Municipal wastewater treatment by phycoremediation technique

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***Abstract*— Phycoremediation is the use of algae for the removal pollutants from wastewater. In this study, we examine the impact of *Spirulina platensis* on removal of physicochemical impurities from municipal wastewater treatment from Sangvi collection tank. The objective of this study was to treat the wastewater by phycoremediation and to analyze the physico-chemical parameters before and after treatment. The phycoremediation carried out in the presence of sunlight gave better results. The Results have shown 68.17 & 75.16% improvement in reducing COD for I (3 tray) & II (2 tray) sets of trays and 85.36% removal in case of Tank with Aerator. The BOD, Sulphates, Phospates, Hardness and Chlorides removal 51 &65.81%, 67.23 & 58.53%, 91.76 & 56.27%, 80.73 & 70.64 and 69.21 & 76.2% was observed for both the sets of Trays .Similarly the BOD, Sulphates, Phospates , Hardness and Chlorides removal rate in case of Tank with induced aeration was observed as 69.42, 57.83, 98, 70.55 and 48.78% respectively. Thus spirulina sp. was found to be a very efficient and cost effective method for wastewater treatment.**

***Index Terms*— phycoremediation,Spirulina sp BOD,Sulphates, Phospates, Hardness ,Chlorides.**

I. INTRODUCTION

The wastewater is used to represent the water which is having poor Quality that contains more amounts of pollutants, microbes etc. The untreated wastewater discharged into water bodies creates hazardous impact on the environment and lead to cause Euthrophication (Bharti and Sailaja, 2014). To remove the nutrients in

the wastewater several processes have been used but the main disadvantages of that process is high cost required and increased sludge production. To overcome this problem the alternative to wastewater treatment is the use of microalgae for removing nutrients (Dr and Sailaja, 2014). Microalgae uptake nutrients during their metabolism and do not generate additional pollution when the biomass is harvested, therefore allow efficient recycling of the nutrients (De la Noue *et al* 1992). Domestic wastewaters constitute the major components of waste generated in developing country like India etc. Algae based wastewater treatment plants treat the wastewater by natural oxidation processes (Rinhofer and Smith, 2011, Sah et al., 2012). Microalgae are superior as more amount of toxic and other waste can be treated efficiently and they are non pathogenic. Algae utilize the waste as nutritional source and degrade the pollutants (Oswald, 1988).The large amount of carbon dioxide is emitted into the atmosphere during the degradation of organic pollutants present in the wastewater (Wang et al, 2010).

The Rapid urbanization and industrialization is placing an unpredictable pressure on the water quality and its demand (Kumar, 2015; Kumar and Chopra 2016). There are other constraints such as inefficient infrastructure, weak urban and municipal regulations, inadequate financial services together to set bring deterioration in environment quality (Padmapriya and Murgesan *et al*, 2012

The world is facing problem of wide variety of pollutants and contaminants present in the atmosphere from various developmental activities. The population increase has resulted to increase in the polluted area of water. The quality and quantity of waste generated and discharging into natural river bodies has indicated to utilize different strategies to overcome water quality deterioration (Kshirsagar, 2013). In India the present population growth rate is 109% per annum and the population is expected to be 105 billion mark by 2050 (Water Resource Management,2005). Therefore, the unwanted wastes must not reach waterbodies untreated and for it, satisfying legislation limits are mandatory. Such technology needs to achieve zero liquid discharge norms set by central pollution control board (CPCB 2003)In terms of fast growth Pune and Pimpri Chinchwad cities are one of the growing cities of India.

Water and Environmental Concern;

More than 70 % of our planet's surface is covered by water. The actual situation is that less than 3% of our planet's surface is covered by the fresh water and 69% is frozen in the Ice gaps and glaciers. The total water resource available on the earth is 1% for humans. It is not difficult to imagine that with the help of the data of the World's population growth that, in the future water will be a very scarce resource (Gleick, 1966). Since water misuse can be related as a society's major problem and the wasteful manners of human kind will not help the current situation. The discharges are increasing day by day due to the existing plan for water supply networks set-up in many villages(N Abdel Raouf and A A Homaidan,2012). It is nowadays recognized that pollution associated problem are major concern to the society. (N Abdel Raouf,A A Homaidan;2012). The Environmental laws are given more applicability and the enforcement has been increased strictly (Aaron Schwabach,2006).So in terms of health, environment and economy ,the fight against pollution has become a major issue. The pollution is a manmade arising when the concentrations of naturally occurring substances are increased or when non natural synthetic compounds are released into the environment as a result of domestic, agricultural and industrial water activities lead to organic and inorganic pollution.(Mouchet,1986:Lim et al.,2010).

