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# Treatment of domestic wastewater by potential application of a submerged aquatic plant *Hydrilla verticillata* Casp

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**Abstract**
All over the world wastewater pollution is common. Untreated municipal wastewater posing eutrophication, where water is enriched with nutrients and unhygienic to use. Control of eutrophication is burning issues for aquatic sites around the world. In such a state, remediation of nutrients by aquatic plants is remarkable for municipal wastewater treatment. Present study was conducted by off-site experiment, where *Hydrilla verticillata* Casp was cultured in a tub for subsequent seven days over one year. Second one of the tub was used as control. The quality of domestic wastewater was assessed before and after the experiment by analyzing physicochemical parameters following APHA-AWWA-WPCF-1980. The results of the present experiment revealed the significant improvement in the quality of municipal wastewater, as indicated by the decrease in values of most physicochemical parameters studied, except pH, Dissolved oxygen and plant biomass. That showed efficiency and potentiality of aquatic plant for the purpose.

**Keywords:** Eutrophication, *Hydrilla verticillata* Casp, Wastewater, Nutrients, NPP, Physico-chemical parameters.

## INTRODUCTION

Remediation of nutrients from wastewater is an emerging technique of environmental biotechnology in which various living organisms used for environmental clean up and pollution control. Water quality impairment by nutrient enrichment from varied sources has been a global concern. Biodegradable wastes constitute one of the greatest challenges to the environment. Developing cost effective and eco-friendly technology for the remediation of polluted water with toxic substances is a matter of global interest. Rapid urbanization has caused an increase in urban population of every city of the country. It is mainly responsible for production of domestic wastewater in huge quantity. Very few cities of the country have systematic treatment plants and disposal system while in majority of the cities like Raipur; there is no proper disposal system and treatment plant or any stabilization pond to treat the domestic wastewater. It is because of higher cost of treatment, municipalities are unable to afford the cost of treatment.

In such a situation, untreated domestic wastewater is disposed in to water bodies of low-lying area around the city. In many of the cities low-laying areas function as stabilization and oxidation ponds. Domestic wastewater treatment and its proper disposal are major problems being faced by all the municipalities of growing cities throughout the country. The high price of treatment plant has forced many of the municipalities to discharge domestic wastewater without any treatment.

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.

Researches on domestic wastewater demonstrated the higher quantity of nitrogen and phosphorus in municipal wastewater. In most of the cities in the country, untreated domestic wastewater is simply diverted in to aquatic bodies like ponds and lakes located in the low lying area, where it is posing a serious problem of eutrophication and leads degradation of water quality. In eutrophic aquatic body N, P coexists stimulatingly. Nutrient enrichment of water creates to deterioration of aquatic environment and some times even to eutrophication especially in density polluted areas.

Many researches have emphasized biological functions and biomanipulatuion, which stresses management of polluted ecosystem to eutrophication from of nutrients (Reddy and Debusk, 1985, Gersberg etal., 1986, Hammer, 1989, Shen et al., 2006). Eutrophicated water promotes the growth of phytoplankton and macrophytes in aquatic body. Enormous growth of phytoplankton is deteriorating the water quality day by day. When aquatic plants cultured in wastewater that perform several functions including assimilating and storing contaminants, transporting oxygen from atmosphere to the root zone facilitating aeration of wastewater. The high productivity and nutrient removal capacity of aquatic plants have created substantial interest for wastewater treatment.

In above perspective, remediation of nutrients by aquatic plants may become a better method of municipal wastewater treatment where aquatic plants are used for eliminating inorganic & organic pollutants by degradation and assimilation. This technique has great potential of domestic wastewater treatment in order to

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prevent an early eutrophication of water bodies. Aquatic plants based treatment system can be effectively used to reduce pollutant levels in water bodies. Literature cited on wastewater treatment using aquatic plants such as Boyed, 1970, Wolverton and McDonald, 1979, Wooten et al. , 1979, Abbasi and Nipany, 1985, Reddy et al., 1985, Gersberg et al., 1986, Oron et al., 1986, Zirschky and Reed, 1988, Brix, 1989, Debusk, 1989, Karpiscak et al., 1994, Mandi,1994, El – Gendy et al., 2005, Zimmles et al., 2006. Some scientists who utilized aquatic plants for heavy/trace metal removal from wastewater studied by Wolverton *et al*. (1979), Brix and Schierup (1989), Guilizzoni,1991, Chandra et al., 1993, Delgado, 1993, Dirilgen and Inel, 1994 and Rai et al. 1995, Zayed, 1998, Carvalho and Martin, 2001.

