain of University Campus-nearby Mahakaleshwar Temple at GBPUA&T, Pantnagar.

Water quality analysis

Domestic wastewater samples were collected from study site and tap water were analyzed for physico-chemical and biological parameters such as pH, Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP), Total Potassium (TK) and Sodium (Na). For sample collection, preservation and analysis, general guidelines given in Standard Methods for the Examination of Water and Wastewater [9], was followed. The percentage reduction was calculated by observing the average influents and effluents concentration of three samples collected on consecutive days for same HRT time.

Plant species

Aquatic and some other plants have phytoremediation potential for removal of water pollutants and these plants make the repid accumulation of pollutants into their differnt body parts and biomass. Therefore, two plants species namely, Pistia *(Pistia stratiotes)* and Canna *(Canna indica)* were selected for this lab experiment (Fig. 1). Initially the experiment was carried out in lab condition for acclimatization and standardization.

Table 1. Comparison of pollutants concentration to assess the phytoremediation efficiency of Pistia and Canna at 5, 10 and 15 days HRT's.

Parameters	Initial concentration		Pollutants concentration after 5 days				Pollutants concentration after 10 days				Pollutants concentration after 15 days			
			Canna		Pistia		Canna		Pistia		Canna		Pistia	
	TW	WW	TW	WW	TW	WW	TW	WW	TW	WW	TW	WW	TW	WW
pH	7.70	8.86	7.51	8.10	7.62	8.37	7.4	7.7	7.5	7.9	7.2	7.5	7.1	7.6
EC (µs cm^{-1})	251	552	213	466	209	472	204	448	200	457	192	412	196	416
COD (mg L^{-1})	6.38	380	4.94	292	5.01	302	3.49	276	3.94	284	2.74	213	2.97	208
BOD (mg L^{-1})	3.95	50.4	3.12	39.7	3.20	40.9	2.89	34.6	2.96	36.5	2.01	28.7	2.23	32.6
TS (mg L^{-1})	281	425	220	340	225	353	197	322	211	315	172	284	182	265
TDS (mg L^{-1})	161	289	117	213	121	224	98	199	110	212	79	170	92	187
TSS (mg L^{-1})	120	145	103	127	104	129	99	123	101	103	93	114	90	78
TN (mg L^{-1})	1.71	36.5	1.42	29.3	1.53	31.6	1.21	22.1	1.32	24.8	0.92	16.5	1.12	18.7
TP (mg L^{-1})	1.37	7.42	1.25	6.23	1.32	6.74	0.93	5.92	1.01	6.19	0.67	4.31	0.79	4.39
TK (mg L^{-1})	0.95	2.30	0.87	1.93	0.89	2.01	0.62	1.62	0.53	1.73	0.41	0.98	0.47	1.29
Na (mg L^{-1})	4.68	8.84	3.94	7.43	4.16	7.24	2.21	6.37	2.95	6.85	1.78	4.35	1.01	3.12

Lab experiments

A lab experiment was conducted in the month of August and September, 2016 in ambient atmosphere at GBPUA&T Pantnagar. The objective of this study was to standardize the system for phytoremediation of domestic wastewater in floating rafts and constructed wetland and validates the system at laboratory scale before field level study.

Treatments detail :

TW–100% Tap water

WW– 100% Waste water

A lab experiment conducted to assess the phytoremediation efficiency of Pistia and Canna separately in 10 liter volume plastic pots using wastewater and tap water as mention above.

Results and Discussion

Water samples were frequently collected and analyzed for plant pollutants removal efficiency and results are presented inTable 1. Each reading or data represent the mean of three samples. On the basis of overall water analysis it can be conclude that, Canna was observed to be having more pollutants removal efficiency as compared to Pistia plant species, probably due to more root hair zone and thicker leaves of Canna, however the long time detailed study needs for further support to the result.

The initial values/concentration (IC) of pH for tap water (TW) and wastewater (WW) were 7.70 and 8.86 (Table 1), respectively, which was reaching towards neutral pH (7.00) as both (Canna and Pistia) plants become aging, this trend of pH was similarly observed up to 15 days HRTs (hydraulic retention time). The initial Electrical Conductivity (EC) of wastewater was 552 µs cm^{-1}, which was reduced by 15.5% and 14.5% at 5 days HRTs by Canna and Pistia, respectively. At 10 and 15 days HRTs the Canna was observed more superior as compared to Pistia (Fig. 2).