PHYCOREMEDIATION

Phycoremediation means the use of microalgae for the removal of pollutants including nutrients and xenobiotics from wastewater and CO2 from waste air(Olguin ,2003).Since the last few decades efforts has been made for use of microalgal cultures to perform the biological tertiary treatment for treating secondary effluents(Oswald and Gotaas,1957;De la Noue et al,1992).The assumption is that the microalgae will transform some of the contaminants into non hazardous materials enabling the treated water to be reused or discharged safely.(Oswald,1988).As microalgae use carbon dioxide as a carbon source, they can grow photoautotrophically without the addition of an organic carbon source. The use of microalgae for removal of nutrients from different wastes have been discussed by many authors (Beneman et al,1980; De-Bashan et al, 2002; Gantar et al,1991; Queiroz et al,2007). Microalgae offers a low cost and cost effective method to remove nutrients and other contaminants in wastewater treatment, while produce a high quality biomass because of high capacity for inorganic nutrient uptake. (Bolan et al, 2004; Munoz and Guieyssea, 2006). In addition microalgae play an important role during treatment of domestic wastewater in maturation ponds or small to medium scale treatment in facultative or aerobic ponds (Aziz and Ng, 1993; Mara and Pearson, 1986; Oswald, 1995).

In addition, The microalgae play an important role during the tertiary treatment of domestic wastewater in maturation ponds or the treatment of small- to middle-scale municipal wastewater in facultative or aerobic ponds(Aziz and Ng, 1993; Mara and Pearson, 1986; Oswald, 1995).

They have been used for removing nitrogen and phosphorus from wastewater (Oswald, 1988) and have the potential to be used to remove various pollutants, including oxides of nitrogen (NOx) (Nagase et al., 2001). Similarly, degradation of complex organic carbon substrates in tannery wastewater has been attempted in high-rate algal ponding systems (Dunn, 1998).

Sewage Treatment

It is the process of removing contaminants from wastewater primarily from household sewage.It includes physical,chemical and biological processes to remove these contaminants and produce environmentally safer and treated wastewater. A byproduct of sewage treatment is usually a semi solid waste or slurry called sewage sludge that has to undergo further treatment before being suitable for disposal or land application.(Metcalf and Eddy,1972). Sewage treatment may be referred as wastewater treatment. For most cities, the sewer system will also carry a proportion of industrial effluent to the sewage treatment plant which has received pretreatment at the factories themselves to reduce the pollutant load. If the sewer system is a combined sewer then it will also carry urban runoff (storm water) to the sewage treatment plant. Sewage water can travel towards treatment plants through piping and in a flow with gravity and pumps. The first part of filtration of sewage includes a bar screen to filter solids and large objects which are then collected in dumpers and disposed of in landfills. Fat and grease is also removed before the primary treatment of sewage,(Metcalf and Eddy,1972).

Wastewater Stabilization Ponds (WSP);

WSP defines that as an oxidation pond is shallow pond designed for sewage treatment by natural purification processes under the influence of air and sunlight. The process largely consists of interactions of bacteria and algae. Bacteria digest and oxidize the constituents of sewage and make it harmful and odour free. Algae utilize carbon dioxide and other substances from bacterial action and through photosynthesis produce oxygen needed to sustain bacteria in the treatment. During the detention period theobjectionable properties of the sewage largely disappear (Mara 2004).

Lagoons also called ponds provide settlement and biological improvement when stored in large manmade ponds or lagoons.The lagoons are highly aerobic Small filter-feeding invertebrates such as Daphnia and species of Rotifera greatly assist in treatment by removing fine particulates (V.Vijayashanthimeena and G Vijayakumar, (2017).

The arrangement of the ponds is in which the wastewater is first subjected to preliminary treatment; screening and grit removal to remove large and heavy solids. The design of the preliminary treatment stage is the same as that used for conventional electro mechanic WWTP, but for WSPs the simplest systems are generally used (manually raked screens and manually cleaned constant velocity grit channels).Basically the primary treatment is carried out in anaerobic ponds, secondary treatment in facultative ponds and tertiary treatment in maturation ponds. Anaerobic and facultative ponds are used for removal of organic matter (BOD) and the maturation ponds for the removal of faecal viruses and nutrients (phosphorous, etc)(Pena and Mara 2004).

