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Research Article

PERFORMANCE OF *Cyperus rotundus L.* MACROPHYTES FOR THE SEWAGE TREATMENT AT DIFFERENT CONCENTRATIONS IN THE FLOATING CONSTRUCTED WETLAND REACTORS

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A B S T R A C T

The quantity of sewage generation is increasing day by day especially in cities and its treatment has become a big challenge. Treatment of sewage before disposal is essential to reduce the effect of pollution on the environment which can be achieved by phytoremediation using *Cyperus rotundus* L. macrophyte. The present investigation was aimed to study the treatment performance and phytotoxic response of *Cyperus rotundus* L. macrophyte at different concentrations of sewage using a newly developed model of Floating Constructed Wetland Reactor system. The pre-characterized sewage was treated in the batch mode at its different concentrations in Floating Constructed Wetland Reactors (FCWRs) made up of plastic crates having layers beds of thermocol sheet, stone crush aggregates and sand, and was equipped with 120 saplings of *Cyperus rotendus L.* macrophytes in each reactor planted in 5 rows and 6 columns with 4 saplings at each point. The experiments were carried out in same environment with similar operating conditions to justify comparative treatment performances at different sewage concentrations in terms of reduction in different parameters such as TSS, TDS, TS, BOD, COD, sulphtes, nitrates, phosphates and chlorides. There was considerable reduction in terms of all pollution parameters. The highest BOD reduction of 83.88%, was recorded in 20% sewage set with COD reduction upto 86.36%, TSS reduction upto 81.48%, TDS reduction upto 82.19% without any sign of phytotoxicity. within 35 days of treatment period. The results indicate that the design fabricated is perfectly workable for phytoremediation using *Cyperus rotundus* macrophyte.

INTRODUCTION

Conventional treatment of sewage and wastewater is costly, requires electricity and skilled personals for system operation are also essential. Phytoremediation is one of the sustainable, natural and cheap methods for treating the domestic sewage, industrial effluents and agricultural liquid wastes. Now a day, the contaminated wastewater treatment is a challenge before the human society due to its environmental complications as it is contaminated with many impurities like heavy metals, fecal waste and organic contaminants. Therefore, its efficient treatment is necessary to avoid the adverse effects on environment. The present investigation was aimed to investigate the phytoremediation treatment potential, toxicity tolerance to concentrations of sewage and treatment performance of *Cyperus rotendus L.* species which is studied using different sewage concentrations, each in the separate plastic crates with lower bed of thermocol sheets, followed by a middle layer of stone crushed aggregates and sand as uppermost layer. The details of design and construction of FCWR systems are described elsewhere [1].The macrophyte *Cyperus rotundus* L. is commonly known as coco-grass, red nut sedge or purple nut sedge. It is a species of sedge family belongs to Cyperaceae. It is native to Africa, southern and central Europe and southern Asia. The root system of a young *C. rotundus* plant initially forms white, fleshy rhizomes. Some of these rhizomes grow upward and then they form bulb-like structures from which new shoots and roots grow. From these newly formed roots, new rhizomes grow [2].

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MATERIALS AND METHODS

The locally available aquatic macrophyte plant of *Cyperus rotundus* L. was planted, acclimatized for sewage for a month and the used for treatment studies at various concentrations of sewage in a batch mode of operation. The holding tank made up of iron sheet was used as batch effluent holder in which the floating constructed wetland reactor system was floated. The sewage samples were collected from the local nala flowing across Paithan road at Itkheda area of Aurangabad. The floating constructed wetland reactor setups with *Cyperus rotundus* L.were floated for batch studies in the holding tank containing municipal sewage in different concentrations along

with the control using tap water were arranged simultaneously after characterizing the holding contents for initial characterization in terms of pollution parameters. The characteristic studied included physiochemical parameters like pH, EC, TSS, TDS, TS, BOD, COD, Nitrates, phosphates, sulphates and chlorides using standard methods [3]. The parameters were determined from the liquid solutions of the plastic trays as and when it was needed. Mainly, at the initial stage, final stage and at suitable stages of intermediate periods with the interval of 7 days. The analyses were carried out with required filtering for sulphates, nitrates, sulphates and chlorides, as required otherwise. The methods of analysis were in consistent with the standard methods (3-8). During the experimental period of treatment, the adequate samples were taken for intermediate analysis at the interval of 7 days. These samples were analyzed for intermediate stages of treatment as done earlier [1] and also by the others [9-10]. The treatment experiment was continued for 35 days for final analysis. The results obtained before phytoremediation were noted as initial values while the results obtained after phytoremediation treatment are indicated by final values for the data analysis.

