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APPLICATION OF PHYCOREMEDIATION TECHNOLOGY IN THE TREATMENT OF SEWAGE WATER TO REDUCE POLLUTION LOAD

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ABSTRACT

Phycoremediation is the use of algae for the removal or biotransformation of pollutants from waste water. Employing this technology in the treatment of municipal waste effluents presents an alternative to the current practice of using conventional methods, including physical and chemical methods. In the present study the effluents from sewage drains were treated using algal species isolated from the sewage drains itself. The objective of this study was to treat the effluent by phycoremediation (pilot-scale laboratory study) and to analyze the physical and chemical parameters before and after treatment.The results obtained showed that out of 22 isolated cloacal algae(sewage algae) three species i.e. *Gloeocapsa gelatinosa, Euglena viridis* and *Synedra affinis* were found most prominent.On 25th day of mixed algal culture treatment there was cent percent removal of NO_3-N, NO_2-N, Phosphate, iron, zinc and copper and there was a significant reduction in BOD, COD, NH_3-N, Org.-N and hardness.

KEY WORDS: Phycoremediation, cloacal algae, sewage drain, batch culture, effluent

The cloacal algae (Sewage algae) offer a low cost and effective approach to remove excess nutrients and other contaminants in tertiary wastewater treatment, while producing potentially valuable biomass, because of high capacity for nutrient uptake (Bolan et al., 2004; Munoz and Guieyssea, 2006).They have been used for removing nitrogen and phosphorus from waste water and have the potential to be used to remove various pollutants, including oxides of nitrogen (Nagase et al., 2001)

Sewage consists of water borne wastes of the community and is almost water containing organic and inorganic impurities. In Agra, sewage water is disposed off by 11 major and minor drains into Yamuna river which involves serious risks to health and sanitation. They lead to the evolution of bad odours, spread of enteric diseases and fish mortality. It is, therefore, necessary to treat sewage prior to its disposal. This treatment of sewage water has been designed to render the organic matter in sewage harmless and inoffensive to living beings.

The oxidation ponds, a cheaper alternative treatment process is quite efficient in removing the pollutants where meeting of O_2 requirement is done by algal photosynthesis. The use of algae as a waste water treatment, was pioneered by Oswald et al. (1953). A good deal of work on the treatment of water waste by algal species has also been done by Sengar et al. (1990), Olguin (2003) and Zhang et al. (2008).

In the present study the emphasis has been laid to know the efficiency of algal species (isolated from sewage drains) in removing the pollutants from sewage water. This investigation is an endeavour in the direction of treatment of city sewage before being discharged into any water body.

MATERIALS AND METHODS

The studies were conducted in triplicates in the glass vessels. The raw water was collected from the drain, from a place, where the drain opens into the river Yamuna, in the previously rinsed plastic containers. The quantitative analysis of various pollutants was made following standard methods (APHA, 2000). For the present study naturally occurring algal population has been exploited for the treatment of waste water. The studies were conducted in batch culture in 6"x 6"x 6" size glass vessels. To know the capability of algal species in reducing pollution load, vessels (in triplicate) were set up and incubated at 30 ± 1°C under uninterrupted fluorescent (2400 lux) light. For these trials, the raw water collected from drain was filtered through Buchner filter to remove all algae occurring naturally. Thereafter, the filtered water was filled into the clean experimental glass vessels and then inoculation was

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done by the mixed algal species. The vessels were incubated as stated above. In all three experimental sets the analysis of various pollutants was done at 5 days intervals up to 25 days, drawing the required volume of water from the experimental vessel. The algal biomass was also calculated at 5 days intervals.

RESULTS

The results of the quantitative changes in algal biomass and different pollutants of sewage water during the treatment period are presented in the table 1-2 and figures 1-2. It was observed that sewage water incubated in glass vessels at optimum light and temperature, the naturally occurring algal forms present in unfiltered raw water multiplied and made their visible appearance on 5th day. The maximum algal biomass (dry wt.) production was noticed on 25th day of experiment which was in increasing order from 5th day. This growth of algae has changed the pollution load of sewage water.

The pH of pre-treated water was 8.1 and then no change was found on 5th day but from 10th day onward decrease in pH was noticed and finally on 25th day it became 7.1.The initial DO of sewage water was 0.8mg/l and on 5th day onward there was an increase in DO content and on 25th day there was 875% increase of dissolved O_2. On the other hand there was decrease in BOD and COD level from 5th day treatment to 25th day and it has reduced to the level of 96.2% and 82.0% respectively.

