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Comparative eco-physiological potential of a submerged and a free floating aquatic plant to treat domestic wastewater

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Abstract
Domestic wastewater treatment has become a remarkable aquatic environmental problem for all over the world. Due to non-availability of cheaper methods and higher cost of treatment plants, municipalities are diverting untreated domestic wastewater in to aquatic bodies like ponds and lakes, where it is causing eutrophication due to higher concentration of nutrients and leads water unhygienic to use. Present research experimented by culturing *Hydrilla verticillata*, and *Pistia stratiotes* seprately in domestic wastewater for subsequent seven days over the year. The quality of domestic wastewater before and after the treatment/culture was evaluated by analyzing physico-chemical parameters of domestic wastewater followed by APHA-AWWA-WPCF (1980).The results of physico-chemical analysis of domestic wastewater and estimation of net primary productivity of experimental aquatic plants after the culture have indicated an improvement in water quality and increase in biomass. Both the aquatic plants proved to be efficient in treatment of domestic wastewater and their increased weight in culture has potential value in biomass generation.It is concluded that both the aquatic plants perform significant potential to remove nutrients from domestic wastewater and also showed seasonal variation for the purpose.

Keywords: Domestic wastewater, Eutrophication, *Hydrilla verticillata*, NPP, Nutrient removal, Physico-chemical parameters, *Pistia stratiotes*

INTRODUCTION

Domestic wastewater disposal problem is as old as the formation of larger settlements. In developing countries like India, new challenges in the field of environment all over the world. Almost none of the cities posses proper disposal system and treatment plants for domestic wastewater, consequently almost all the cities are facing the problem of wastewater treatment and disposal. Use of stabilization ponds is also an expensive method for treating domestic wastewater in small communities. Disposal of domestic wastewater in to rivers and other aquatic bodies, without or with partial settlement, in crude tanks will soon offer a serious problem to health and hygiene.

The treatment and disposal of domestic wastewater have posed a serious problem in recent time for municipalities. The growing population has increased the per capita demand of water and hence the amount of disposed water. Today every growing city like Raipur in the country is producing large amount of domestic wastewater every day but without any proper disposal system available for the hygienic discharge of domestic wastewater, hence, the raw domestic wastewater is diverted in to surrounding low lying areas generally through earthen channel.

Climate of the area and habits of the people have a marked effect on the wastewater characteristics. Concentrations are also affected by the amount of water used per person, since in many communities the amount of solids added per person varies within relatively narrow limits. Thus, domestic wastewater characteristics vary not only from city to city but also from season to season and even hour to hour.

Domestic wastewater treatment is a major aquatic environmental problem almost facing by every municipality of the growing city in our country. In most of the cities, in absence of proper treatment facility, untreated domestic wastewater is directly diverted in to low lying areas and in to near by aquatic bodies like ponds and lakes Disposal of domestic wastewater in to fresh water bodies is constantly adding nutrients in to water, which is mainly responsible for increase in the concentration of nitrogen and phosphorus. The presence of nitrogen in wastewater is undesirable, because ammonical form of nitrogen is toxic to fish and many other aquatic organisms. It is also an oxygen-consuming compound, which can deplete the dissolved oxygen in water. The depletion of dissolved oxygen in water is a problem in aquatic ecosystems, since maintenance of high oxygen concentration is crucial for survival of most of the life forms in aquatic ecosystems.

The high productivity and nutrient removal capacity of aquatic plants not only show a significantly interest but also for domestic wastewater treatment and recovery of natural resources.

The efficiency and significance cited by (Hammer, 1992) for wetlands based on floating aquatic macrophytes system are (1) High rate of productivity (2) Much nutrient value and (3) Easy to harvest and stock Constructed wetlands as useful for wastewater treatment was suggested like Hammer, 1992; Brix, 1993,. Research on domestic wastewater (Ph. D. Thesis, Kanungo, 1987) has been demonstrated that the domestic wastewater is highly enriched with vital growth promoting nutrients like Nitrogen and Phosphorous. It's

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continuous addition in to aquatic bodies in greater quantity causes equtroplication, which supports the growth of aquatic flora which leads decreasing the depth by gradual death & decay and posing problem for the existence of water body. To over come of this problem, present study was carried out.