Researches over the last decade have shown that the mechanism for removal of nutrients from wastewater systems may be complex involving physiological characters of plants, physio-chemical and biological reactions in aquatic environment. Utilization of aquatic plants for removal of various nutrients from wastewater was examined by Sutton and Orens, 1975, Dings, 1978, Wolverton and Donald 1979, Abbasi and Nipaney 1985, Goal et al., 1985, Reddy and Debusk, 1985, Brix and Schierup, 1989, Chandra et al., 1993, Gumbricht, 1993, Wu et al., 1993, Aoi and hayashi, 1996, Vermaat and Hanif, 1998, Saha and Jana, 2002, Das, 2005 and Shobha and Harilal, 2005. Nutrient removal capacities of aquatic plants are utilized for control of eutrophication in constructed wetlands and artificial ponds was suggested like Hammer, 1992, Brix, 1993.

The main objective of the presented research was to evaluate the effectiveness and potential of *Hydrilla verticillata* Casp (a submerged aquatic plant of family hydrocharitaceae), in removing nutrients from domestic wastewater.

## MATERIALS AND METHODS

### Experimental technique

Experimental aquatic plant (*Hydrilla verticillata* Casp.) is a submerged aquatic plant, native of Africa, Australia and parts of Asia, which can quickly overcome other plant species because of the ability to grow with less light and more efficiently take-up nutrients from aquatic system.

Remediation of nutrients from domestic wastewater was studied by using a *Hydrilla verticillata* Casp. A fixed amount of 100gms of this aquatic plant was cultured in a plastic tub of 0.173 m diameter, six inches deep and 20 Liter capacities containing domestic wastewater, for a week interval. At the same time second one was left without aquatic plant but filled with municipal wastewater, used as control. (Fig. – 1 and 2.) Experiment was run up for one year to observed seasonal change in wastewater quality as well as nutrient removal efficiency of the experimental aquatic plant. 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 plant was collected in plastic bag clean and rinsed with double distilled water. In laboratory the aquatic plant was carefully washed than young individuals were taken for further experiment. A water sample from treatment and control plots were weekly analyzed per month of one year for assessment of physico-chemical changes in domestic wastewater and for biomass estimation. Criteria for experimental individual choice was their availability, adaptability, high rate of oxygen transport capacity and tolerance power as primarily tested in trial experiment.

### Physico-chemical examination of domestic wastewater

The remediation potential of aquatic plant in order to eliminate nutrient load from municipal wastewater was observed in weekly interval during the year 2004, by estimating quality of municipal wastewater before and after the experiment. The water quality was determined by analyzing physico-chemical parameters following APHA-AWWA-WPCF - 1980.

Instrumental analysis was done for Physical parameters like - Temperature, pH, Turbidity, Salinity, Electrical conductivity and Total dissolved solids, while Chemical parameters viz - Alkalinity, Free $CO_2$. Chloride, Dissolved oxygen, Chemical oxygen demand, Total hardness, Calcium hardness and Calcium were analyzed titrimetrically and Ammonical, Nitrite, Nitrate Nitrogen and Phosphate contents in all the forms were determined by spectrophotometeric method. Percentage Oxygen saturation, Total $CO_2$ and Magnesium values were determined by using prescribed formula.

### Biomas of experimental aquatic plant (NPP)

The changes in biomass of aquatic plant in a week interval after experiment, over one year was observed and values were subjected in Net Primacy Productivity determination.

## RESULTS AND DISCUSSION

### Physico-chemical examination of domestic wastewater

Macrophytes / aquatic plants grow normally in water bodies polluted by nutrients of varied sources and utilized the nutrients to produce large amount of biomass. The results of physico-chemical analysis of municipal wastewater before & after the remediation by using a submerged aquatic plant *Hydrilla verticillata* Casp shown in (Table - 1). Physical parameter Temperature plays an important role in change of various chemical parameters and physiological process of aquatic plant. Due to presence of aquatic plant and their intraction with aquatic environment, monthly variation was noted as per the seasonal change. Temperature and light impact on water hyacinth reported by Olga and Alenka, 1989.

