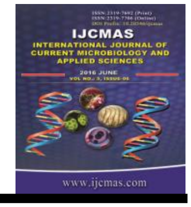
Int.J.Curr.Microbiol.App.Sci (2016) *5*(6): 97-104

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 5 Number 6 (2016) pp. 97-104**
Journal homepage: http://www.ijcmas.com



Original Research Article http://dx.doi.org/10.20546/ijcmas.2016.506.012

Impact of Plant Density on the Sewage Treatment through selected Aquatic Macrophytes Using Angular Horizontal Subsurface Flow Constructed Wetland

V.P. Dhulap* and S.S. Patil

[1]Department of Environmental Science, Solapur University, Solapur - 413255(MS), India
[2]Department of Environmental Science, Dr. B.A.M. University, Aurangabad- 431004, (MS), India
**Corresponding author*

A B S T R A C T

Constructed wetland treatments are engineered systems that have been designed and constructed to utilize the wetland vegetation, soils and microbial populations to treat contaminants from surface water, ground water and wastewater. The use of constructed wetlands to treat wastewater is rapidly emerging as a feasible alternative at worldwide. A pilot scale study was conducted to examine the feasibility study and impact of plant density on the sewage treatment through selected wetland rooted plant species using Angular Horizontal Subsurface Flow (AHSSF) constructed wetland. In the present study *100 % sewage concentration and Cana indica, Pannicum maximum, Colocasia esculenta, Typha latifolia, Pennisetum purpureium Schumach and Eichhornia crassipes* of plant species were used and planted in equal numbers in the media bed and examined its impact on the sewage treatment. *In this investigation only plant growth and pollutants removal efficiency was studied in various seasons during sewage treatment. In this overall study the Pennisetum purpureium of emergent and Eichhornia crassipes* of free floating plants removed greatest and maximum organic and inorganic pollutants from the sewage. The constructed wetland bed of all plants shows greenery, leafier and seems flowering and also most of the faunal species were attracted towards the experimental bed.

Keywords

Constructed wetland, Plant Biomass, Sewage treatment, Angular Horizontal Subsurface Flow, Pennisetum purpureium, pollutants removal efficiency.

Article Info

Accepted:
07 May 2016
Available Online:
10 June 2016

Introduction

The system of planting aquatic plants such as reeds or bulrushes in a wet (often gravel) substrate medium for gray water recycling is called a "Constructed Wetland" or "Artificial Wetland" or "Human Engineered Wetland". Constructed wetlands with emergent vegetation have been used to treat various types of wastewaters (Wallace and Knight, 2006). They are efficient in removal of organics through microbial degradation and settling of colloidal particles. Suspended solids are effectively removed via settling and filtration through the dense vegetation (Kadlec and Wallace, 2008).The use of constructed wetlands can be a cost-effective treatment alternative (Baltic Deal, 2011; Salomon and Sundberg, 2012; Hegazy *et al*., 2013). Subsurface flow wetland is considered to be advantageous as compared to the open surface wetlands and which are more commonly used for individual households. Constructed wetlands generally consist of one or more lined beds, or cells. Microorganisms and plants seem to work together symbiotically in constructed wetlands, as the population of microorganisms is much higher in the root areas of the plants than in the gravel alone. In comparison with conventional treatment systems, constructed wetlands have lower energy and chemical requirements. Another attraction of constructed wetlands is simplicity in operation, with less need for highly skilled manpower in day to day operations. They can be incorporated into the rural or urban landscape quite effectively, even in difficult terrain (Mayor and Sarana, 1950). Constructed wetlands are also appropriate for developing countries but they still have to become better known there (Mohamed, 2004; Heers, 2006; Kamau, 2009). Constructed wetlands have been used as an alternative option to treat wastewater.

The present study was conducted to assess the performance of AHSSF constructed wetland as a low cost facility to remediate (physically and biologically) pollution in wastewater phytoremediation treatment using planted macrophytes and study was conducted to examine the impact of plant density on the sewage treatment.