Many researchers had studied the potential of aquatic plants for removing heavy/trace metals from wastewater viz Wolverton *et al.,* 1979; Brix. H., Schierup; 1989, Chandra *et al.,* 1993; Delgado, 1993; Rai *et al.,* 1995. Nutrient removal from wastewater has been extensively researched with aquatic plants such as Rogers, 1972; Sutton and Orens, 1975; Cornell *et al.,* 1977; Dings , 1978; Rai and Datta, 1978; Wolverton and Donald 1979; Abbassi and Nipaney, 1985; Goal *et al.,* 1985; Reddy and Debusk, 1985; Reddy and Smith, 1987; Brix and Schirup, 1989; Chandra *et al.,* 1993; Vatta *et al.,* 1995; Aoi and hayashi, 1996; Vermaat and Hanif, 1998; Zayed, 1998; Shobha and Harilal, 2005.

The contaminants of domestic wastewater are mainly organic in nature containing "nutrients" like organic carbon, nitrogen and phosphorus, with relatively high concentrations of microorganisms. Nitrogen and Phosphorus are two most important elements helping the growth of algae and aquatic plants in receiving water and are generally termed as life giving elements. As domestic wastewater contain significant quantities of nitrogen and phosphorus, therefore removal of these nutrients has become an important aim of wastewater treatment. Higher concentration of nitrogen in domestic wastewater can affect public health also. Despite knowing the severity of harmful effects, domestic wastewater with rich nutrient load is disposed untreated because of the higher cost of treatment.

Some researchers who studied the growth of various aquatic plants in culture media containing liberal supply of nutrients for wastewater treatment such as Boyed, 1974; Wooten et al., 1979; Abbasi and Nipany; 1985, Reddy & De busk, 1985; Gersberg *et al.,* 1986; Clough, 1987; Zirschky and Reed, 1988; Brix, 1989; Debusk, 1989; Karpiscak *et al.,* 1994; Vatta *et al.,* 1995; El – Gendy et al., 2005 and Zimmles *et al.,* 2006. Domestic wastewater treatment by aquatic plants (Phytoremediation) in constructed wetlands as well as artificial ponds is for remarkable output. The removal efficiency depends on their versatility, stability, wastewater type, age and local environment.

Each aquatic plant has a specific and remarkable potential for nutrient removal and biomass generation in particular aquatic habitat. Tolerance capacity under adverse environment and physiological efficiencies of aquatic plant determine the progressive increment of biomass, that may be vary season to season and even individuals to individuals of aquatic plant as free floating aquatic plants are comparatively more sensitive against Temperature, pH etc., and showing lower biomass during summer season. On other hand submerged aquatic plants showing much tolerance to environment than of free floating aquatic plants and perform better to produce large biomass during higher Temperature range. Floating aquatic plants are of well potential to treat biodegradable wastewater.

The objectives of the present study was to compare the efficiency as well as potential utility of a submerged aquatic plant Hydrilla verticillata and free floating aquatic plant water lettuce (Pistia stratiotes) with separately (Monoculture) culturing them off site.

MATERIALS AND METHODS

Experimental setup

The treatment of domestic wastewater was studied in a ex - situ culture experiment with aquatic plants; during the year 2004, three plastic tubs of 0.173 meter diameter and six inches depth and twenty liter capacity were selected.

Two of the tubs were used for culturing submerged aquatic plant *Hydrilla verticillata* and free floating aquatic plant *Pistia stratiotes* (100gm each- monoculture) separately in domestic wastewater. Out of three, one tub was selected for control experiment. Experimental duration was of seven days throughout one year.