pH Value was recorded around 7.0 before culture but after the culture (ending of the experiment) little increase was noticed due to reaction of aquatic plant in water. Higher values of Turbidity (above 30 NTU) was recorded during summer months May and June because of an increase in concentration of wastewater, excessive evaporation but greater reduction in values made by the aquatic plant was observed during winter month October. Higher value for Salinity was recorded 0.903 ppt during the month of June, while August and December recorded the lower value of 0.374 ppt. The maximum decrease in value of salinity was observed in the month of September. Salinity effect on growth of aquatic vegetation was studied by Haller et al, 1974, Hammer, 1992. Turbidity and Salinity values were decreased after the culture during the entire study period.

Electrical conductivity was above 0.900 micro mhos per cm during the summer months from April to June, while lowest value of 588.60 micro mhos per cm was observed in the month of August. This change was observed due higher Temperature range during summer and dilution in rainy months. The rate of reduction was found lower during the months of November and December, because of decrease in Temperature, which reduced the rate of absorption. Total dissolved solids had indicated an identical pattern with higher value of 620.30 ppm during the month of May but lowest rate of reduction was noted in the month of January. The values for both the parameter had exhibited decrease in value after the experiment.

Total Alkalinity was recorded before culture was above 300mg $CaCO_3$/L during March to May and September to November, while minimum value of 232.5mg/L was noted in the month of December. Except the months of February and March free $CO_2$ value was recorded below 100mg/L, while minimum value was observed (28.02 mg/L) in the month of August. Total $CO_2$ had a peak value 436.56mg/L, during the month of March. The reduction in Total alkalinity was reduced due to absorption of dissolved solids, while the values of Free $CO_2$ and Total $CO_2$ were reduced in culture because of absorption of $CO_2$ by the aquatic plant *Hydrilla verticillata* Casp for photosynthetic activity.

Table 1. Physico-chemical characteristics of municipal wastewater before & after the culture of "Hydrilla verticillata"