All four types of nitrogen were recorded in the raw sewage water. Out of all NH_3-N and Org,-N were recorded in high quantities. There was cent percent removal of NO_3-N and NO_2-N on 20th day. The Phosphate is also an essential nutrient for the healthy growth and development of algal species. In the pre-treated sewage water, initial concentration of phosphate was very low i.e. 0.12 mg/l There was complete removal of phosphate on 20th day.

Like other pollutants the reduction in hardness was maximum i.e. 19.2, 39.2, 58.9, 86.8 and 96.9% on 5th, 10th, 15th, 20th and 25th day respectively. The removal of heavy metals was also found appreciable. Complete removal of Fe, Zn and Cu was observed on 20th day. Iron was also completely used by all remaining algal species on 20th day in table-1.

Algal Species Recorded During Mixed Culture Treatment

After removing the suspended matter from the sewage water, the decanted sewage water was taken for the microscopic examination to observe the algal species in it for their quantitative and qualitative observation. On the basis of percentage abundance the algal species were classified into three categories i.e. highly prominent (abundance more than 10%), prominent(between 3-10%) and less prominent(less than 3%). In the pre treated sewage water total 22 species were recorded out of which only three species i.e. *Gloeocapsa gelatinosa, Euglena viridis* and *Synedra affinis* were observed most prominent. But during the experiment, *Oscillatoria sp*. and *Phormidium corium* multiplied and achieved their position in most prominent category while *Gloeocapsa gelatinosa* and *Synedra affinis* became less prominent respectively, While on 25th day *Oscillatoria sp., Phormidium corium, Spirulina laxisima, Scenedesmus quadricauda, Euglena viridis* and *Navicula viridula* were observed highly prominent.This indicated the competition between the 22 algal species during the treatment period for the utilization of pollutants in table 2.

DISCUSSION

Sewage contains almost all the nutrient elements required for growth of algae. These nutrients are present in the form of complex organic compounds in sewage water; therefore, they are first to be oxidized into assimilable forms before being utilized by algae. This oxidation is brought about by the complex symbiosis of algae and bacteria. The O_2 liberated by algae is utilized by bacteria which oxidize the organic compounds of the sewage into simple forms which are suitable for healthy growth and development of cloacal algae. Although many kinds of algae are sensitive to large amount of organic wastes in their environment, others are tolerant. During mixed algal treatment process Lakshmi et al., 1990 observed that on first day of experiment *Scenedesmus* and *Chlorella* were dominant while at the end of experiment *Microcystis, Navicula* and *Nitzschia* were dominant but in the present study *Oscillatoria sp, Spirulina*

Table 1: Treatment of sewage water by mixed Algal Population

Parameter	Pre-treated sewage water	POST TREATED SEWAGE WATER									
		5th day		10th day		15th day		20th day		25th day	
		mgl^{-1}	% change	mgl^{-1}	% change	mgl^{-1}	% change	mgl^{-1}	% change	mgl^{-1}	% change
Algal Biomass	1.1	17.6	-	38.4	-	69.6	-	104.6	-	136.4	-
pH	8.1	8.1	00	7.8	-3.7	7.6	-6.2	7.4	-8.6	7.1	-12.3
DO	0.8	0.7	-12.5	1.9	+137.5	3.6	+350.0	5.5	+587.5	7.8	+875.0
BOD	390.0	456.0	+16.9	342.0	-12.3	179.0	-54.1	94.0	-75.9	15.0	-96.2
COD	378.0	348.0	-7.9	287.0	-24.1	191.0	-49.5	138.0	-63.5	68.0	-82.0
NH_3-N	16.42	14.94	-9.0	12.47	-24.1	7.32	-55.4	3.44	-79.0	1.36	-91.7
Org.-N	14.49	13.53	-6.6	10.44	-27.9	6.28	-56.7	2.32	-84.0	15.0	-98.9
NO_3-N	0.96	0.75	-21.9	0.48	-50.0	0.2	-73.9	00	-100	00	-100
NO_2-N	0.49	0.33	-32.7	0.21	-57.1	0.08	-83.7	00	-100	00	-100
Phosphate	0.12	0.10	-16.7	0.05	-58.3	0.02	-83.3	00	-100	00	-100
Hardness	426.0	344.0	-19.2	259.0	-39.2	175.0	-58.9	56.0	-86.8	13.0	-96.9
Iron	0.81	0.66	-18.5	0.35	-56.8	0.17	-79.0	00	-100	00	-100
Zinc	0.62	0.51	-17.7	0.29	-53.2	0.17	-72.6	00	-100	00	-100
Copper	0.25	0.19	-24.0	0.0	-64.0	0.0	-88.0	00	-100	00	-100