Examination of domestic wastewater

Water samples were collected in plastic bottles that had been previously soaked in ten percentage nitric acid for 24 hour and thoroughly rinsed with double distilled water. Aquatic plans were collected in plastic bag clean and rinsed with double distilled water. In laboratory the aquatic plants were carefully washed than 100 gm of each young individual were taken for further experiment. Basis for the selection of experimental aquatic plants was the presence, adaptation to local environment and high propagating capability.

The quality of domestic wastewater was assessed (before and after the culture of experimental aquatic plants) by analyzing various physico-chemical parameters as Instrumental analysis was applied for Physical examination of domestic wastewater whereas chemical parameters were determined by titration and by using spectrophotometer. Some parameters like Total carbon dioxide, Percentage oxygen saturation, Magnesium and Organic phosphate were calculated by formula), following APHA-AWWA-WPCF, (1980) and Trivedy, R. K. and Goel, P. K., 1984, Chemical and biological methods for water pollution studies. Karad (India).

Estimation of Net Primary Productivity

The estimation of biomass of both the aquatic plants before and after the culture was done by determining net primary productivity following Trivedy, R. K. and Goel, P. K., 1984), Chemical and biological methods for water pollution studies. Karad (India).

RESULTS

The quality of domestic wastewater was estimated by determining the physico-chemical characters of domestic wastewater before and after the culture of Hydrilla verticilllata and Pista stratiotes for the period of seven days, in the year 2004 listed in (Table-1). Table – 2 showing varied Net Primary Productivity in complete study period.

Physico - chemical characteristics

Temperature of domestic wastewater before and after the culture had an influence of climatic condition therefore registered lower value in the month of January and higher in the month of May. *Eichhornia crassipes* and *Pistia stratiotes* are sensitive to environmental temperature as in high temperature range these aquatic plants leaves goes to dry (Clough et al., 1987, Aoi and Hayashi, 1996). Temperature and light impact on water hyacinth reported by Olga and Alenka, 1989. All the parameters except pH and Dissolved oxygen had exhibited increase in the value after the treatment for 7 days in culture. pH registered slightly lower value than the 7.00 before the culture for the month January to April, other months showered value higher than 7.00 after the treatment and value shifted to minor basic after experiment. Turbidity, Salinity and Electrical conductivity value registered slightly higher values during summer month May and June as compared to other months. Salinity effect on growth of aquatic vegetation was studied by Haller, 1974, Hammer, 1992. Total dissolved solids exhibited lower values during winter months October to December with a fluctuating value for other months.

The minimum value of Alkalinity was estimated in the month of January while the maximum value for the month of May. Free carbon dioxide and Chloride value registered lowest value in the rainy month August with a maximum value in month of March. The most promising use of submerged macrophytes in treatment of wastewater (Brix and Schierup, 1989). Submerged macrophytes increase the dissolved oxygen and deplete dissolved carbon dioxide in water due to photosynthetic activities.

Dissolved Oxygen value showed an increase almost double of the value after the treatment for all the months, however, lower values were recorded in summer months for May and June while maximum values was recorded for the month of December.

Chemical oxygen demand had maximum value in summer month May while minimum in winter month November. Total hardness, Calcium hardness Calcium had observed decrease in value from October to December while other months exhibited a fluctuating trend. Magnesium content was maximum in the month of January and lowest in the month of August. Nitrate form of Nitrogen was recorded higher values than amonomical and Nitrite nitrogen. Nitrates had a maximum value of 33.91 mg/L for the months of March and minimum 11.86 mg/L for the month of June. A decreasing trend was observed for the value in the month of April to June, other months have showed a fluctuating trend.

TABLE-1. COMPARATIVE PHYSICO-CHEMICAL VARIATION OF DOMESTIC WASTEWATER BEFORE & AFTER THE CLUTURE OF "*Pistia stratiotes*" AND "*Hydrilla verticillata*" DURING 2004.