| Sl. No. | PARAMETERS | UNIT | MONTHS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | JANUARY | | FEBRUARY | | MARCH | | APRIL | | MAY | | JUNE | |
| | | | Initial | Final | Initial | Final | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| 1 | Temperature | $^0C$ | 24.8 | 22.9 | 26.6 | 25.3 | 32.2 | 27.3 | 35.6 | 33.3 | 36.6 | 33.5 | 36.3 | 32.2 |
| 2 | pH | - | 6.98 | 7.63 | 6.93 | 7.73 | 6.96 | 7.26 | 6.94 | 7.26 | 7.56 | 7.89 | 7.15 | 7.83 |
| 3 | Turbidity | NTU | 18.1 | 10.1 | 19.2 | 14.1 | 25.3 | 16.2 | 27.9 | 16.9 | 33.1 | 19.8 | 38.9 | 25.7 |
| 4 | Salinity | $^0/_{00}$ | 0.553 | 0.469 | 0.686 | 0.625 | 0.606 | 0.511 | 0.602 | 0.504 | 0.891 | 0.788 | 0.903 | 0.798 |
| 5 | Electrical Conductivity | mmhos | 835.10 | 720.30 | 734.80 | 627.60 | 883.60 | 789.20 | 906.10 | 849.10 | 961.60 | 820.60 | 921.60 | 873.30 |
| 6 | Total Disolved Oxygen | ppm | 538.10 | 468.90 | 480.80 | 413.90 | 571.60 | 499.60 | 586.10 | 512.60 | 620.30 | 545.30 | 588.60 | 507.60 |
| 7 | Total Alkalinity | $mgCaCo_3/L$ | 260.0 | 155.0 | 277.5 | 192.5 | 305.0 | 205.0 | 327.5 | 205.0 | 377.5 | 275.0 | 295.0 | 195.0 |
| 8 | Free $Co_2$ | mg/L | 78.93 | 41.36 | 112.28 | 100.98 | 168.16 | 126.72 | 83.60 | 47.43 | 73.92 | 35.15 | 48.57 | 10.78 |
| 9 | Total $Co_2$ | mg/L | 307.73 | 177.76 | 356.48 | 270.38 | 436.56 | 307.12 | 371.80 | 227.83 | 406.12 | 277.15 | 308.17 | 182.38 |
| 10 | Chloride | mg/L | 108.45 | 103.10 | 104.86 | 100.74 | 137.75 | 132.10 | 88.92 | 88.78 | 94.06 | 89.44 | 91.49 | 87.38 |
| 11 | Dissolved Oxygen | mg/L | 2.6 | 7.5 | 2.3 | 6.0 | 2.4 | 6.2 | 2.1 | 6.1 | 1.4 | 5.9 | 1.8 | 5.8 |
| 12 | Oxygen Saturation | $^0/_0$ | 33.3 | 82.0 | 29.0 | 70.0 | 32.8 | 76.0 | 31.0 | 84.0 | 21.6 | 78.0 | 27.0 | 76.0 |
| 13 | Chemical Oxygen Demand | mg/L | 144.0 | 100.8 | 194.4 | 165.6 | 122.4 | 86.4 | 208.8 | 158.4 | 223.2 | 158.4 | 201.6 | 6 |
| 14 | Total Hardness | $mgCaCo_3/L$ | 335.62 | 256.08 | 298.76 | 205.64 | 353.08 | 263.84 | 331.74 | 230.86 | 215.34 | 151.21 | 267.72 | 199.82 |
| 15 | Calcium Hardness | $mgCaCo_3/L$ | 184.14 | 140.58 | 170.28 | 122.76 | 198.00 | 148.50 | 223.74 | 168.30 | 122.76 | 83.10 | 172.76 | 131.92 |
| 16 | Calcium | mg/L | 73.80 | 56.34 | 68.24 | 49.20 | 79.35 | 59.57 | 89.67 | 67.45 | 49.20 | 33.33 | 69.04 | 53.96 |
| 17 | Magnesium | mg/L | 36.46 | 27.68 | 31.01 | 19.72 | 37.43 | 27.64 | 26.02 | 14.76 | 27.19 | 14.60 | 23.01 | 16.66 |
| 18 | Ammonical - N | mg/L | 12.89 | 6.74 | 14.69 | 6.85 | 9.50 | 6.27 | 22.64 | 18.19 | 18.14 | 13.90 | 20.15 | 14.43 |
| 19 | Nitrite - N | mg/L | 0.362 | 0.242 | 0.378 | 0.227 | 0.332 | 0.124 | 0.311 | 0.108 | 0.477 | 0.280 | 0.389 | 0.187 |
| 20 | Nitrate - N | mg/L | 57.04 | 29.11 | 54.76 | 35.95 | 48.49 | 14.86 | 57.90 | 30.82 | 61.32 | 35.38 | 39.90 | 12..87 |
| 21 | Total Ortho Phosphate | mg/L | 0.611 | 0.390 | 0.732 | 0.430 | 0.842 | 0.460 | 0.651 | 0.339 | 0.641 | 0.329 | 0.530 | 0.239 |
| 22 | Acid Hydrolyzable Phosphate | mg/L | 0.251 | 0.171 | 0.271 | 0.131 | 0.221 | 0.101 | 0.412 | 0.212 | 0.421 | 0.151 | 0.520 | 0.211 |
| 23 | Total Phosphate | mg/L | 1.657 | 1.154 | 1.255 | 0.701 | 1.200 | 0.701 | 1.587 | 0.812 | 1.667 | 0.872 | 1.556 | 0.822 |
| 24 | Organic Phosphate | mg/L | 0.795 | 0.593 | 0.252 | 0.140 | 0.222 | 0.140 | 0.524 | 0.261 | 0.605 | 0.392 | 0.502 | 0.372 |