RESULTS AND DISCUSSION

Characterization of wastes is essential to insure the effectiveness of treatment with phytoremediation using any aquatic macrophytes. Initial characterization helps to insure the treatment by serving as baseline to insure the treatment at different time intervals in the course of treatment periods. It helps find the treatment efficiency over the treatment periods and effectiveness of macrophytes, if simultaneous experiments are arranged using different macrophytes in the same environment with similar operating conditions and by adopting same experimental procedures. It is also helpful in the choice of any other treatment methods deciding the extent of treatment as it reflects wastewater purification capacity of treatment technology under consideration. The initial analysis of wastewater or sewage gives details of pollution levels in each particular case which is advisable and may be used during initial stage of planning for wastewater or sewage treatment units. The municipal sewage contains both, the domestic and industrial wastewater. It can differ from place to place, location to location and city to city depending upon the type of sewage generating sources, status of people, habits of native residents and nature of human settlement and trade establishments discharging effluents to sewerages. The important characteristics of sewage at different dilution concentrations are presented in Table 1.

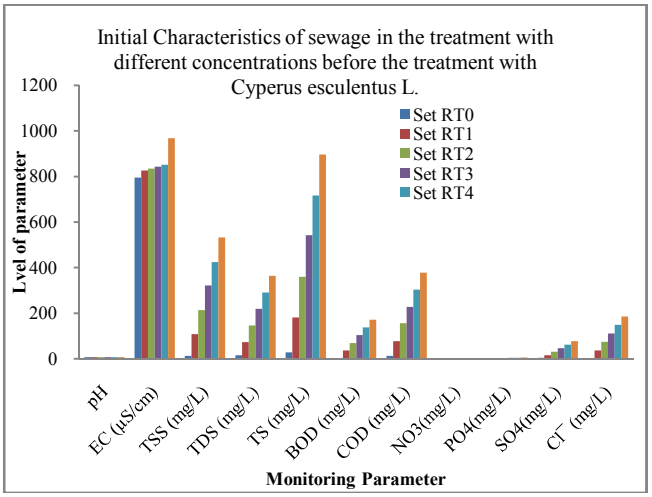

Fig 1 Initial Characteristics of sewage in the treatments with different concentrations before the treatment with *Cyperus rotundus* L.

The characteristics of wastewater initially analyzed for arranging the study are graphically presented in Fig.1 for the comparative easiness of the readers. The characteristics of tap water used for preparing different concentrations of sewage by dilutions indicated that the pH was 7.1, EC was 796 µS/cm, TSS contents were 12 mg/L, TDS contents- 16 mg/L, BOD-1.2 mg/L, COD 12.3 mg/L with the nitrate level of 0.11 mg/L, phosphate level to 0.01 mg/L, sulphate contents upto 4.4 mg/L and chloride contents upto 1.0 mg/L.

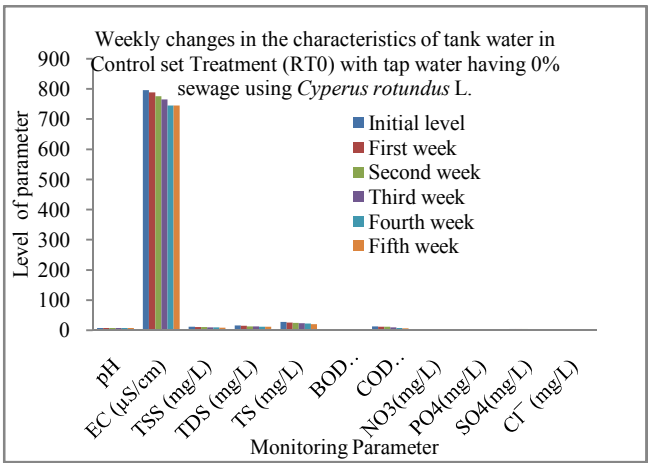

Fig 2 Weekly changes in the characteristics of tank water in Control set Treatment (RT_0) with tap water having 0% sewage using *Cyperus rotundus* L.