Materials and Methods

Experimental Setup;

Use of Tray in the presence of Sun light:

The Trays were cleaned and placed in open area where sunlight is readily available. The 3 liters wastewater was poured in the trays in triplicate and 50 ml of *Spirulina plantesis* algae culture was added for the treatment. Samples were sampled at 3, 6, 9 and 12 days of treatment and used for analysis. Two sets were used (One set in triplicate and One set in duplicate was arranged).

Use of Tank in the presence of Aeration and Sun light

The test was carried out in tank of size 50cm*29 cm*20 cm and trays. The tank was cleaned and prepared for test on a platform where natural sunlight was available. The 10 L wastewater was poured into the tank and 200 ml of *Spirulina plantesis* algae culture were added into the tank. The treated wastewater was collected from tank through tap at bottom side to analyze the laboratory parameters such as pH, COD, BOD5, Chloride, Sulphate and Phosphate for twelve days. The entire tests were performed as per standards procedure (APHA, 1989). The tank was under observation in october 2017.

Fig 1:I Set of 3 Trays in presence of sunlight

II. RESULTS AND DISCUSSIONS

The water samples were collected for testing in October 2017.The wastewater testing was performed at a period of 3 days for trays and on daily basis for tank. The various parameters such as pH, COD, BOD, Sulphates (SO_4^-), Chlorides(Cl^-),Hardness(TH), Phosphates (PO_{4-})etc were calculated.

Study of effect of pH on Algal growth,

pH is a term used to express the intensity of the acid or alkaline condition of a solution. It is a way of expressing the hydrogen-ion concentration or the hydrogen-ion activity. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C .Solutions with a PH less than 7 are said to be acidic and solutions with a PH greater than 7 are said to be basic or alkaline.

Table1 Study of effect of pH on Algal growth,.

Sr NO	pH	***Initial wt of filter paper***		**Algae+Filter Paper(gm)**		**Weight of Algae(gm)**	
		At 0 Day	After 8 Days	At 0 days	After 8 Days	At 0 days	After 8 days
1	2	1.286	1.272	3.847	2.390	2.561	1.118
2	4	1.272	1.274	3.594	1.734	2.322	0.460
3	6	1.257	1.267	3.776	2.678	2.519	1.411
4	8	1.270	1.256	3.943	3.956	2.673	2.700
5	10	1.286	1.262	3.981	3.984	2.695	2.722

6	12	1.283	1.263	3.968	1.929	2.685	0.666

Performance of Spirulina Plantesis on waste water in set of Trays and Tank with induced aeration

The table shows characteristics of wastewater after using spirulina algae for corresponding Sets of trays.In the process all above parameters get reduced day by day. Ttable shows the result for trays for 12 days period.The amount of Spirulina algae added was 100 ml per trays.

Table 2 Physiochemical parameters after 12 days for I Set of 3 Trays

Parameter	Characteristics				
	Before phycoremediation		After phycoremediation		
	Days				
	0	3	6	9	12
PH	7.1(±0.628)	8.55(±0.03)	8.70(±0.031	8.83(±0.015	8.87(±0.017)
EC	0.85(±0)	1.36(±0.08)	2.02(±0.09)	2.40(±0.013)	2.74(±0.07)
BOD	192.5 (±0)	175.67 (± 3.91),	162.19 (±3.89),	131.22 (±4.80)	94.38 (±4.09)
COD	315(±0)	268.86 (± 3.13),	214.67 (±2.77)	161.77 (±2.71)	99.53 (±4.25)
Chlorides	61.53(±0)	50.88 (±8.28)	39.03 (±1.17)	21.3 (±2.37)	14.64 (±2.03)
Hardness	215.55 (±2.0)	174.81 (±11.06),	115.55 (±6.41),	74.04 (±4.14)	41.5 (±1.96)
Sulphates	85 (±0) and	51(± 2.64),	40(±2.08),	30(±1)	27.83 (±1.58)
Phosphate	6.4 (±6.28)	1.8(± 0.1)	1.133 (±0.233)	0.833 (±0.08)	0.533(±0.033)

Effect of Spirulina on Wastewater for 12 days
I Set of 3 Trays in presence of sunlight

Analysis of various parameters after and before treatment has been reported in table 2.