| Sl. No. | PARAMETERS | UNIT | MONTHS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | JULY | | AUGUST | | SEPTEMBER | | OCTOBER | | NOVEMBER | | DECEMBER | |
| | | | Initial | Final | Initial | Final | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| 1 | **Temperature** | $^0C$ | **27.5** | 28.0 | **28.7** | 27.1 | **28.6** | 25.8 | **29.4** | 26.1 | **28.9** | 24.0 | **26.3** | 22.0 |
| 2 | **pH** | - | **7.36** | 7.61 | **7.27** | 7.81 | **7.08** | 7.43 | **7.19** | 7.70 | **7.21** | 7.74 | **7.12** | 7.73 |
| 3 | **Turbidity** | NTU | **18.9** | 11.9 | **16.8** | 12.3 | **19.6** | 11.2 | **10.3** | 5.7 | **16.5** | 11.7 | **17.8** | 10.1 |
| 4 | **Salinity** | $^0/_{00}$ | **0.583** | 0.481 | **0.374** | 0.286 | **0.501** | 0.398 | **0.429** | 0.331 | **0.442** | 0.343 | **0.374** | 0.288 |
| 5 | **Electrical Conductivity** | mmhos | **891.10** | 725.90 | **588.60** | 470.30 | **751.20** | 583.10 | **691.70** | 571.50 | **683.20** | 556.30 | **604.80** | 449.40 |
| 6 | **Total Disolved Oxygen** | ppm | **521.60** | 428.30 | **319.90** | 259.80 | **429.90** | 333.90 | **378.70** | 316.80 | **371.60** | 308.60 | **368.80** | 296.80 |
| 7 | **Total Alkalinity** | $mgCaCo_3/L$ | **275.0** | 177.5 | **240.0** | 152.5 | **305.0** | 192.5 | **330.0** | 240.0 | **322.5** | 227.5 | **232.5** | 125.0 |
| 8 | **Free $Co_2$** | mg/L | **79.77** | 40.96 | **28.02** | 12.93 | **43.12** | 10.78 | **40.96** | 10.78 | **62.52** | 36.65 | **58.21** | 17.24 |
| 9 | **Total $Co_2$** | mg/L | **321.77** | 197.16 | **239.22** | 147.13 | **311.52** | 180.18 | **331.36** | 221.98 | **346.32** | 236.85 | **262.81** | 127.24 |
| 10 | **Chloride** | mg/L | **121.82** | 117.19 | **74.53** | 70.93 | **97.15** | 93.55 | **85.32** | 82.24 | **91.49** | 87.89 | **78.13** | 74.53 |
| 11 | **Dissolved Oxygen** | mg/L | **3.8** | 8.2 | **5.2** | 8.3 | **4.9** | 8.5 | **5.0** | 8.4 | **5.4** | 8.6 | **5.5** | 9.0 |
| 12 | **Oxygen Saturation** | $^0/_0$ | **48.9** | 98.0 | **69.1** | 97.1 | **62.0** | 98.0 | **63.1** | 97.9 | **72.5** | 96.2 | **72.0** | 98.0 |
| 13 | **Chemical Oxygen Demand** | mg/L | **158.4** | 108.0 | **57.6** | 21.6 | **86.4** | 36.0 | **108.0** | 72.0 | **115.2** | 72.0 | **122.4** | 64.8 |
| 14 | **Total Hardness** | $mgCaCo_3/L$ | **271.60** | 195.95 | **217.28** | 147.44 | **267.72** | 190.12 | **322.04** | 242.50 | **267.72** | 195.94 | **228.92** | 151.32 |
| 15 | **Calcium Hardness** | $mgCaCo_3/L$ | **170.28** | 128.70 | **164.34** | 130.68 | **190.08** | 146.52 | **188.10** | 148.50 | **158.40** | 118.80 | **146.52** | 104.96 |
| 16 | **Calcium** | mg/L | **68.24** | 51.58 | **65.86** | 52.37 | **76.18** | 61.89 | **75.39** | 59.51 | **63.48** | 47.61 | **58.12** | 42.05 |
| 17 | **Magnesium** | mg/L | **24.21** | 16.11 | **12.45** | 4.01 | **18.51** | 10.23 | **32.36** | 22.43 | **26.25** | 18.32 | **20.10** | 11.03 |
| 18 | **Ammonical - N** | mg/L | **26.19** | 22.17 | **8.86** | 5.36 | **12.78** | 6.58 | **11.99** | 7.70 | **6.53** | 2.08 | **10.29** | 4.15 |
| 19 | **Nitrite - N** | mg/L | **0.353** | 0.181 | **0.481** | 0.263 | **0.372** | 0.173 | **0.336** | 0.242 | **0.378** | 0.166 | **0.345** | 0.189 |
| 20 | **Nitrate - N** | mg/L | **58.75** | 31.96 | **42.51** | 21.70 | **52.77** | 16.86 | **51.34** | 31.96 | **50.49** | 28.83 | **49.35** | 23.98 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | **Total Ortho Phosphate** | mg/L | **0.681** | 0.369 | **0.722** | 0.339 | **0.882** | 0.279 | **0.782** | 0.299 | **0.651** | 0.209 | **0.892** | 0.359 |
| 22 | **Acid Hydrolyzable Phosphate** | mg/L | **0.382** | 0.182 | **0.392** | 0.242 | **0.410** | 0.302 | **0.312** | 0.252 | **0.262** | 0.160 | **0.299** | 0.212 |
| 23 | **Total Phosphate** | mg/L | **1.425** | 0.732 | **1.446** | 0.792 | **1.742** | 1.053 | **1.456** | 0.752 | **1.224** | 0.641 | **1.516** | 0.802 |
| 24 | **Organic Phosphate** | mg/L | **0.362** | 0.181 | **0.332** | 0.211 | **0.733** | 0.472 | **0.362** | 0.201 | **0.310** | 0.242 | **0.332** | 0.231 |