Material and Methods

In the present work planted equal numbers of plants in the plant media or in the media bed and this seems its impact on the sewage treatment. The experiment was performed in the Department of Environmental Science, Solapur University Solapur (M.S) India. In experimental designing and fabrication of constructed wetlands there are three sets of buckets with different sizes and dimensions were used. The root zone bed set was prepared in three layers which were prepared with pebbles, sand and garden sieved soil. Selective healthy, small, young, locally available saplings of macrophytes were transplanted and which were arranged in rows and columns. The plant bed was provided 10^0 slopes and kept in the slanting position. Inlet and outlet flow rates were preset by using bucket and timer (Dhulap and Patil, 2014; Dhulap *et al*., 2014). In this study 100 % sewage concentration were tested using *Cana indica, Pannicum maximum, Colocasia esculenta, Typha latifolia, Pennisetum purpureium Schumach* and Eichhornia *crassipes* plant species. Each plant species of their densities and their treatment efficiencies were calculated.

Result and Discussion

Cana indica plant growth results shows that, plant biomass or number of *Cana* was increase 40 numbers at 0 day, 42 at 1st day, 45 at 2nd day, 48 at 3rd day, 53 at 4th day and 59 numbers at 5th day respectively (Fig. 1). On the same time studied sewage characteristics at 0 day to 5th day. The sewage result reveals pH values were changed by 6.83 at 0 day to 7.3 at 5th day. BOD (mg/L) was reduced by 51.44 at 0 day to 3.44 at 4th day. COD (mg/L) was reduced by 118 at 0 day to 8.9 at 4th day. Study showed the maximum pollutants removed at 4th day (Table 1).

Pannicum maximum shows that, plant biomass or number of *Pannicum* was increase 40 numbers at 0 day, 48 at 1st day, 66 at 2nd day, 74 at 3rd day, 79 at 4th day and

88 numbers at 5th day respectively (Fig. 2). The pH values were changed by 6.79 at 0 day to 7.29 at 5th day. BOD (mg/L) was reduced by 42.0 at 0 day to 3.50 at 4th day. COD (mg/L) was reduced by 118 at 0 day to 11.2 at 4th day. Study showed the maximum pollutants removed at 4th day (Table 2).

Colocasia esculenta shows that, plant biomass or number of *Colocasia* was increase 40 numbers at 0 day, 41 at 1st day, 46 at 2nd day, 54 at 3rd day, 63 at 4th day and 69 numbers at 5th day respectively (Fig. 3). The pH values were changed by 6.79 at 0 day to 7.91 at 5th day. BOD (mg/L) was reduced by 42.0 at 0 day to 3.82 at 4th day. COD (mg/L) was reduced by 121 at 0 day to 11.86 at 4th day respectively. Study showed the maximum pollutants removed at 4th day (Table 3).

Table.1 Effect of plant growth of Cana indica (Density) on wastewater treatment through various parameters at 100% concentration of sewage

S.N.	Parameters	0 Day	1st Day	2nd Day	3rd Day	4th Day	5th Day
1.	Plant Growth (Numbers)	40	42	45	48	53	59
2.	Ph	6.83	7.8	7.65	7.56	7.43	7.03
3.	EC (µMoh/Cm)	2.56	1.12	0.92	0.88	0.82	0.84
4.	TSS (mg / L)	394	223	203	109	100	102
5.	TDS (mg / L)	1364	1129	961	612	458	462
6.	TS (mg / L)	1758	1352	1164	721	558	564
7.	BOD (mg / L)	51.44	37.04	12.36	7.27	3.44	3.48
8.	COD (mg / L)	118	92.82	31.08	19.02	8.9	9.1
9.	NO_3 (mg / L)	26.8	19.06	15.02	9.05	3.02	3.06
10.	PO_4 (mg / L)	21.60	17.81	12.48	7.08	2.41	2.48
11.	SO_4 (mg / L)	107	94.0	78.0	31.0	19.46	19.51

Table.2 Effect of plant growth of Panicum maximum (Density) on wastewater treatment through various parameters at 100% concentration of sewage

S.N.	Parameters	0 Day	1st Day	2nd Day	3rd Day	4th Day	5th Day
1.	Plant Growth (Numbers)	40	48	66	74	79	88
2.	pH	6.79	6.96	7.86	7.52	7.21	7.29
3.	EC (µMoh/Cm)	2.63	2.12	1.89	1.07	0.89	0.93
4.	TSS (mg / L)	392	291	143	112	97	102
5.	TDS (mg / L)	1360	1091	784	490	465	469
6.	TS (mg / L)	1752	1382	927	602	562	571
7.	BOD (mg / L)	42.0	34.8	21.6	9.26	3.50	3.54
8.	COD (mg / L)	118	92.7	36.7	21.8	11.2	11.7
9.	NO_3 (mg / L)	26.8	19.6	11.7	9.3	3.9	4.2
10.	PO_4 (mg / L)	21.60	17.92	12.41	8.66	2.80	3.12
11.	SO_4 (mg / L)	107.0	89.0	66.0	39.0	22.0	24.7

