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Efficacy of Microalgae on the Removal of Pollutants from Wastewater

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Abstract: *Expansion of urban populations, increased coverage of domestic water supply and sewerage give rise to greater quantities of municipal wastewater. With the current emphasis on environmental health and water pollution issues, there is an increasing discharge of waste water in developing countries. Present technologies in developing countries for treating waste water are not sufficient and cost effective. Chlorella vulgaris is a form of green microalgae efficient for pond-based wastewater treatment, rather than bacterial strains for their ability to flocculate Chlorella vulgaris in a culture suspension. A microbial flocculent would be significantly cheaper than traditional flocculants and is believed to be less potentially toxic than synthetic polymers which are currently available. Chlorella vulgaris absorbed more pollutant compared to Chlamydomonas sp., which reveals that Chlorella vulgaris is efficient than Chlamydomonas sp., for treating waste water.*

Keywords: *micro algae, waste water, technology, urbanization, chlorella, chlamydomonas*

I. Introduction

Wastewater is a general term used to represent the water with poor quality that contains more amounts of pollutants and microbes. If wastewater is discharged into the nearby water bodies, it can cause serious environmental and health problems to human beings. Wastewater treatment is an important measure to reduce the pollutant and other contaminants present in wastewater[6].

The study was carried out to assess the treatment efficiency of phytoremediation technology[3] using *Chlorella vulgaris* and *Chlamydomonas sp.*, in removing the contaminants by using artificial small scale laboratory constructed wetlands of the Vrishabhavathi water flowing in the Jnana Bharathi campus. Presently the river is a receptacle to wastes discharged from industrial, residential and agricultural areas of the catchment, carrying toxic elements and wastes. The valley has variegated industries including chemical industries, paper mills, battery industries, electroplating, tanneries, drug, distilleries, rubber industries etc. discharging their raw effluents into the river. Visually the river water is highly decolorized with froth and form on the surface of the water accompanied by bad odor for miles around. Often, the treatment of industrial waste water by industries established alongside or close to the river is highly unsatisfactory and without genuine environmental commitments.

II. Materials and Methods

A. Study area

The Vrishabhavathi river flows in the Jnana Bharathi campus, Bangalore University. The upper Vrishabhavathi watershed lies between 12°55' – 13°05'N and 77°30' – 77°35'E, covering an area of about 97 sq.km. The river has two tributary streams viz., River Vrishabhavathi and Nagarabhavi Thori. The drainage pattern is dendritic. Of the many river systems in existence in Karnataka, going by the scale, Vrishabhavathi River can be considered a small river system. Regarded as the tributary of river Cauvery, the river originates in North-East of the city and flows towards South before it confluences with river Arkavathi near Muduvadidurga. The combined sewer joins Cauvery at Sangama. In its course the river touches the Byramangala reservoir that is located about 16 km from the city.

B. Sampling and Methods

Criteria for selection of sampling points are mainly based on the proximity, accessibility towards the sampling points and the effluent from the residential settlement and other socio-economic activities around the river system. Physico-chemical parameters such as electrical conductivity, total dissolved solids, alkalinity, total hardness, calcium hardness, chloride, phosphates, nitrates, sulphates, dissolved oxygen, chemical oxygen demand and biological oxygen demand were determined by following standard methods [1]. For Physico-chemical analysis, the measurement of pH was done using Digital pH Meter. The electrodes used were clean and buffer standards were applied for accurate calibration.

C. Phytoremediation Technology

- **Isolation and Culturing of *Chlorella vulgaris***

Chlorella vulgaris was cultured from natural lakes rich in phytoplankton and zooplankton species. 100ml of lake water samples were inoculated in to 200ml of commercially available *Chlorella vulgaris* Isolation Agar media (HiMedia, M769) in aseptic condition and incubated for 6-7 days under natural light and fluorescent lighting (40Watt Tubes) either continuously or controlled to give a photoperiod of L:D 14:10 (fluorescent light: Day light)[2] [4].