Table 2. Monthly variation in net primary producutivity gm.m-2.day-1 of hydrilla verticillataistia casp ( oven dry biomass ) after culture for a week in municipal wastewater during 2004.

| MONTHS | PERIOD | PRODUCTION | N.P.P. |
|---|---|---|---|
| | | gm.m$^{-2}$ | gm.m$^{-2}$.day$^{-1}$ |
| JAN | $15^{th}$ - $22^{nd}$ | 12.71 | 1.81 |
| FEB | $19^{th}$ - $26^{th}$ | 6.06 | 0.86 |
| MAR | $17^{th}$ - $24^{th}$ | 13.35 | 1.90 |
| APR | $12^{th}$ - $20^{th}$ | 15.14 | 2.16 |
| MAY | $12^{th}$ - $20^{th}$ | 16.99 | 2.42 |
| JUN | $16^{th}$ - $23^{rd}$ | 17.51 | 2.51 |
| JUL | $06^{th}$ - $13^{th}$ | 14.56 | 2.08 |
| AUG | $16^{th}$ - $23^{rd}$ | 9.07 | 1.29 |
| SEP | $15^{th}$ - $22^{nd}$ | 15.78 | 2.25 |
| OCT | $19^{th}$ - $26^{th}$ | 9.07 | 1.29 |
| NOV | $16^{th}$ - $23^{rd}$ | 9.71 | 1.38 |
| DEC | $14^{th}$ - $21^{st}$ | 12.71 | 1.81 |
| MEAN X | - | 12.72 | 1.81 |
| ± SD | - | 3.57 | 0.51 |

A minor variation was observed in chloride contents due to its non-utilization by the aquatic plant. In domestic wastewater Dissolved oxygen and Percentage oxygen saturation values were increased significantly, after the experiment, as *Hydrilla verticillata* Casp played a vital role in oxygen transfer in to water system. Dissolved oxygen and Percentage oxygen saturation had exhibited comparatively lower rate of increase in winter months. Chemical Oxygen Demand of municipal wastewater was recorded higher value above 200 mg/L during summer months April to June and lower value of 57.6 mg/L in August, which indicated the inorganic pollution. The more availability of oxygen is directly related to an increase in rate of oxidation, which reduced the quantity of organic matter and COD of the municipal wastewater. The peak values of Total hardness and Calcium hardness (353.08 and 223.74 mg $CaCO_3$/L) was observed in month of March and April respectively, however, minimum values for both the parameters were determined in the month of May.

Throughout the study period Calcium value was above 50 mg/L while Magnesium value was recorded below 50 mg/L. Ca & Mg are essential nutrients hence, absorbed by the submerged aquatic plant *Hydrilla verticillata* Casp for their growth in culture. Maximum value of Calcium content (89.67 mg/L) was estimated in the month of April, while Magnesium had maximum value (37.43 mg/L) in the month of March. Significant absorption by the submerged aquatic plant had reduced the value of Total hardness, Calcium hardness, Calcium and Magnesium during a week interval, in culture.

Nitrogen contents were examined as Ammonical, Nitrite and Nitrate form. As Nitrate nitrogen is the stable product of oxidation. In most of the months Nitrate nitrogen had recorded maximum value above 40 mg/L, while Nitrite nitrogen recorded 0.3 to 0.5 mg/L with an intermediate value of Ammonical nitrogen in the range of 6.53 to 26.19 mg/L. All the forms of nitrogen were reduced after the culture but the experimented aquatic plant preferred the Nitrate form of nitrogen therefore, it was absorbed in higher amount as compared to Nitrite and Ammonical form of Nitrogen. Ammonical and Nitrite form of nitrogen had a lower rate of absorption during rainy months, while minimum absorption of Nitrate nitrogen was noted in the winter month January.