Sl No.	PARAMETERS	UNIT	MONTHS																	
			JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
			BC	AC		BC	AC		BC	AC		BC	AC		BC	AC		BC	AC	
				P	H		P	H		P	H		P	H		P	H		P	H
1	Temperature	^0C	**24.8**	23.4	22.9	**26.6**	25.1	25.3	**32.2**	29.6	27.3	**35.6**	33.8	33.3	**36.6**	34.6	33.5	**36.3**	32.8	32.2
2	PH	-	**6.98**	7.78	7.63	**6.93**	7.65	7.73	**6.96**	7.19	7.26	**6.94**	7.26	7.26	**7.56**	7.71	7.89	**7.15**	7.86	7.83
3	Turbidity	NTU	**18.1**	12.9	10.1	**19.2**	12.1	14.1	**25.3**	21.9	16.2	**27.9**	24.6	16.9	**33.1**	31.1	19.8	**38.9**	36.1	25.7
4	Salinity	$^0/_{00}$	**0.553**	0.521	0.469	**0.686**	0.643	0.625	**0.606**	0.581	0.511	**0.602**	0.589	0.504	**0.891**	0.882	0.788	**0.903**	0.889	0.798
5	Electrical Conductivity	µmhos/cm	**835.10**	793.80	720.30	**734.80**	680.40	627.60	**883.60**	849.80	789.20	**906.10**	886.20	849.10	**961.60**	943.80	820.60	**921.60**	888.60	873.30
6	Total Disolved Solids	ppm	**538.10**	509.30	468.90	**480.80**	442.20	413.90	**571.60**	552.30	499.60	**586.10**	571.10	512.60	**620.30**	611.80	545.30	**588.60**	575.80	507.60
7	Total Alkalinity	$mgCaCo_3/L$	**260.0**	235.0	155.0	**277.5**	237.5	192.5	**305.0**	285.0	205.0	**327.5**	317.5	205.0	**377.5**	370.0	275.0	**295.0**	282.5	195.0
8	Free Co_2	mg/L	**78.93**	53.76	41.36	**112.28**	73.26	100.98	**168.16**	143.60	126.72	**83.60**	68.99	47.43	**73.92**	64.68	35.15	**48.57**	28.02	10.78
9	Total Co_2	mg/L	**307.73**	260.56	177.76	**356.48**	282.26	270.38	**436.56**	394.40	307.12	**371.80**	348.39	227.83	**406.12**	390.28	277.15	**308.17**	276.06	182.38
10	Chloride	mg/L	**108.45**	105.37	103.10	**104.86**	99.72	100.74	**137.75**	134.16	132.10	**88.92**	85.84	88.78	**94.06**	91.49	89.44	**91.49**	89.44	87.38
11	Dissolved Oxygen	mg/L	**2.6**	5.8	7.5	**2.3**	7.0	6.0	**2.4**	4.8	6.2	**2.1**	4.3	6.1	**1.4**	3.0	5.9	**1.8**	4.0	5.8
12	Oxygen Saturation	$^0/_0$	**33.3**	68.0	82.0	**29.0**	81.0	70.0	**32.8**	62.0	76.0	**31.0**	58.3	84.0	**21.6**	42.1	78.0	**27.0**	54.0	76.0
13	Chemical Oxygen Demand	mg/L	**144.0**	100.8	100.8	**194.4**	129.6	165.6	**122.4**	86.4	86.4	**208.8**	180.0	158.4	**223.2**	201.6	158.4	**201.6**	172.8	129.6
14	Total Hardness	$mgCaCo_3/L$	**335.62**	259.96	256.08	**298.76**	223.10	205.64	**353.08**	298.76	263.84	**331.74**	271.60	230.86	**215.34**	180.18	141.06	**267.72**	234.74	199.8
15	Calcium Hardness	$mgCaCo_3/L$	**184.14**	144.54	140.58	**170.28**	130.68	122.76	**198.00**	174.24	148.50	**223.74**	190.08	168.30	**122.76**	108.90	83.10	**172.76**	154.44	131.9
16	Calcium	mg/L	**73.80**	57.93	56.34	**68.24**	52.37	49.20	**79.35**	69.83	59.57	**89.67**	76.18	67.45	**49.20**	43.64	33.33	**69.04**	61.89	53.96
17	Magnesium	mg/L	**36.46**	27.66	27.68	**31.01**	22.05	19.72	**37.43**	30.11	27.64	**26.02**	19.39	14.76	**27.19**	17.02	14.60	**23.01**	19.21	16.66
18	Ammonical - N	mg/L	**12.89**	7.64	6.74	**14.69**	8.33	6.85	**9.50**	6.48	6.27	**22.64**	18.24	18.19	**18.14**	16.28	13.90	**20.15**	16.28	14.43
19	Nitrite - N	mg/L	**0.362**	0.240	0.242	**0.378**	0.217	0.227	**0.332**	0.145	0.124	**0.311**	0.177	0.108	**0.477**	0.376	0.280	**0.389**	0.244	0.187
20	Nitrate - N	mg/L	**57.04**	37.38	29.11	**54.76**	28.83	35.95	**48.49**	32.82	14.86	**57.90**	46.78	30.82	**61.32**	51.56	35.38	**39.90**	31.39	12..8
21	Total Ortho Phosphate	mg/L	**0.611**	0.299	0.390	**0.732**	0.239	0.430	**0.842**	0.530	0.460	**0.651**	0.420	0.339	**0.641**	0.470	0.329	**0.530**	0.390	0.239
22	Acid Hydrolyzable Phosphate	mg/L	**0.251**	0.141	0.171	**0.271**	0.171	0.131	**0.221**	0.161	0.101	**0.412**	0.312	0.212	**0.421**	0.332	0.151	**0.520**	0.371	0.211
23	Total Phosphate	mg/L	**1.657**	0.742	1.154	**1.255**	0.540	0.701	**1.200**	0.842	0.701	**1.587**	1.164	0.812	**1.667**	1.305	0.872	**1.556**	1.144	0.822
24	Organic Phosphate	mg/L	**0.795**	0.623	0.593	**0.252**	0.130	0.140	**0.222**	0.150	0.140	**0.524**	0.432	0.261	**0.605**	0.503	0.392	**0.502**	0.392	0.372

