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APPLICATION OF PHYCOREMEDIATION TECHNOLOGY IN THE TREATMENT OF INDUSTRIAL EFFLUENT

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Abstract: **Phycoremediation" is one of pollution control technologies that use physical and biological systems to remove the pollutants and biodegradation or transformation of various toxic chemicals to less harmful forms. Industrial pollution is the major cause for degradation of environment around us affecting the water we use, the air we breathe and the soil we live on. The exponential increase in industrialization is not only effecting large areas of agricultural lands, but simultaneously causing serious environmental degradation of soil as well. Water pollution causes loss to soil, plants, human and animals and spread epidemic and chronic diseases. As a part of study effluent samples were collected from a highly polluted region of Gayathri Sugars Pvt. Ltd. situated at Adloor yellareddy village, Sadashivanagar mandal of Nizamabad district in Telangana for analysis of physico-chemical and biological parameters. The Objective of the present work is to evaluate the efficiency of algae for removal of heavy metals. The present study aimed at a comparative study of phycoremediation before and after treatment of industrial effluent. As algae is used as source of food it is necessary to remove the heavy metals present in industrial effluent, which is possible using not only higher plants but also employing some genera of algae. In the present experimental work BGA and green algae like *Chlorella, Scenedesmus, Spirogyra, Cladophora* and *Oedogonium, Spirulina, Anabaena, Lyngbya, Oscillatoria* were employed in removal of heavy metals from industrial effluent.**

Keywords: **Effect of algae, removal of heavy metals, industrial effluent.**

1. INTRODUCTION

The sugar industry is playing an important role in the economic development of the Indian sub continent. If Effluents released were left untreated, receiving water bodies such as rivers, lakes and streams would lead to depletion of oxygen, phenomenon eutrophication. (**Aarti Narasimham, Sumathi and Subrahmanian** 2008). The effluents released produce a high degree of organic pollution in both aquatic and terrestrial ecosystems. They also alter the physico-chemical characteristics of aquatic bodies like lakes reservoirs ponds. (Saranraj**** and Stella et al., 2012)*** and affect aquatic flora and fauna. Industrialization has led to increased emission of pollutants into ecosystems. Metal pollutants can easily enter the food chain and if heavy metal-contaminated soils are used for production of food crops, it results in decrease of production in toxic metal polluted areas (**Gosavi *et al*., 2004**). Accumulation of toxic metals like Hg, Cu, Cd, Cr and Zn in humans has several consequences such as growth and developmental abnormalities, carcinogenesis, neuromuscular control defects, mental retardation, renal malfunction **(Inouhe *et al*., 1996).**

Among the effluent discharging industries, sugar mills play a major role in polluting the water bodies. As shown in the statistics received from USDA Foreign Agriculture Service, sugar consumption rate is highest in India. However, as far as the production is concerned, India has notched up 2nd position following Brazil, the largest sugar producer in the World.

Sugar industry is one of the most important agro based industries in India and is highly responsible for creating significant impact on rural economy in particular and countries economy in general. Sugar industries rank second among the agro based industries in India (***Saranraj* and .Stella et al., 2012)***. Heavy metal Phycooremediation involves removal of heavy metal from industrial waste water through metabolically mediated or physico-chemical pathways. The idea of the application of microalgae in bioaccumulation of heavy metal ions was proposed for the first time by (***Oswald and Gootas., 19570)*** but this topic has gained attention only recently (***Oswald 1988; Doshi et al., 2007).*** This natural and environmental friendly technology is cost effective. Out of several methods that are used in the treatment of industrial effluents, Phycoremediation is a cheaper and environmentally friendlier alternative for biological degradation of industrial effluents. An alga is promising factor for purification of waste water containing heavy metals. Many years ago, the accumulation of heavy metals by algae had been studied extensively for bio-monitoring or bioremediation purposes ***(Nakajima. 1982).***

The choice of micro algae to be used in wastewater treatment is determined by their robustness against wastewater and by their efficiency to grow in and to take up nutrients from wastewater (***Olguin., 2003*).** In well oxygenated high rate ponds, climax cultures that are not readily grazed consist mainly green algae and blue green algal forms ***(Oswald. 1998***). Present study is on treatment of sugar effluent by using Algae to degrade or remove hazardous pollutants from the effluent. Pollution is a common problem in almost all industrial areas of Telangana State because of organic and industrial wastes. Nizamabad district is one among the polluted districts and “hot spots" in Telangana state. Gayatri Sugars Pvt. Ltd. Is taken as choice of study because it is seasonal in nature and operates only for 120 to180 days in a year, large amount of waste is generated during the manufacture of sugar from suspended solids, organic matters, effluent, sludge, press mud and biogases.