Table.3 Effect of plant growth of *Colocasia esculenta* (Density) on wastewater treatment through various parameters at 100% concentration of sewage

S.N.	Parameters	0 Day	1st Day	2nd Day	3rd Day	4th Day	5th Day
1.	Plant Growth (Numbers)	40	41	46	54	63	69
2.	pH	6.79	7.12	7.23	7.61	7.82	7.91
3.	EC (µMoh/Cm)	2.63	2.17	1.72	1.02	0.98	0.99
4.	TSS (mg / L)	402	339	201	115	103	111
5.	TDS (mg / L)	1360	1043	726	502	471	481
6.	TS (mg / L)	1762	1382	927	617	574	579
7.	BOD (mg / L)	42.0	36.04	21.05	9.86	3.82	4.2
8.	COD (mg / L)	121	93.7	37.9	24.3	11.86	12.87
9.	NO_3 (mg / L)	26.8	19.2	13.2	9.5	4.3	4.7
10.	PO_4 (mg / L)	24.60	18.81	12.46	8.67	2.92	3.2
11.	SO_4 (mg / L)	109.0	84.0	59.0	31.0	23.0	24.2

Table.4 Effect of plant growth of *Typha latifolia* (Density) on wastewater treatment through various parameters at 100% concentration of sewage

S. N.	Parameters	0 Day	1st Day	2nd Day	3rd Day	4th Day	5th Day
1.	Plant Growth (Numbers)	40	47	59	68	77	84
2.	pH	6.62	7.59	7.52	7.49	7.48	7.82
3.	EC (µmohs/cm)	2.63	2.20	1.17	0.98	0.92	1.01
4.	TSS (mg/L)	335	297	210	134	96	102
5.	TDS (mg/L)	1631	1371	1064	752	548	551
6.	TS (mg/L)	1966	1668	1274	886	644	653
7.	BOD (mg/L)	46.0	32.0	21.4	14.7	4.26	4.39
8.	COD (mg/L)	111.0	76.2	26.8	12.4	9.2	11.2
9.	NO_3 (mg/L)	21.0	17.6	13.1	9.2	3.0	3.6
10.	PO_4 (mg/L)	17.0	12.5	9.3	6.2	1.82	2.9
11.	SO_4 (mg/L)	96.0	88.0	67.0	58.0	46.0	54.0

Table.5 Effect of plant growth of *Pennisetum purpureium* (Density) on wastewater treatment through various parameters at 100% concentration of sewage

S. N.	Parameters	0 Day	1st Day	2nd Day	3rd Day	4th Day	5th Day
1.	Plant Growth (Numbers)	40	47	53	64	72	86
2.	pH	6.72	7.80	7.61	7.56	7.42	7.38
3.	EC (µmohs/cm)	2.56	1.10	0.89	0.88	0.78	0.83
4.	TSS (mg/L)	394	210	144	97	88	93
5.	TDS (mg/L)	1364	1038	920	524	451	458
6.	TS (mg/L)	1758	1248	1064	621	539	551
7.	BOD (mg/L)	51.44	36.00	12.00	7.08	3.38	3.42
8.	COD (mg/L)	118	90.16	29.80	18.20	8.07	8.09
9.	NO_3 (mg/L)	26.8	18.60	14.40	8.22	2.09	3.03
10.	PO_4 (mg/L)	21.60	16.40	11.58	6.50	2.32	2.40
11.	SO_4 (mg/L)	107	89.0	62.0	29.0	18.20	18.42

Table.6 Effect of plant growth of *Eichhornia crassipes* (Density) on wastewater treatment through various parameters at 100% concentration of sewage

S. N.	Parameters	0 Day	1st Day	2nd Day	3rd Day	4th Day	5th Day
1.	Plant Growth (Numbers)	40	49	57	66	78	91
2.	pH	6.81	7.97	7.86	7.57	7.42	7.34
3.	EC (µmohs/cm)	0.6	1.3	1.9	2.2	3.2	3.7
4.	TSS (mg/L)	1920	1773	1066	838	595	607
5.	TDS (mg/L)	1240	1772	768	712	545	547
6.	TS (mg/L)	3160	2945	1834	1550	1140	1154
7.	BOD (mg/L)	230	220	200	165	118	120
8.	COD (mg/L)	315	290	192	172	156	162
9.	NO_3 (mg/L)	9.2	8.0	6.0	5.1	1.23	3.0
10.	Chlorides mg/L)	44.2	28.40	26.98	24.14	22.10	23.10