Phosphorous contents were estimated as Total ortho, Acid Hydrolyzable, Total and Organic phosphate. All the forms were absorbed by the aquatic plant in culture due to its essentiality for the growth. The peak value of Total ortho phosphate (0.892 mg/L), Acid hydrolysable phosphate (0.520 mg/L), Total phosphate (1.742 mg/L) and Organic phosphate (0.795 mg/L) were observed in the month of December, June, September and January respectively. Month of June recorded the minimum value of Total ortho Phosphate (0.530 mg/L), while other forms of phosphate had exhibited their minimum value in the month of March.

**Percentage changes in physico-chemical parameters**

Variable nutrient removal tendency and Net Primary Productivity was marked in complete tenure of research.

**Physical changes**

Temperature minimized 9.89 percentage and pH shifted above of 6.58 %. Reduction in Turbidity, Salinity noticed 37.00 and 17.42 %. Due to ionic absorbing tendency of *Hydrilla verticillata* Casp in experiment, Electrical conductivity and Total dissolved solids were deducted in 15.66 and 15.80 % relatively.

**Chemical changes**

34.50 % Reduction was found for Total alkalinity. Remarkable utility of Carbon dioxide in photosynthetic activity Total and Free carbon dioxide reduced in 51.56 and 36.91 %. Because of significant release of oxygen in water by *Hydrilla verticillata* Casp Dissolved oxygen values increased to 140.1 % and Oxygen saturation 113.0 %. Little change in Chloride (4.38%) was found. Chemical oxygen demand decline average of 36.14 %. Total hardness, Calcium hardness, Calcium, Magnesium values were reduced by percentage of 28.71, 24.96, 24.39 and 37.16 individually.

More than 39.00 % reduction rate was noticed for Nitrogenous and Phosphorous compounds like Ammonical – N (39.45 %), Nitrite – N ( 47.59 %), Nitrate – N ( 50.35 %) and Total ortho phosphate (52.58% ), Acid hydrolysable phosphate (42.85 %) and 44.69 % for Total phosphate. Organic phosphate reduction value in percentage was 36.41 after the experimentation in municipal wastewater with *Hydrilla verticillata* Casp under average study of one year.

**Statistical analysis**

Analyzed data before and after experimentation in domestic wastewater were subjected to compare the results is significant or not. Difference between individual means were tested (Student "t" test) using least significance difference at 0.05 significance level.

**Biomas of experimental aquatic plant (NPP)**

The economic success of energy production and water treatment using aquatic plant or biomass production depends to a large extend on the successful physiological events and survival in the treatment system. Aquatic Macrophytic based wastewater System (AMS) mainly consists of mono or poly-culture of aquatic plants. Minimum temperature, nutrients, high concentration of salts prevents the up-take capacity of this aquatic plant. The results on relative growth rates of aquatic plant cultured under identical condition have been reported, (Reddy and Debusk, 1985). Diverse aquatic plants and their efficient utility for biomass (NPP) generation have been observed by Oki and Uki, 1978a, Wolverton and Donald, 1979, Reddy and Sutton, 1984 and Verma and Singh, 2006. Variable biomass was produced by experimental/aquatic plant in complete study period was noticed. Amount of biomass depends on physiological capability, age, species and related environment.

The usefulness of submerged aquatic plant *Hydrilla verticillata* Casp for remediation of nutrients from municipal wastewater was supported by the results obtained for net primary productivity (NPP) value (Table- 2) calculated after the experiment. The month of June recorded a higher value of NPP 2.51 gm $m^{-2}$ $day^{-1}$, while minimum 0.86 gm $m^{-2}$ $day^{-1}$ in the month of February. Average NPP was 1.81 gm $m^{-2}$ $day^{-1}$. The observed higher NPP value during summer months had proved that the summer month is comparatively better for the remediation through *Hydrilla verticillata* Casp.

Above results indicated that submerged aquatic plant *Hydrilla verticillata* Casp had an efficient applicability to reduce significant amount of nutrients from domestic wastewater and also for biomass production. The method proved to be a cheap, low cost, eco-friendly and pollution free techniques for wastewater treatment.

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