BC - Before of culture, *P- Pistia stratiotes*

AC - After 07 days of culture, *H-Hydrilla verticillata*

The value for Nitrite nitrogen was lower as comparted to other forms. Minimum value of Nitrite nitrogen was observed in the month of April, while maximum in the August. Ammonical form of nitrogen recorded lowest value in the month of March while the highest value in the month of December. Phosphorous contents were estimated as Total ortho, Acid hydrolysable, Total and organic phosphate. The value of Total phosphate was maximum and the minimum values were recorded for Acid hydrolysable phosphate. Total ortho phosphate values were greater than organic and acid hydrolysable phosphate. Total ortho phosphate values were greater than organic and acid hydrolysable phosphate.

Abbassi & Nipaney, (1985) reported higher values of NH_4 – Nitrogen, Ortho and total Phosphate. The decrease in Total ortho phosphate value was observed from March to June, however, maximum value recorded in the month of December and minimum in June while reverse trend was observed for organic phosphate. Both Acid hydrolysable and Total phosphate maintained a higher value in the month of February while lower values were obtained in the month of July and November respectively.

Net Primary Productivity (gm. m^{-2} day^{-1}) of *Pistia stratiotes* and *Hydrilla verticillata* after seven days of culture in domestic wastewater during the year 2004.