Note : All Values of parameters are in mgl^{-1} except pH

Table 2: Development of algal species during mix culture treatment method

S.No.	ALGAL SPECIES	Algae observed at the beginning of experiment	Algae observed during experiment	Algae observed at the end of experiment
1.	*Arthrospira platensis*	++	+	-
2.	*Gloeocapsa gelatinosa*	+++	+	-
3.	*Merismopedia punctata*	+	+	+
4.	*Oscillatoria limosa*	++	+	+
5.	*Oscillaroria sp*	++	+++	+++
6.	*Phormidium corium*	++	+++	+++
7.	*Spirulina laxissima*	++	++	+++
8.	*Synchocystis aquatilis*	+	-	-
9.	*Ankistrodesmus falcatus*	+	-	-
10.	*Chlamydomonas conferta*	++	+	-
11.	*Chlorococcum humicola*	++	+	+
12.	*Chlorella vulgaris*	+	+	+
13.	*Scenedesmus carinatus*	++	+	-
14.	*Scenedesmus qudricauda*	++	++	+++
15.	*Euglena viridis*	+++	+++	+++
16.	*Phacus pleuronectus*	++	++	++
17.	*Cyclotela operculata*	++	+	+
18.	*Diatoma vulgare*	+	-	-
19.	*Melosira varians*	++	+	+
20.	*Navicula viridula*	+	++	+++
21.	*Nitzschia subtilis*	++	+	++
22.	*Synedra affinis*	+++	+	+

+++ Highly prominent, **++** Prominent, **+** Less prominent, - Absent

Figure 1 : Histograms showing the effect of algal species in reducing pollution load in drain water on different days of treatment