Table 1 Initial Characteristics of sewage in the treatment with different concentrations before the treatment with *Cyperus rotundus* L.

Pre-treatment Details of all Experimental Set Ups	Treatment Set with Initial Characteristics of sewage at different concentrations					
Parameters	**Reference set (T_0) with 0% Conc. of sewage(Tap water)**	**Treatment (T_1) with 20% Conc. of sewage**	**Treatment (T_2) with 40% Conc. of sewage**	**Treatment (T_3) with 60% Conc. of sewage**	**Treatment (T_4) with 80% Conc. of sewage**	**Treatment (T_5) with 100% Conc. of sewage**
pH	7.1	7.3	7.3	7.4	7.4	7.5
EC (µS/cm)	796	826	834	843	852	968
TSS (mg/L)	12	108	214	322	425	532
TDS (mg/L)	16	73	146	220	291	364
TS (mg/L)	28	181	360	542	716	896
BOD (mg/L)	1.2	36	68.8	104	138.2	172
COD (mg/L)	12.3	77	155.6	227.3	303.4	378
NO_3(mg/L)	0.11	0.043	0.087	0.130	0.175	0.22
PO_4(mg/L)	0.01	1.26	2.46	3.78	5.04	6.13
SO_4(mg/L)	4.4	15.44	31.06	47.04	61.95	77.4
Cl^- (mg/L)	1.0	37.2	74.4	111.6	148.8	186

Weekly changes in the characteristics of tank water in Control set Treatment (RT0) with tap water having 0% sewage using *Cyperus rotundus* L. and are presented in Fig. 2 for reference purpose. There was considerable reduction in pollution parameters in first two weeks of treatment in almost all treatment concentrations of sewage treated with *Cyperus rotundus* L.

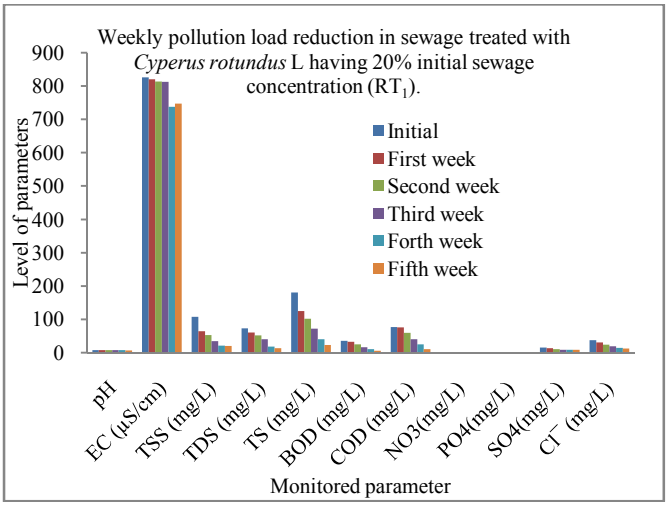

Fig 3 Weekly changes in the characteristics of tank water in Control set Treatment (RT_1) having 20% sewage using *Cyperus rotundus* L.

The concentration of TSS was reduced to 64 mg/L after first week, 53 mg/L after second week. It was 34.5 and 21.5 after third and fourth weeks and finally reduced to 13 mg/L after fifth weeks of treatment. The total solids were reduced from 181 mg/L to 23 mg/L in five weeks of treatment period. During this time of treatment, the BOD was reduced from 36 mg/L to 5.8 mg/L and COD was reduced from 77 mg/L to 10.5 mg/L during this treatment period of five weeks. The changes observed in terms of pollution parameters in the set of 20% sewage (Set RT_1) treated with *Cyperus rotundus* L. are presented in Fig.3.