In the present experimental work BGA and green algae like *Chlorella, Scenedesmus ,Spirogyra, Cladophora* and *Oedogonium* (Chlorophyceae), *Spirulina, Anabaena, Lyngbya, Oscillatoria* (Cyanophyceae) were employed in removal of heavy metals from industrial effluent.

2. MATERIALS AND METHODS

The samples were collected in sterilized bottles during crushing season, from out flowing region of industrial area. Collected samples were analysed for physico-chemical and biological parameters The samples were analyzed for Physicochemical and biological parameters of raw effluents using standard analytical procedures recommended by ***American Public Health Association (APHA) 1998 and*** (***Gupta., 2004***). Concentration of heavy metals in water samples were analyzed using ***atomic absorption spectrophotometer*** (**AAS)**. Effluent samples were analyzed and determined on the basis of 18 important parameters-pH, Total dissolved Solids, Chemical oxygen demand, Biological oxygen demand, Chlorides, Sulphates, Oil & Grease, Electrical conductivity, Calcium, Magnesium, Nitrates, Color, Lead , Copper, Zinc, Iron and Temperature. The average values of the samples at location for all the eighteen parameters were compared to the corresponding standard curves provided by the ***National Sanitation Foundation (NSF) (Brown et al., 1970***). Physicochemical and biological parameters of raw effluents can be attributed to dissolution of various heavy metals during crushing period.

PROCESS OF EFFLUENT TREATMENT:

PHYSICAL PROCESS: Removal of large and suspended particles involves methods such as precipitation, flocculation, and filtration. In the process of sedimentation, physical phenomena relating to the settling of solids by gravity were allowed to operate. This consists of simply holding a wastewater for a short period of time in a tank under quiescent conditions, allowing the heavier solids to settle, and removing the “clarified” effluent. In filtration process wastewater is passed through a filter medium to separate solids by using the sand filters to further remove entrained solids from a treated wastewater followed by sedimentation. Permitting greases or oils which float to the surface and skim, physically removing them from the wastewaters is often carried out as part of the overall treatment process. (***Mukesh Doble, Anil Kumar, in Bio treatment of Industrial Effluents.,2005).***

TREATMENT OF EFFLUENT BY ALGAE:

COLLECTION OF ALGAL SAMPLES: Algal samples showing luxuriant growth were collected from different natural water bodies such as Amruthapur Lake and CMC Lake (Christian Medical College). These are Fresh water lakes situated nearby Telangana University. Samples were collected in sterilized bottles from multiple sites of large bodies. The micro algae were identified and further used., *Chlorella vulgaris, Chlorella pyrinoidosa, Scenedesmus, Spirogyra, Cladophora glomerata, Anabaena, Nostoc, Lyngbya, Oscillatoria, Spirulina*.

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GROWTH OF ALGAL spp in vitro : In order to select a suitable organism for the treatment process, algal samples were collected. Among the eukaryotic **green algae**; *Chlorella vulgaris*, *Chlorella pyrinoidosa*, *Scenedesmus*, *Spirogyra*, *Cladophora glomerata and* **Blue-green algae**: *Anabaena*, *Nostoc*, *Lyngbya*, *Oscillatoria*, *Spirulina*. were microalgae, the most potential for sugar mill effluent.

The isolated Blue green algae were maintained in BG 11culture medium. Microalgal cultures were examined under a microscope and identified according to the monograph of ***(Desikachary*., 1959**). The axenic culture of the isolated blue green algae was maintained in improvised BG11 medium ***(Rippka et al., 1979***). Isolated green algal species were grown in soil extract medium and also grown in Bristol's Modified Medium (BMM).