The chemical oxygen demand (COD), removed by Canna was 23.1% in wastewater and 22.5% in tap water at 5 days HRTs, similarly decreased in COD concentration was also observed at 10 and 15 days HRTs. The trend of COD removal by Pistia was similar to the Canna's trend, but the removal efficiency was lower than Canna. Canna and calamus floating beds/ plant removal rates for COD were 42.3% and 36.3%, respectively [10]. Sun et al. [11] also showed that 39.9% COD reduction from 38.1 to 22.9 mg L^{-1} in 5 days through Canna grown floating system in polluted water.

Biological oxygen demand (BOD) was initially 3.95 and 50.4 mg L^{-1}, for tap water and wastewater. The removal rate of BOD for Canna was accordingly 21.2%, 31.3% and 43.0% at 5, 10 and 15 days HRTs. Navarro et al. [12] reported maximum 70% BOD re-

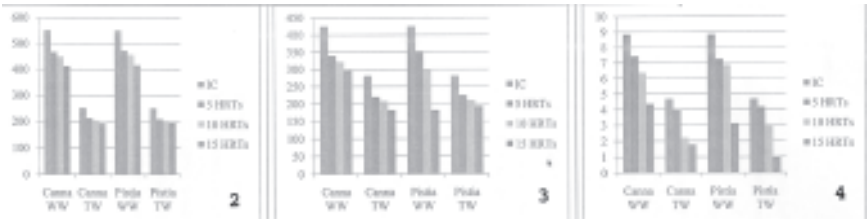

Fig. 2. Electrical Conductivity (EC). **Fig. 3.** Total solids (mg L^{-1}) removal trend. **Fig. 4**. Sodium (Na) concentration (mg L^{-1}).

duction from 325 to 98 mg L^{-1} in one day HRT for treatment of lemon industry wastewater by *Eishhornia crassipes* (Water hyacinth).

Initially total solids (TS) were 281 and 425 mg L^{-1} in tap water and wastewater, respectively. Canna was observed to remove the TS between 20 and 30% in case of wastewater, where 20% TS removed at 5 days HRTs and 30% removal rate was observed at 15 days HRTs (Fig. 3). Maximum 76% total solids reduction from 405 to 95 mg L^{-1} in one day HRT was observed by Navarro et al. [12] for treatment of lemon industry wastewater using *Eishhornia crassipes.* Similar decreasing trend was also observed for total dissolved solids (TDS) and total suspended solids (TSS) at all given HRTs (5, 10 and 15 days) and the Canna had shown the more efficient to remove these solids as compared to Pistia.

Total nitrogen (TN) in the tap water and wastewater were 1.71 and 36.5 mg L^{-1} (Table 1). The maximum reduction rate of 54.7% was observed by Canna at 15 days HRTs followed by 39.4% at 10 days HRTs. The maximum removal rate for Pistia was 48.7% in case of wastewater at 15 days HRTs. Total phosphorus and total potassium removal trend was similar to the trend of total nitrogen reduction, the maximum removal was done by Canna at all given HRTs as compared to Pistia. Aquatic plants have a good efficiency to remove nitrogen and phosphorus elements from wastewater [13, 14]. Cress has observed strong capacity to remove TN and TP, which was 76.86% and 90.45%, respectively at 20 days treatment [15].

The initial sodium (Na) of 4.68 and 8.84 mg L^{-1} were found in the tap water and wastewater, respectively (Fig. 4). Canna's removal rate for Na was 15.9% in wastewater at 5 days HRT, while it was 18.0% by Pistia. Similarly at 15 days HRT the Pisita's removal rate (64.7%) was higher than Canna's removal rate (50.7%). However, at 10 days HRT Canna was more efficient to remove the Na as compared to Pistia.

The result of this experiment was relatively assess to select plant species out of Canna and Pistia, as more efficient phytoremediation plant for above selected parameters and more efficient one, that was Canna, subjected to further extension of this method at field level for phytoremediation of domestic wastewater discharge through residential colony at (Mahakaleshwar Temple, Pantnagar) G..B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

Cunclusion

Increased concern about pollution free environment and huge generation of wastewater encourages enough to treat the wastewater and its reuse for non-potable applications after certain treatment using phytoremediation process as plant based green technology. On the basis of laboratory analysis of all above mentioned parameters, the relative comparison for phytoremediation potential between Canna and Pistia was done and concluded that, the Canna was found more potential for pollutants removal at all selected HRTs as compared to Pistia, and the Canna was again selected and presently under process for field level experiment at GBPUA&T, Pantnagar.

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