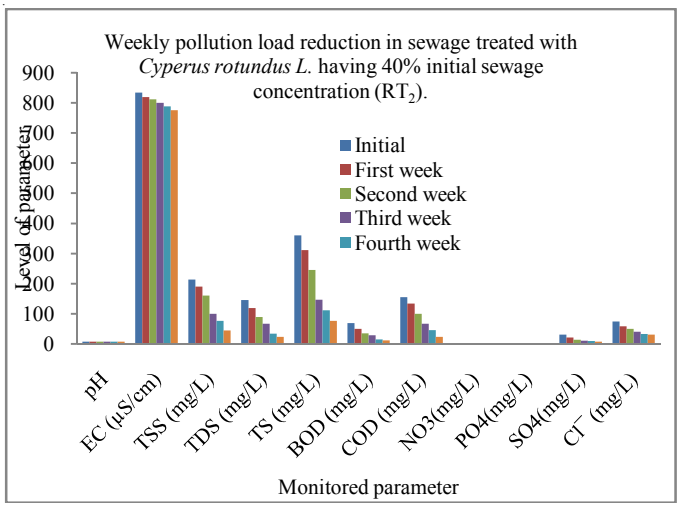

Fig 4 Weekly pollution load reduction in sewage treated with *Cyperus rotundus L.* having 40% initial sewage concentration (RT_2).

The reduction in terms of pollution parameters in the treatment set of 40% sewage (Set RT_2) was highest as compared to other tratment sets. The TSS contents and TDS contents in Set RT_2 were reduced to 45 mg/L and 23 mg/L from 214 mg/L and 146 mg/L respectively in the treatment period of five weeks. The BOD and COD were reduced to 11.4 mg/L and 23.5 mg/L from 68.8 mg/L and 155.6 mg/L respectively during this period. The results obtained in terms of treatment performance in different weeks of treatment in set RT_2 are presented in Fig.4.

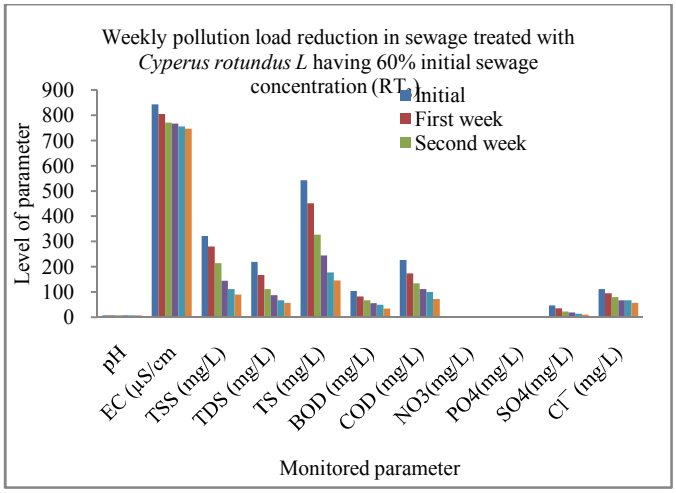

Fig 5 Weekly pollution load reduction in sewage treated with *Cyperus rotundus L* having 60% initial sewage concentration (RT_3).

Sewage treatment at its 60% (RT_3) concentration using Cyperus rodundus L. was also efficient in terms of pollution parameter reduction. The total solids were reduced to 146 mg/L from initial level of 542 mg/L with reduction of TSS and TDS contents from 322 mg/L and 220 mg/L to 90 mg/L and 56.5 mg/L respectively. The BOD was reduced to 34.5 mg/L from 104 mg/L and COD was reduced to 72.3 mg/L from 227.3 mg/L. The overall treatment performance in terms of major parameters monitored in set RT_3 during the period of five week treatment is presented in Fig. 5.