- **Isolation and Culturing of *Chlamydomonas sp.,***

Chlamydomonas sp., was cultured from natural lakes rich in phytoplankton and zooplankton species. 100ml of lake water samples were inoculated in to 200ml of Tris-Acetate Phosphate Buffer (TAP Medium) in aseptic condition and incubated for 6-7 days under natural light and fluorescent lighting (40Watt Tubes) either continuously or controlled to give a photoperiod of L:D 14:10 (fluorescent light: Day light)[2] [4].

- ***Chlorella vulgaris* and *Chlamydomonas sp.,* Enrichment**

The *Chlorella vulgaris* culture medium were transferred to 1000ml of Bold's Basal Medium in aseptic condition and incubated in room temperature between 15-25^{o}C under the natural light and fluorescent lighting (40Watt Tubes) and were harvested for *Chlorella vulgaris* after 4-6 weeks. Basal Bold medium were supplemented during incubation period[2] [4].

- **Harvesting and Purification of *Chlorella vulgaris* and *Chlamydomonas sp.,* cell suspension**

The *Chlorella vulgaris* species were harvested by gravitational centrifuge method. The matured culture broths were centrifuged at 500-600rpm for 10mins. Supernatants were collected and purified with water collected by Reverse osmosis method at 200-300rpm for 5mins. Aliquots were removed and supernatants were suspended in 5ppm of Basal Bold Medium[2] [4].

III. Results and Discussion

The samples collected from both upstream and downstream of Vrishabhavathi River were subjected to analysis and the results are discussed.

Table 1: Physico-chemical characteristics of Vrishabhavathi waste water

Parameters	Unit	IS: 2296 – 1982 (TL)	Up stream	Down stream
pH	--	6.5 – 8.5	7.78	7.78
EC	µmhos/cm	2250	1047	1044
TDS	mg/L	500	299	303
Chlorides	mg/L	600	213	206
Alkalinity	mg/L	200	471	475
Total Hardness	mg/L	300	303	299
Ca Hardness	mg/L	75	203	207
Mg Hardness	mg/L	30	100	93
DO	mg/L	4	0.33	0.34
BOD	mg/L	30	253	248
COD	mg/L	250	340	320
Nitrate as NO_3-N	mg/L	50	7.7	8.2
Phosphate	mg/L	5	88	90.1

The study indicated that the pH, Electrical Conductivity (EC), Turbidity, Dissolved Oxygen, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chloride, Phosphate (PO_4), Nitrates and Total Alkalinity were found to decrease, with the increase of sewage flow when compared to that of upstream and downstream sites. The phosphate level in waste water exceeds the Indian standard for inland surface water[5] and this may due to the usage of detergents in the daily life, domestic wastes and human activities. The presence of phosphate accelerated the activities of some of the microorganism, and the DO level was depleted due to pollution loadand further depletion of Dissolved Oxygen concentration in river water was due to increased values of other parameters as mentioned above. The transparency also decreased due to the addition of variety of pollutants and Quantity of suspended matter.

A. Efficiency of *Chlorella vulgaris* for absorption of pollutants in wastewater

The analysis of physico-chemical parameters of Vrishabhavathi waters showed that Nitrate, phosphate, chloride, Calcium and magnesium pollutants were drastically decreased after the treatment with *Chlorella vulgaris*, whereas pH increased slightly from 7.78 to 8.25 after the treatment with microalgae. Electrical conductivity was reduced by 25.7%, recorded as 1240 µmhos/cm after treatment and initial EC was recorded as 1645µmhos/cm. Similarly Total Dissolved solids also considerably reduced by 47.6% were found to be 540mg/L and Initial TDS was recorded as 850mg/L.

Initial Dissolved Oxygen level was 0.335mg/L and it increased to 2.75mg/L. BOD and COD was recorded 250.5mg/L and 330mg/L respectively before treatment, after treatment it was reduced by 31.2% and 13.9% respectively was found to be 175mg/L and 287.5mg/L respectively.

Nitrate and Phosphate contents in raw sewage was recorded 7.9mg/L and 89mg/L respectively, after treatment these pollutants were significantly reduced by 97.5% and 85.8% which was recorded as 0.28mg/L and 13.53mg/L respectively. Similarly, Chlorides and Alkalinity also considerably reduced to 31.3% and 48.4% respectively. The estimated chlorides and Alkalinity in raw sewage was 209.5mg/L and 473mg/L and after treatment were 146.2mg/L and 249.8mg/L.