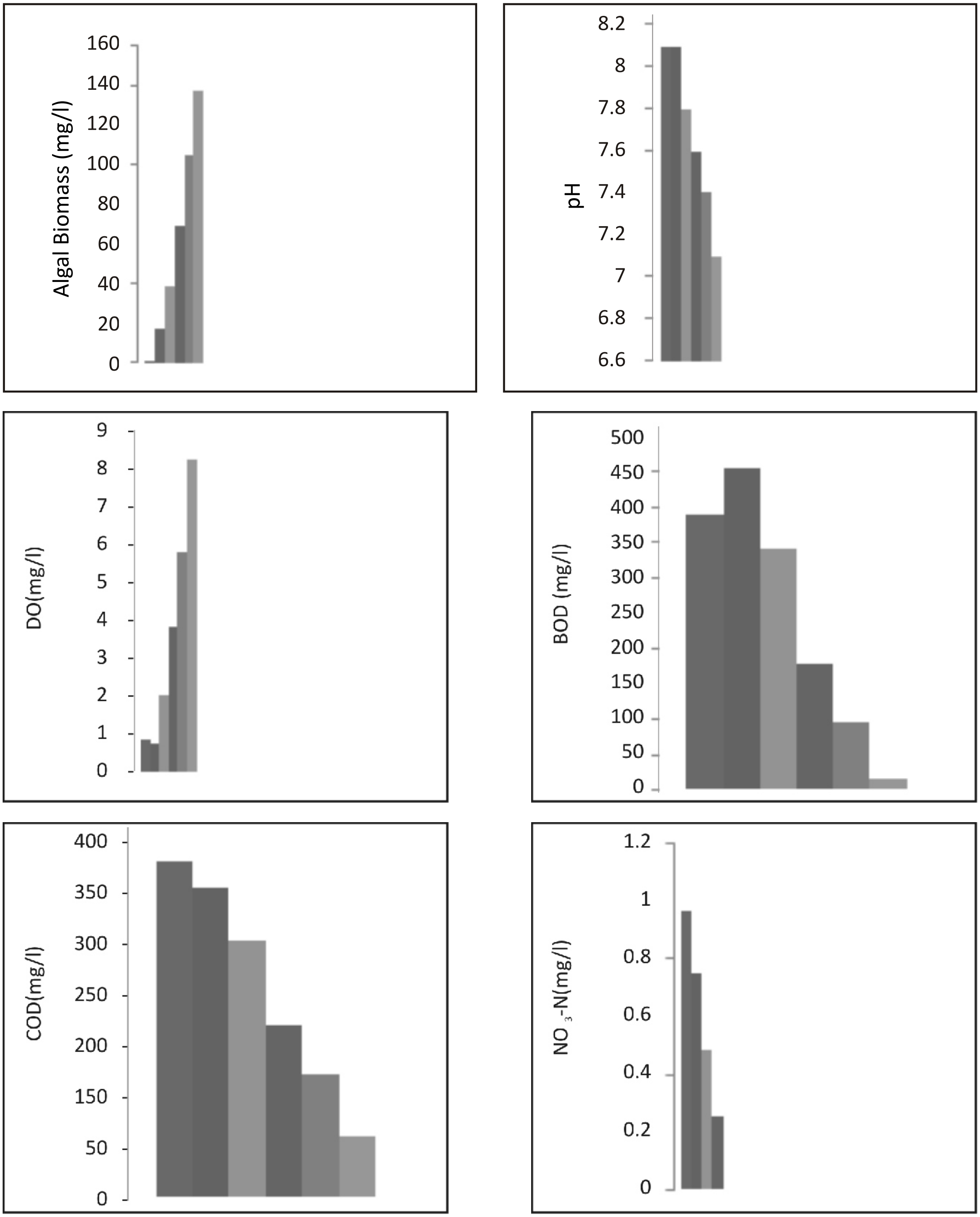
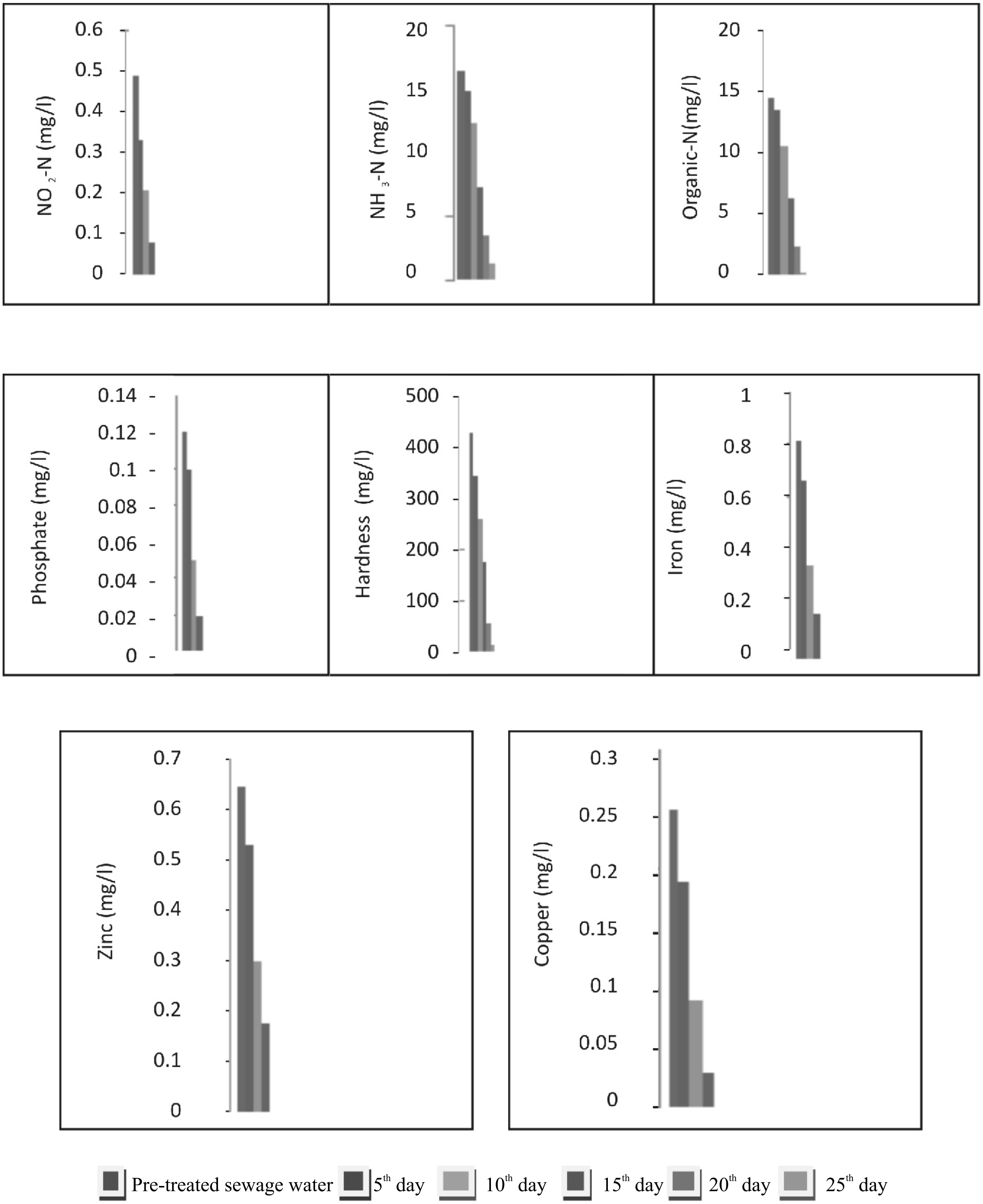