Fig.1 Growth of *Cana indica*

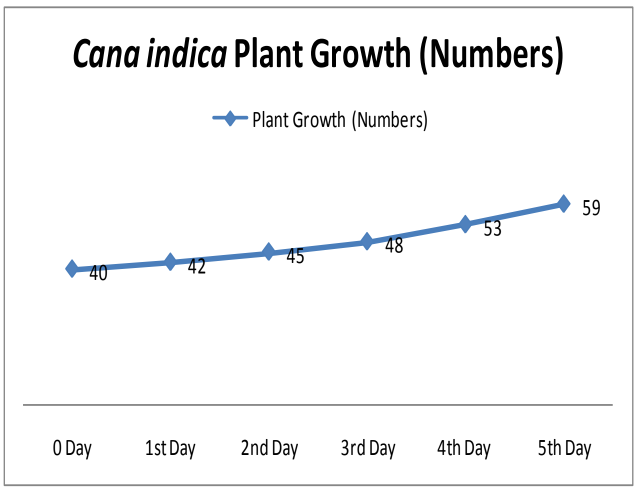


Fig.1 Growth of Panicum maximum

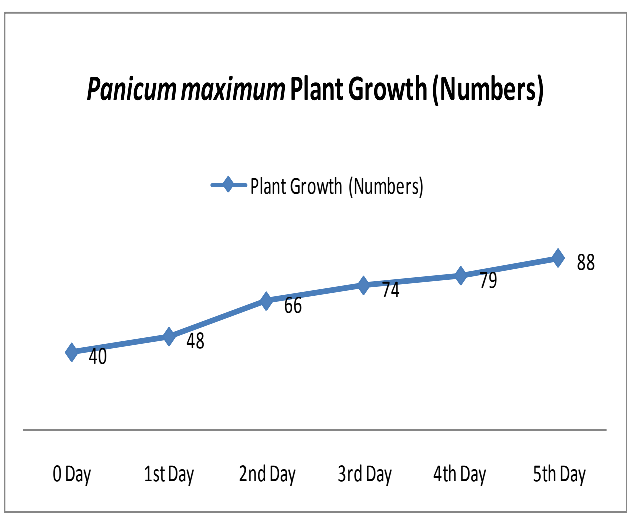


Fig.3 Growth of *Colocasia esculenta*

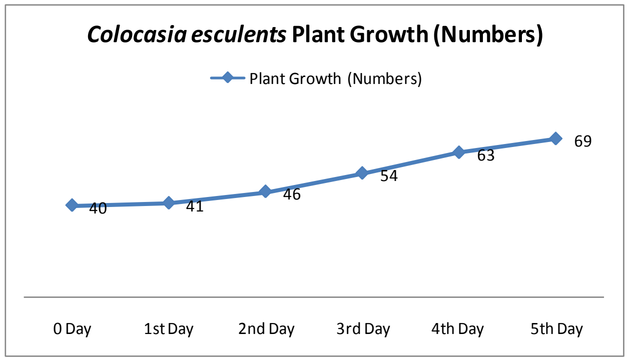


Fig.4 Growth of *Typha latifolia*

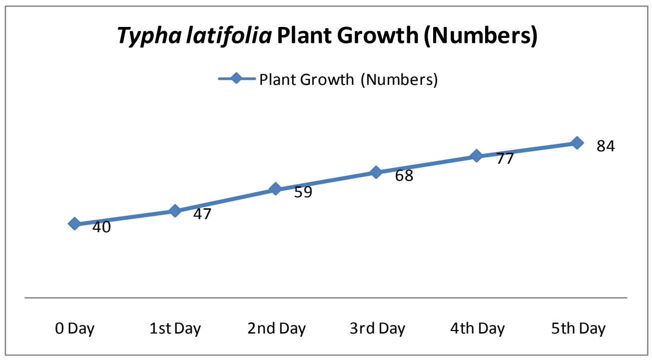


Fig.5 Growth of *Pennisetum purpureium*

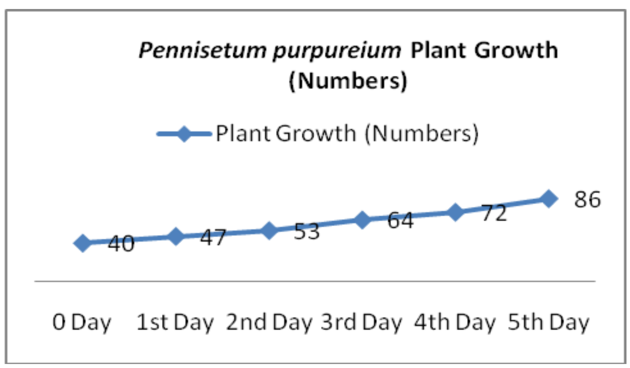
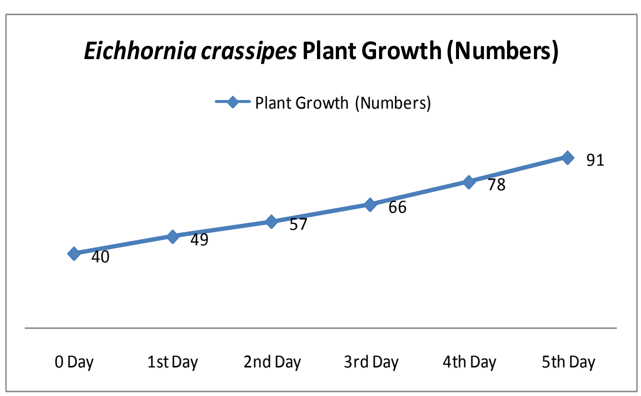


Fig.6 Growth of *Eichhornia crassipes*



Typha latifolia shows that, plant biomass or number of *Typha* was increase 40 numbers at 0 day, 47 at 1st day, 59 at 2nd day, 68 at 3rd day, 77 at 4th day and 84 numbers at 5th day respectively (Fig. 4). The pH values were changed by 6.62 at 0 day to 7.82 at 5th day. BOD (mg/L) was reduced by 46.0 at 0 day to 4.26 at 4th day. COD (mg/L) was reduced by 111 at 0 day to 9.2 at 4th day respectively. Study showed the maximum pollutants removed at 4th day (Table 4).

Pennisetum purpureium shows that, plant biomass or number of *Pennisetum* was increase 40 numbers at 0 day, 47 at 1st day, 53 at 2nd day, 64 at 3rd day, 72 at 4th day and 86 numbers at 5th day respectively (Fig. 5). The pH values were changed by 6.72 at 0 day to 7.38 at 5th day. BOD (mg/L) was reduced by 51.44 at 0 day to 3.38 at 4th day. COD (mg/L) was reduced by 118 at 0 day to 8.07 at 4th day respectively. Study showed the maximum pollutants removed at 4th day (Table 5).