The estimated Total Hardness in waste water was found to be 301mg/L and after treatment it’s reduced to 192.4mg/L. Similarly calcium and magnesium Hardness also reduced considerably. The Calcium was found to be 205mg/L and after treatment it’s reduced to 143.7mg/L. Magnesium Hardness also reduced from 96.5mg/L to 52.4mg/L.

Table 2: Comparison of pollution load before and after in Vrishabhavathi water using *Chlorella vulgaris*

Parameters	Unit	IS: 2296 – 1982 (TL)	Before	After
pH	--	6.5 – 8.5	7.78	8.25
EC	µmhos/cm	2250	1645	1240
TDS	mg/L	500	850	540
Chlorides	mg/L	600	209.5	146.2
Alkalinity	mg/L	200	473	249.8
Total Hardness	mg/L	300	301	192.4
Ca Hardness	mg/L	75	205	143.7
Mg Hardness	mg/L	30	96.5	52.4
DO	mg/L	4	0.335	2.75
BOD	mg/L	30	250.5	175
COD	mg/L	250	330	287.5
Nitrate as NO_3-N	mg/L	50	7.9	0.28
Phosphate	mg/L	5	89	13.53

B. Efficiency of *Chlamydomonas sp.*, for absorption of pollutants in waste water

The analysis of physico chemical parameters of Vrishabhavathi waters shows that Nitrate and phosphate, chloride, Calcium and magnesium pollutants were decreased after the treatment with *Chlamydomonas sp.*, whereas pH increased slightly which was found to be 8.36, initial pH of raw sewage was recorded 7.78. Electrical conductivity (EC) was reduced by 12.8%, recorded as 1452 µmhos/cm after treatment and initial EC was recorded as 1645µmhos/cm. Similarly Total Dissolved solids (TDS) also considerably reduced 30.2% were found to be 602mg/L. Initial TDS was recorded as 850mg/L.

Initial Dissolved Oxygen level was 0.335mg/L and it increased to 2.50mg/L. BOD and COD was recorded 250.5mg/L and 330mg/L before treatment and after treatment it reduced by 29.9% and 13.1% was found to be 178.5mg/L and 290.2mg/L.

Nitrate and Phosphate contents in raw sewage was recorded 7.9mg/L and 89mg/L and after treatment these pollutants were significantly reduced by 78.9% and 76.0% which was recorded as 2.46mg/L and 20.53mg/L. Similarly, Chlorides and Alkalinity also considerably reduced to 20.9% and 45.6%. The estimated chlorides and Alkalinity in raw sewage was 209.5mg/L and 473mg/L and after treatment were 168.0mg/L and 263.8mg/L.

The estimated Total Hardness in waste water was found to be 301mg/L and after treatment it reduced to 203.4mg/L. Likewise calcium and magnesium Hardness also reduced considerably. The Calcium was found to be 205mg/L and after treatment it reduced to 154.7mg/L. Magnesium Hardness also reduced from 96.5mg/L to 64.4mg/L.

Table 3: Comparison of pollution load before and after in Vrishabhavathi water using *Chlamydomonas sp.,*

Parameters	Unit	IS: 2296 – 1982 (TL)	Before	After
pH	--	6.5 – 8.5	7.78	8.36
EC	µmhos/ cm	2250	1645	1452
TDS	mg/L	500	850	602
Chlorides	mg/L	600	209.5	168.0
Alkalinity	mg/L	200	473	263.8
Total Hardness	mg/L	300	301	203.4
Ca Hardness	mg/L	75	205	154.7
Mg Hardness	mg/L	30	96.5	64.4
DO	mg/L	4	0.335	1.96
BOD	mg/L	30	250.5	178
COD	mg/L	250	330	290.2
Nitrate as NO_3-N	mg/L	50	7.9	2.46
Phosphate	mg/L	5	89	20.53

C. Comparison of absorption efficiency of pollutants by *Chlorella vulgaris and Chlamydomonas sp.,*

Analysis of efficiency of absorption of pollutants in Vrishabhavathi water by *Chlorella vulgaris* and *Chlamydomonas sp.*, shows that *Chlorella vulgaris* is more efficient than *Chlamydomonas sp.*, for treating waste water.