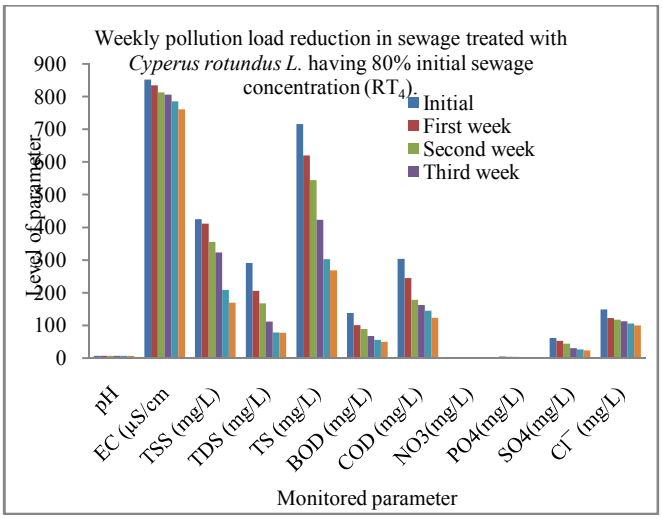

Fig 6 Weekly pollution load reduction in sewage treated with *Cyperus rotundus L.* having 80% initial sewage concentration (RT_4).

The sewage treatment with Cyperus rotundus L. at 80% concentration (RT_4)was rapid in first three weeks and comparatively slow in last two weeks. The initial concentration of TSS content was 425 mg/L and was reduced to 169 mg/L in five weeks of treatment. The total solids were reduced from 716 mg/L to 268 mg/L. The level of BOD was decreased from 138.2 mg/L to 50.3 mg/L and COD was decreased from 303.4 mg/L to 123.3 mg/L during this treatment period of five weeks. The weekly treatment

performance in set RT_5 in terms of all monitored parameters is presented in Fig.6.

The sewage was treated with *Cyperus rotundus* L. without diluting it (Set-RT_5) and the treatment performance in terms of monitored parameters is presented in Fig. 7. The results indicated that the total solids were reduced from 896 mg/L to 468 mg/L with the reduction of TSS contents from 532 mg/ to 261 mg/L and reduction of TDS contents from 364 mg/L to 192 mg/L respectively in five week period. The BOD and COD levels were reduced from 172 mg/L and 378 mg/L to 67 mg/L and 189 mg/L respectively.

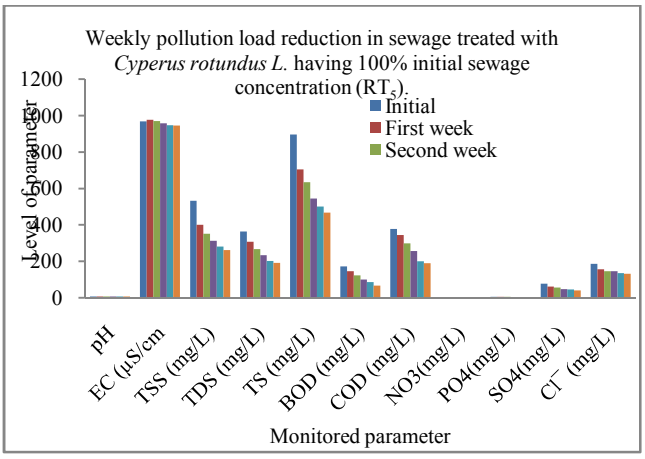

Fig 7 Weekly pollution load reduction in sewage treated with *Cyperus rotundus L.* having 100% initial sewage concentration (RT_5).

Generally, the domestic sewage contains considerable quantities of nitrogen, phosphorus, sulfer and chloride contents those take care of the needs of the biological growth in treatment process. The organic matters in sewage have adequate nitrogen content. Phosphorus is contributed to domestic sewage from food residues and use of increased quantities of synthetic detergents adds substantially to the phosphorus content to the sewage and is to support biological wastewater treatment. Concentration of chlorides in sewage is greater than the normal chloride content of water supply. The chloride concentration in sewage is always in excess than the water supplied. These all major nutrients supported the growth of *Cyperus rotundus* L. and in the sewage treatment process. The comparative treatment performances in terms of monitored parameters of all sets of treatments are presented in Fig.8. The major nutrients in terms of nitrates, phosphates, sulphates and chlorides were considerably reduced in all treatment sets evidenced by their levels in these all sets.