After the treatment of wastewater in trays for a period of 12 days, the initial COD values at 0 day was 315 (±0)and were reduced to 268.86 (± 3.13), 214.67 (±2.77), 161.77 (±2.71) and 99.53 (±4.25) mg/l after the period of 3, 6, 9 and 12 days respectively. The analysis of various parameters before and after treatment has been reported in (Table 2). The Spirulina is used for removal of pollutants. After treatment with spirulina COD removal efficiency for 3, 6, 9 and 12 days was 14.64% (±0.99), 36.96% (±5.76), 48.61% (±0.87) and 68.17% (±1.59).

In case of BOD the values at 0 day was 192.5 (±0) and were reduced to 175.67 (± 3.91), 162.19 (±3.89), 131.22 (±4.80) and 94.38 (±4.09) mg/l after the period of 3, 6, 9 and 12 days respectivel. After treatment with Spirulina BOD removal efficiency for 3, 6, 9 and 12 days was 8.74% (±2.03), 16.08% (±2.33), 31.82% (±2.50) and 51% (±2.06).

In Case of SO_4^- the values at 0 day was 85 (±0) and were reduced to 51(± 2.64), 40(±2.08), 30(±1) and 27.83 (±1.58) mg/l after the treatment at 3, 6, 9 and 12 days respectively. After treatment with Spirulina $SO4^-$ removal efficiency for 3, 6, 9 and 12 days were 40% (±3.11), 52.93% (±2.44), 64.69% (±1.17) and 67.23% (±1.87) (Fig3).

PO_4^- values at 0 day was 6.4 (±6.28) after treatment of 3, 6, 9 and 12 days the BOD values reduced to 1.8(± 0.1), 1.133 (±0.233), 0.833 (±0.08) and 0.533(±0.033) mg/l respectively. The PO_4^- removal efficiency obtained after treatment with spirulina for 3, 6, 9 and 12 days were 8.74% (±1.56), 16.08% (±3.64), 31.82% (±1.36) and 51% (±0.52).The Cl^- values at 0 day was 41 (±0) , After the treatment of 3,6,9 and 12 days the Cl^- values reduced to 38.83

(±0.51), 30.49 (±0.26), 21.29 (±0.45) and 12.61(±0.45) respectively.The Cl^- removal efficiency obtained after treatment with spirulina for 3, 6, 9 and 12 days were 5.28% (±1.26), 25.61% (±0.64), 48.04% (±1.11) and 69.21% (±1.09).

The hardness (TH) values at 0 day was 215.55 (±2.0) the period of 3, 6, 9 and 12 days the TH values were reduced to 174.81 (±11.06), 115.55 (±6.41), 74.04 (±4.14) and 41.5 (±1.96) respectively.TH removal efficiency obtained after treatment with *Spirulina plantisis* at 3, 6, 9 and 12 days were 18.8% (±5.12), 46.37% (±2.96), 65.61% (±1.90) and 80.73% (±0.94).

The following table shows reduction of parameters for 2 sets of trays.

Table.3 Physiochemical parameters after 12 days for I Set of 2 Trays Tray 1

Parameters	**0th day**	**3rd day**	**6th day**	**9th day**	**12th day**
pH	7.15	8.12	8.31	8.52	8.76
EC	0.88	1.83	2.2	3.1	3.32
TS	1520	-	-	-	968
TDS	1040	-	-	-	715
TSS	480	-	-	-	253
COD	332	276	208	128	72
BOD	243.2	212.87	141.91	101.37	91.2
Chlorides	61.53	42.6	37.86	18.93	12.61
Hardness	193.33	140	106.67	86.67	51.23
Phospate	11.1	10	7.8	5.2	4.6
Sulphate	82	79	66	40	33

Table. 4 Physiochemical parameters after 12 days for II Set of 2 Trays Tray 2

Parameters	**0th day**	**3rd day**	**6th day**	**9th day**	**12th day**
pH	7.15	8.30	8.42	8.72	8.82
EC	0.88	1.9	2.3	2.8	3.3
TS	1520	-	-	-	845
TDS	1040	-	-	-	578
TSS	480	-	-	-	267
COD	332	272	216	124	90
BOD	243.2	223.01	131.78	106.4	75.01
Chlorides	61.53	59.16	40.2	23.67	16.67
Hardness	193.33	146.67	100	93.34	62.3
Phospate	11.1	9.5	8.1	5.9	5.1
Sulphates	82	74	64	43	35

Effect of Spirulina on Wastewater for 12 days II Set of 3 Trays in presence of sunlight

The COD analysis was conducted on the sets of 2 trays for 12 days period with use of *Spirulina plantisis.* The COD values at 0 day was 332 (±0), while after the treatment of 3, 6, 9 and 12 days the COD values reduced to 274 (± 2), 212(±4), 126 (±2) and 81(±9) mg/l respectively. The COD removal efficiency obtained after treatment with *Spirulina plantisis* for 3, 6, 9 and 12 days were 17.43% (±0.46), 36.14% (±0.98), 62% (±0.49) and 75.6% (±2.21) .