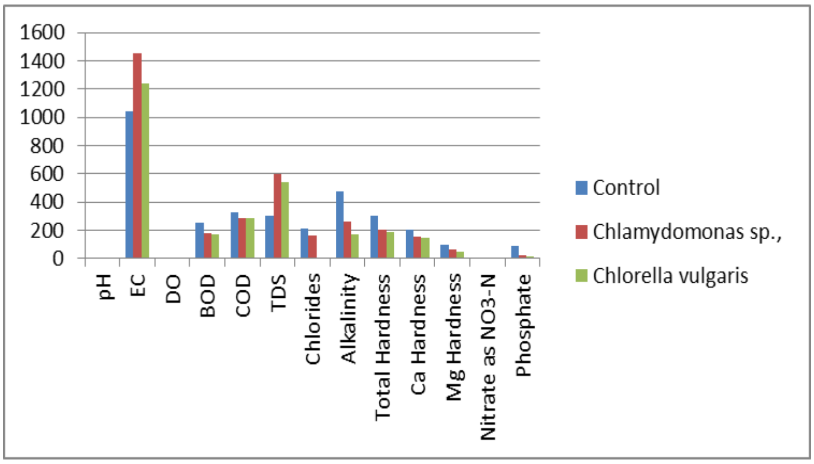

Figure 1: Comparison of absorption of pollution Efficiency of *Chlorella vulgaris and Chlamydomonas sp.,*

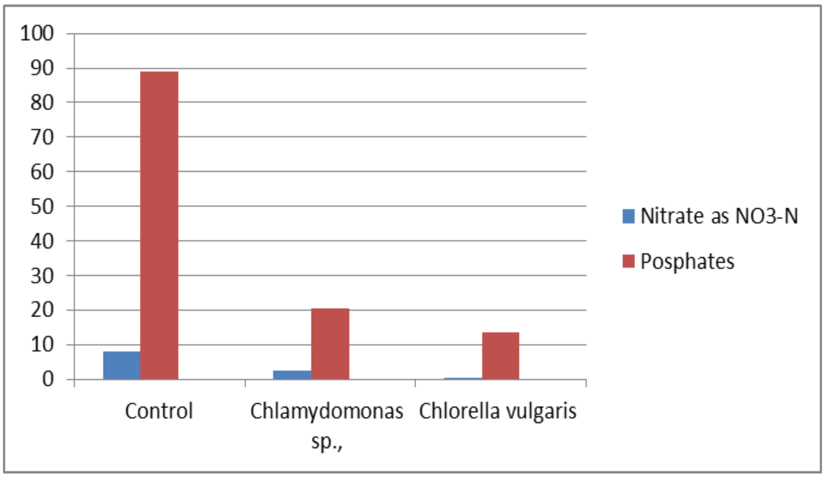

Figure 2: Comparative study of *Chlorella vulgaris* and *Chlamydomonas sp.*, for absorption of Nitrates and Phosphates

IV. Conclusions

Wastewater treatments using micro algae is sustainable methods and "socio-ecological" and "Socio Economic" method. "Bubble column" photo-bioreactor is best system for waste water treatment through a series of outdoor basins or ponds. The biomass (*Chlorella vulgaris*) can be used as feed, especially for aquaculture, agrochemicals and other bioactive substances, and energy sources such as biodiesel, hydrocarbons, methane, and ethanol. Analysis of efficiency of absorption of pollutants in Vrishabhavathi water by *Chlorella vulgaris* and *Chlamydomonas sp.*, shows that *Chlorella vulgaris* is more efficient than *Chlamydomonas sp.*, for treating waste water. *Chlorella vulgaris* is a form of green algae efficient for pond-based wastewater treatment, rather than bacterial strains for their ability to flocculate *Chlorella vulgaris* in a culture suspension. A microbial flocculent would be significantly cheaper than traditional flocculants and is believed to be less potentially toxic than synthetic polymers which are currently available.

V. References

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