S.N.	MONTHS	Cultured Biomass							Production gm. m^{-2}		N.P.P. gm. m^{-2}. day^{-1}	
		Initial value before culture			Final value after 7 days of culture							
		Cultured fresh weight-gms	Dry weight of P & H. in-gms		Fresh weight		Dry weight					
			P	H	P	H	P	H	P	H	P	H
1	JANUARY	100	7.5	10.5	129	121	9.67	12.70	11.07	11.22	1.58	1.60
2	FEBRUARY	100	7.5	10.5	153	110	11.47	11.55	20.25	5.35	2.89	0.76
3	MARCH	100	7.5	10.5	122	122	9.15	12.81	8.41	11.78	1.20	1.68
4	APRIL	100	7.5	10.5	111	125	8.32	13.12	4.18	13.36	0.59	1.90
5	MAY	100	7.5	10.5	107	136	8.02	14.28	2.65	19.28	0.37	2.75
6	JUNE	100	7.5	10.5	113	129	8.47	13.54	4.94	15.57	0.70	2.21
7	JULY	100	7.5	10.5	116	124	8.70	13.02	6.12	12.85	0.87	1.83
8	AUGUST	100	7.5	10.5	118	115	8.85	12.08	6.88	8.06	0.98	1.15
9	SEPTEMBER	100	7.5	10.5	137	126	10.27	13.24	14.13	13.97	2.01	1.99
10	OCTOBER	100	7.5	10.5	117	115	8.78	12.08	6.53	8.06	0.93	1.15
11	NOVEMBER	100	7.5	10.5	140	116	10.50	12.18	15.30	8.57	2.18	1.22
12	DECEMBER	100	7.5	10.5	150	121	11.25	12.71	19.13	11.27	2.73	1.61

P = *Pistia stratiotes*

H = *Hydrilla verticillata*

Comparative Nutrient uptake Potential (%) of experimental Aquatic plants

Seasonal variation of nutrients uptake capacity and biomass richness was observed. Average percentage change

Physical variation

Wastewater qualitative variations in percentage of physical parameters are (Temperature : P – 8.31, H – 9.89), (Turbidity : P - 25.67, H - 37.00), (Salinity: P - 4.27, H - 17.42), (E.C.: P - 4.82, H - 15.66), (TDS: P - 5.34, H - 15.80). For reduction of above parameters Hydrilla verticillata showing more efficient performance in comparisons of Pistia stratiotes. Little increase of pH was observed (P - 5.66, H - 6.38).

Chemical variation

Total alkalinity – (P-9.06, H-34.50), Free CO2 – (P-37.53, H – 51.56), Total CO2 – (P – 14.53, H – 36.91), Chloride – (P – 3.37, H – 4.39). As generated data based on present research shows that Hydrilla verticillata is more capable to reduce the values of described chemical parameters than Pistia stratiotes. Successful photosynthetic activity leads the mixing of oxygen through plant parts resulted richness in the values in wastewater at the end of the experiment. As evident by percentage increase in Dissolved oxygen (P – 97.1, H – 140.1) and Oxygen saturation (P – 77.8, H- 113.0). Chemical Oxygen Demands removal efficiencies were for Pistia stratiotes -29.09 % and for Hydrilla verticillata it was found 36.14%.

Calcium, Magnesium uptake capacity in % were (Calcium - P- 14.76, H- 24.39), (Magnesium P- 27.89, H – 37.16) differ to individual experimental aquatic plants, which supported the declining the value of Total and Calcium hardness and range was found (P- 18.79, H- 28.71), (P – 14.79, H- 24.96) respectively.

Ammonical – N (P – 35.24, H – 39.45), and Nitrite – N (P – 40.23, H – 47.59) were reduced in with little differences to each other, whereas significant removal for Nitrate – N was seen (P- 32.27, H – 50.35). Phosphorous absorbing capacities of both the aquatic plants were ranged as for Pistia stratiotes –: 31 – 38 % whereas 36 – 53 % of Phosphorous absorption was noticed for Hydrilla verticillata. Scattered % removal data for various forms of phosphorous are as Total ortho Phosphate (P – 44.10, h – 52.58), Acid hydrolysable Phosphate (P- 34.79, H – 42.85), Total Phosphate (P- 37.56, H – 44.69) and Organic Phosphate (31.68, H – 36.41).

Data Analysis

Findings of research data before and after experimentation in domestic wastewater were subjected to compare the results is significant or not. Student "t" test was applied for difference between individual means at 0.05 level of significance.