TREATMENT METHOD BY GREEN ALGAE *IN VITRO* CONDITION:

Sugar effluent was collected from Gayathri Sugars industry, situated at Adloor yellareddy village, Sadashivanagar mandal of Nizamabad district T.S. To study the role of green microalgae in sugar effluent, the following treatment were employed. (A) Effluent inoculated with algal sp (B) soil extract medium inoculated with algal species. Initial physico chemical parameters were done by using standard method APHA (2000). Experiments were conducted in triplicates and repeated at least three times. Five grams of suspension of green algal sp was inoculated as initial inoculums in each 3 litre primary treated effluent and soil water medium containing flasks (A & B). The experiment was conducted for a total duration of 20 days under open condition

TREATMENT METHOD BY BLUE GREEN ALGAE *IN VITRO* CONDITION

To study the role of blue green algae in sugar effluent, the following treatment were employed. (A) Effluent inoculated with algal sp (B) BG 11 medium ***(Rippka et al., 1979***) inoculated with BGA sp. Initial physico chemical parameters were done by using standard method APHA (2000). Experiments were conducted in triplicates and repeated at least three times. Two grams of suspension of BGA was inoculated as initial inoculums in each 2 litre primary treated effluent and BG 11 containing flasks (A & B). The experiment was conducted for a total duration of 15 days under open condition. The results obtained are presented in **Table 1** and **Table 2**

TABLE 1: Physico-Chemical parameters of effluents before and after treatment by Green Algae

S.NO	Parameters	Units	Before treatment	After treatment
1.	Colour	---	Brown & turbid	Light green
2.	pH	---	5.21	---
3.	Temperature	˚C	38	---
4.	Total dissolved Solids	ppm	2556.0	1332.0
5.	Chemical oxygen demand	ppm	3700	1240
6.	Biological oxygen demand	ppm	1126	3345
7.	Oil & greases	ppm	10.88	2.00
8.	Chlorides	ppm	497	179
9.	Sulphates	ppm	422	122
10.	Calcium	ppm	448	233
11.	Magnesium	ppm	155.52	11.01
12.	Nitrates	ppm	28.4	5.01
13.	Lead	ppm	0.068	0.05
14.	Copper	ppm	0.112	0.002
15.	Zinc	ppm	0.32	0.04
16.	Iron	ppm	28.8	7.06
17.	Potassium	ppm	123.0	3.335
18.	Cadmium	ppm	120.0	12.00

TABLE 2: Physico-Chemical parameters of effluents before and after treatment by BGA

S.NO	Parameters	Units	Before treatment	After treatment
1.	Colour	---	Brown & turbid	green
2.	pH	---	5.21	---
3.	Temperature	˚C	38	---
4.	Total dissolved Solids	ppm	2556.0	1132.0
5.	Chemical oxygen demand	ppm	3700	1145

6.	Biological oxygen demand	ppm	1126	3360
7.	Oil & greases	ppm	10.88	2.02
8.	Chlorides	ppm	497	139
9.	Sulphates	ppm	422	136
10.	Calcium	ppm	448	214
11.	Magnesium	ppm	155.52	15.02
12.	Nitrates	ppm	28.4	4.01
13.	Lead	ppm	0.068	0.015
14.	Copper	ppm	0.112	0.006
15.	Zinc	ppm	0.32	0.07
16.	Iron	ppm	28.8	6.09
17.	Potassium	ppm	123.0	3.125
18.	Cadmium	ppm	120.0	14.00

3. RESULTS AND DISCUSSION

The experiments were carried out amended with BG11 medium. 2 gm of BGA sp was inoculated amended in **BG11** media separately. The entire set of sugar effluent experiment was carried out for 15 days. 5 gm of Green algae sp was inoculated emended **soil extract medium** separately; the entire set sugar effluent was carried out for 20 days.

In the present study, effluent treated with algae, colour of effluent changed from Brown on the 5th day and on 7th day it changed to light greenish, on 15th day it was completely turned to green. These changes in colour and odour of the sugar effluent may be due to the organic matter present in the effluent and made the water clear. Primary treatment and secondary treatment methods to remove colour of effluent **(*McKay et al., 1981***). The removal of colour and heavy metals from effluent is often more important than the removal of soluble colourless organics, which normally contribute to the major BOD load.

Often in the present study the amount of total dissolved solids(TDS) was reduced from 2556-1332, COD 3700-1240, Oil and greases 10.88-2.00, *Cl* 497-179, Sulphates (SO_4) 422-122, Calcium(Ca) 448-233, Magnesium (Mg) 155.52-11.01, Nitrate(NO_3) 28.4-5.01, lead(Pb)0.068-0.05, Copper(Cu) 0.112-0.002, Zinc(Zn) 0.32-0.07, Iron(Fe) 28.8-6.05, Potassium(K) 123.0-3.135, Cadmium(Cd) 120.0-12.00 and BOD increased from 1126- 3345 by Green algae.