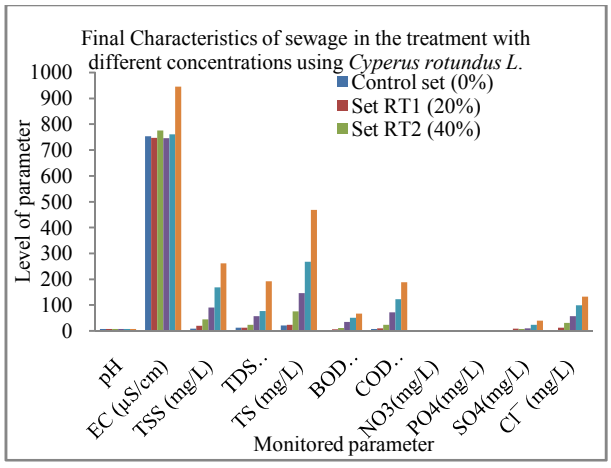

Fig 8 Final Characteristics of sewage in the treatment with different concentrations using *Cyperus rotundus* L.

The overall results indicate that the macrophyte studied is capable to treat the sewage at any of the concentrations. The treatment efficiency varies with the concentrations of sewage. It was noticed that the efficiency was highest at 40% sewage concentration and was slightly less in higher and lower concentrations. The treatment of sewage is possible with the macrophyte studied in present investigation, even without undergoing dilution process for sewage. The treatment efficiencies of sewage treatment in different treatment sets with different concentrations by the treatment with *Cyperus rotundus* L. are graphically presented in Fig. 9.

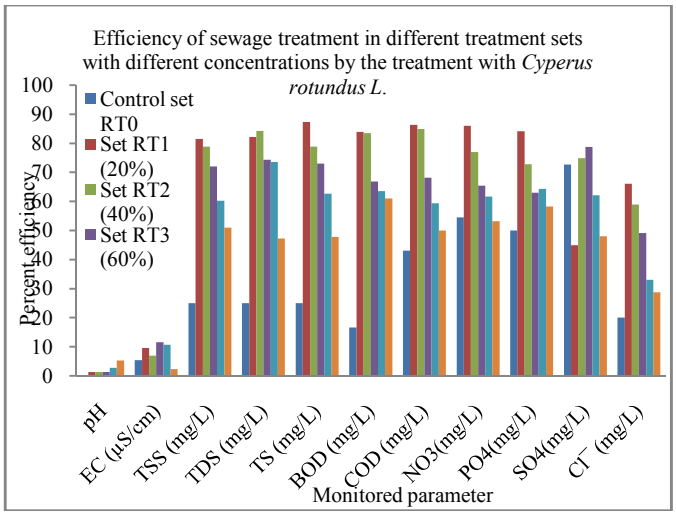

Fig 9 Efficiency of sewage treatment in different treatment sets with different concentrations by the treatment with *Cyperus rotundus* L.

The overall treatment of sewage in all sets was considerable in terms of all parameters. The pH of sewage increased from acidic to slightly alkaline or was gained same levels. The blackish-brown color was removed. The offensive odor was also removed by the treatment process in all sets of treatments. It was observed that the treated water in all sets become relatively clear and odorless and hence can be suggested for the gardening, floor cleaning or similar purposes like irrigation to agricultural fields and for growing aquatic animals. There were no phytotoxic signs in any of the treatment sets indicating the high tolerance of *Cyperus rotundus* L. macrophyte plant for sewage. The floating wetland reactor system was an effective treatment system to employ C*yperus rotundus* L.macrophyte for phytoremediation of sewage and system was found more cost effective as compared to the const of conventional treatment plants. The floating wetland reactor system with *Cyperus rotundus* L. is one of the suitable design workable at any concentration of sewage for phytoremediation process.

CONCLUSIONS

From the study conducted, it is evidenced that the major pollutants such as BOD, COD, TSS, TDS and nitrate were removed remarkably from the sewage by cyperus rotundus successfully using newly designed floating reactor for phytoremediation in 35 days at all sewage concentrations. The highest BOD reduction of 83.88%, was recorded in 20% sewage set with COD reduction upto 86.36%, TSS reduction upto 81.48%, TDS reduction upto 82.19%. The nitrates, phosphates sulphates and chlorides were reduced by 86.05%,

84.13%, 44.95%, and 66.13% respectively. The highest sulphet reduction upto 78.70% was noticed in the treatment set with 60% sewage concentration.

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