NPP estimation

Macrophytes/aquatic plants for biomass production (Net Primary Productivity) was determined by Chadwick and Obeid, 1966, Oki and Uki, 1978a, Wolverton and Donald, 1979, Reddy and Tucker, 1983, Tsutomu and Seiji, 1988, Ripley et al, 2006,

Net primary productivity (NPP) value was comparatively higher for most the months for submerged aquatic plant *Hydrilla verticillata* as compared to free floating aquatic plant *Pistia stratiotes* (Table-2). *Pistia stratioes* showed minmum value of 0.37 $gmm^{-2\ day-1}$ net primary productivity in the month of May while *Hydrilla verticillata* recorded maximum value 2.75 gm m^{-2} day^{-1} for the same month. The maximum value of 2.89 gm m^{-2} day^{-1} net primary productivity was obtained for Pista stratiotes in February.

The lowest value of NPP for *Hydrilla verticillata* was recorded 0.76 gm m^{-2} day^{-1} for the same month. The NPP value for *Pista Stratiotes* showed decreasing trend from March to May but for the same period increasing trend was observed for *Hydrilla verticillata*. An increasing trend in NPP value from June to September was recorded for Pistia stratiotes while decreasing trend from May to August was obtained for *Hydrilla verticillata*. Rest of the month showed a fluctuating trend in the values.

DISCUSSION

Physico- chemical characteristics

Except pH and dissolved oxygen all other parameters showed decrease in value after treatment for all the months throughout the study period. The variation in temperature of cultured domestic wastewater was due to influence of climate and plant cover, while little increase in pH values after the culture was noticed. Salinity and Turbidity values of domestic wastewater decreased due to oxidation of organic matter and absorption of nutrients in culture. The total dissolved solid value was lowered due to absorption of ions which made decrease in electrical conductivity value.

The decrease in the value of Free carbon dioxide and Alkalinity after the treatment was the result of photosynthetic activity. Chloride concentration had registered a minor change as it is not been involved in any physiological process of the aquatic plant. The dissolution of more oxygen in domestic wastewater during the treatment increased the greater susceptibility of organic matter for oxidation, thus resulted in reduction of Chemical oxygen demand value.

Hardness in water was majorly contributed by Calcium and Magnesium carbonate but it's hydrolysis released the Co_2 and subsequently reduced the value of Total and Calcium hardness. The values of Calcium and Magnisum were reduced after the treatment as they were absorbed by the aquatic plants during the culture. Nitrate form of Nitrogen was most stable amongst the three forms therefore, recorded maximum value throughout the year while nitrite was found least stable with intermediate Ammonical form of Nitrogen, hence recorded values in order of Nitrate- N > Ammonical – N > Nitrite- N. All the forms of nitrogen and phosphous recorded reduction in values after the treatment as both are vital nutrients and absorbed significantly by aquatic plants during the culture.

NPP estimation

The higher values of Net Primary Productivity obtained for submerged aquatic plant *Hydrilla verticillata* signifies its suitability to use for the culture throughout the year however the higher values of NPP recorded in summer months viz April, May and June as the temperature enhances growth rate of submerged hydrophyte. The lowest value of NPP for *Pista stratiotes* was observed in summer month during May showed unsuitability for the culture in higher temperature as the plant is free floating and upper part of body directly effected by higher temperature. Out come of the present research is that cold season is better for free floating aquatic plants and for submerged aquatic plants summer season plays a remarkable role in terms of biomass production.

We conclude the present experiment that both aquatic plants have remarkable potential to remove nutrients from wastewater, but each has their own limitations both in terms of period of survival and type of wastewater quality. The efficiency in removal of pollutants is not uniform because of varied physiological process and genetical makeup.

Hydrilla verticillata a submerged aquatic plant found to be more suitable for the treatment of domestic wastewater. As it remove significant amount of organic/inorganic nutrients from domestic wastewater, mixes remarkable oxygen in water system and also achieved more biomass production then the *Pista stratiotes*. Low temperature and nutrients concentration, high salinity level reduces the performance of these aquatic plants to removing nutrients.

Harvested biomass of aquatic plants having potential to use for composting, soil amendments and anaerobic digestion with methane production (Verma *et al.,* 2006). Secondly, harvested biomass can be mixed with manure solids to increase nutritional value for field.

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