Figure 2 : Histograms showing the effect of algal species in reducing pollution load in drain water on different days of treatment



laxissima, Phormidium corium, Scenedesmus quadricauda, Euglena viridis and *Navicula viridula* were highly prominent.

Algae excrete no other gas than O_2 during their exponential phase of growth. Normally only a minimum amount of soluble organic material is excreted and therefore, in a living state, they do not increase the amount of organic matter in a pond. During the experiment initial biomass was very less. But it was observed that algal biomass increased with duration due to multiplication and uptake of necessary nutrients from sewage water. The maximum biomass was achieved on 25th day of culture after that there was declination in growth.

The change in pH was observed in the treated water which decreased gradually. It was due to the removal of various salts or metallic ions. This lowering of pH was also due to the microbial activity which in turn increases the decomposition of organic matter. Klein (1972) stated that pH change cause a shift in the relative abundance of various genera in the aquatic system, which is in conformity with the present investigation where along with the decrease in pH i.e. from 8.4 to 7.1 cause the change in abundance of microalgae like *Oscillatoria, Phormidium, Spirulina, Scenedesmus,Euglena* and *Navicula*.

The DO content in the sewage water may be increased either by absorption of O_2 from atmosphere, advective gains, reduction of nitrate, reduction of nitrite, reduction of sulphates or by photosynthetic oxygenation by cloacal algae. Out of these reasons, the photosynthesis appeared to be the main factor in aquatic habitat. The high DO content in the water of sewage helps in the self purification .In the present investigation, in the initial stage i.e. on 5th day, the DO decrease while BOD increases, it was due to an increased bacterial activity and low algal growth. Similar observations were also reported by Sengar et al., (1990). Jayangouder et al., (1983) studied the reduction of organic pollution load and BOD from slaughter house effluent using *Spirulina* and *Chlorella* sp. and also reported that *Chlorella vulgaris* induced progressive reduction in both BOD and COD of the effluent and this could be attributed to the high algal growth rate and intense photosynthetic activities.

Bokil and John(1981) recorded 78-83% reduction of COD from domestic sewage by mixed algae while authors have noted this reduction from 7.9-82%.Further the removal of all four types of N_2 was more pronounced . Organic-N and NH_3-N were reduced 91.7 and 98.9% respectively on 25th day of treatment, while NO_3-N and NO_2-N were completely removed on 20th day. Since NO_3-N is the best source of nitrogen to algae hence there was manifold increase in algal biomass which in turn increase the removal of various pollutants.

Algae appear to offer the most easily exploited biological system for extracting phosphorus from domestic sewage. In the present investigation there was cent percent removal of phosphorus on 20th day which is in conformity with the data presented by Lakshmi et al., (1990). Similarly various algal species take up the salts from the sewage and thus there was a gradual reduction in hardness level which is co-related with the uptake of Ca and Mg from sewage. There was 96.9% reduction of hardness in the experimental set.

Therefore, it can be said that algal species in sewage may be used as a device for sewage purification and also as a method for the recovery of valuable food materials from the sewage.

Finally the benefits of phycoremediation can be summarized as :

Ability of cloacal algae to tackle more than one problem simultaneously which is not possible by conventional physical and chemical methods.

The commercial benefits could be derived from the biomass and other extracellular products.

Cost effective as it saves energy and lot of chemicals.

Natural oxygenation of environment.

Possible co-production of biofertilisers.

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