The BOD values at 0 day was 243 (±0), after the treatment of 3, 6, 9 and 12 days the BOD values were reduced to 217.94 (± 5.07), 136.85 (±5.06), 103.88 (±2.515) and 83.12 (±8.11) mg/l respectively

BOD removal efficiency obtained after treatment at 3, 6, 9 and 12 days was 10.38% (±1.70), 43.72% (±1.70), 57.28% (±0.84) and 65.81% (±2.72)

The SO_4^- values at 0 day was 82 (±0), while after the treatment of 3, 6, 9 and 12 days SO_4^- values were reduced to 76.5 (± 2.5) ,65 (±1), 41.5 (±1.5) and 34 (±1)mg/l respectively

SO_4^- removal efficiency obtained after treatment of 3, 6, 9 and 12 days were 6.7% (±2.49), 20.73% (±0.99), 49.38% (±1.49) and 58.53% (±0.99)

The PO_4^- values at 0 day was 11.1 (±0), while after treatment of 3, 6, 9 and 12 days the BOD_3 values reduced to 9.75 (± 0.25), 7.95 (±0.15), 5.55 (±0.35) and. 4.85 (±0.25) mg/l respectively.

The PO_4^- removal efficiency obtained after treatment of 3, 6, 9 and 12 days were 12.15% (±1.84), 28.37% (±1.10), 49.99% (±2.57) and 56.27% (±1.85)

Cl^- values at 0 day was 61.53(±0) , while After the treatment of 3, 6, 9 and 12 days Cl^- values reduced to 50.88 (±8.28),39..03(±1.17)**,**21.3(±2.37)and 14.64(±2.03)respectively

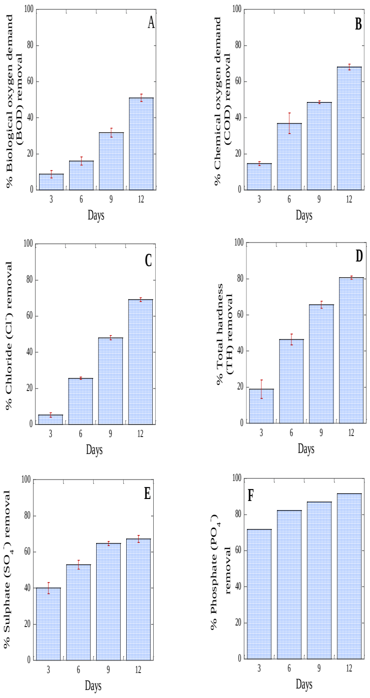

Figure 2; Percentage Removal of *physicochemical parameters of treated municipal waste water A-BOD*,*B*-COD,C-Chlorides,D-hardness,E-Sulphates and F-Phospates for Tray 1, Tray 2, Tray3.

CONCLUSIONS

The study demonstrates the viability of experimental technology for the treatment of domestic municipal sewage wastewater. The removal of various physicochemical impurities such as BOD, COD, Sulphates, Phospates, etc has been carried out by the using of spirulina plantensis algae.

This is one of the novel and economic biological treatment for reducing the physiochemical impurities in municipal wastewater.Spirulina Plantesis is a photosynthetic algae and it consumes nutrients available in municipal wastewater for growth.

By using this method the COD was removed up to 68.17% and 75.6% in 12 days period for the sets of trays .The removal of BOD, Sulphates, Phospates, Chlorides, Hardness by 51.0%, 67.23%, 91.76%, 69.21 and 80.73% for 3 set of trays and 65.81%, 58.53%, 56.27%, 76.2% and 70.64% for 2 sets of trays in 12 days period was achieved.

So Spirulina Plantesis algae will be helpful for mitigation of heavy pollution of any wastewater generated from household activities. So it can be a very innovative and eco friendly technique

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