Eichhornia crassipes shows that, plant biomass or number of *Eichhornia* was increase 40 numbers at 0 day, 49 at 1st day, 57 at 2nd day, 66 at 3rd day, 78 at 4th day and 91 numbers at 5th day respectively (Fig. 6). The pH values were changed by 6.81 at 0 day to 7.34 at 5th day. DO (mg / L) was increased by 0.6 at 0 day to 3.7 at 5th day. BOD (mg/L) was reduced by 230 at 0 day to 118 at 4th day. COD (mg/L) was reduced by 315 at 0 day to 156 at 4th day respectively. Study showed the maximum pollutants removed at 4th day, but the plant growth was increases continuously and plant bed observed the greenery, leafier and seems flowering (Table 6).

In conclusion, this overall study the *Pennisetum purpureium* of emergent and *Eichhornia crassipes* of free floating macrophytes removed greatest and maximum organic, inorganic pollutants from the sewage. All plant beds observed greenery, leafier and seem flowering due to this most of the faunal species was attracted towards the experimental setup of pilot plant.

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How to cite this article:

Dhulap, V.P., and Patil, S.S. 2016. Impact of Plant Density on the Sewage Treatment through selected Aquatic Macrophytes Using Angular Horizontal Subsurface Flow Constructed Wetland. *Int.J.Curr.Microbiol.App.Sci*. 5(6): 97-104.
doi: http://dx.doi.org/10.20546/ijcmas.2016.506.012