While treatment with Blue green Algae the amount of total dissolved solids(TDS) was reduced from 255-1132, COD 3700-1145, Oil and greases 10.88-2.02, *Cl* 497-139, Sulphates (SO_4) 422-136, Calcium(Ca) 448-214, Magnesium (Mg) 155.52-15.02, Nitrate(NO_3)28.4-4.01, lead(Pb)0.068-0.015, Copper(Cu) 0.112-0.006, Zinc(Zn) 0.32-0.04, Iron(Fe) 28.8-3.355, Potassium(K) 123.0-3.125, Cadmium(Cd) 120.0-14.00 and BOD increased from 1126-3360 by Blue green algae.

The higher amount of total dissolved solids present in raw effluent may be due to the presence of higher concentration of biodegradable organic matter in the sugar effluent which is in accordance with earlier reports. The high dissolved solids in different industrial effluents were also reported earlier by (***Sinha.*, 1993, *Amudha and Mahalingam., 1999***) and (***Sundaramoorthy et al.*,2000, *Kotteswari et al., 2007)*** reported 74.37 percent reduction of total dissolved solids, when the oil refinery effluent was treated with *Spirulina*, Similarly, (***Veeralakshmi et al., 2007***) reported 19.16 percent reduction of total dissolved solids, when the petroleum effluent was treated with *Oscillatoria sp.*

The ability of algae to absorb metals has been recognized for many years ***(Megharaja et al., 2003).*** In natural environments, algae play a major role in controlling metal concentration in lakes and oceans**.(*Kim et al.,1998)*** reported 95.3% and 96% removal of nitrogen and phosphorus, respectively, by *Chlorella vulgaris* in 25% secondarily treated swine wastewater after four days of incubation. An algae is promising factor for purification of waste water containing heavy metals. Many years ago, the accumulation of heavy metals by algae had been studied extensively for bio-monitoring or bioremediation purposes. Attempts were made by ***(Nakajima., 1982***) to recover uranium from the sea and freshwater by using algae, yielded satisfactory results.

Algae possess the ability to take up toxic heavy metals from the environment, resulting in higher concentrations than those in the surrounding water ***(Megharaja et al., 2003; Shamsuddoha et al., 2006***). Bio-accumulation studies reveal the *accumulation of the contaminant in the organism via* uptake of food or water containing the contaminant.

The toxicity of Cd has also been well documented in other eukaryotes **(*Rainbow, 1995; Unger and Roesijadi., 1996***). Nickel is a problematic heavy metal ***(Joho et al., 1995***). Higher concentrations of nickel are toxic. ***Shehata et al.***, cultured *Scenedesmus* in different concentrations of copper, cadmium, nickel, zinc and lead to evaluate their effects on the growth

of algae. Various studies have been carried out to show the role of algae in the bioremediation of heavy metals. Some metals such as Cu, Pb, Cd, Co Ni, Cr, Fe, Mn are removed as continuous uptake, Bio absorption of heavy metals from aqueous solution by fresh water algae.

4. CONCLUSION

The result of the present study indicates, that the treatment of sugar effluent by algal species, is very efficient and it also proved to be cost effective and eco-friendly treatment. In this the *Chlorella vulgaris, Chlorella pyrinoidosa, Scenedesmus, Spirogyra, Cladophora glomerata, Anabaena, Nostoc, Lyngbya, Oscillatoria, Spirulina* species play a vital role in the removal of COD, TSS, TDS and other metals. Microalgae can be used for tertiary treatment of wastewater due to their unique capacity to assimilate nutrients. Employing this technology in the treatment of industrial effluents presents an alternative tool to the current practice of using Conventional methods, including physical and chemical methods. The timely and cost-effective remediation of metal and organic contaminated sites mandate an understanding of the extent and mechanisms by which toxic metals inhibit organic biodegradation.

Absorption of metal ions from aqueous system by microalgae has spent much attention for wastewater treatment, which may reduce the metal ion concentration significantly the mechanisms by which metals inhibit biodegradation vary with the composition and complexity of the system under investigation and also include both physiological and ecological aspect. A thorough understanding of these systems, taking into account various levels of complexity is needed to develop new approaches to remediation of contaminated sites. Tertiary treatment process aims to remove all organic ions. It can be accomplished biologically or chemically. The biological tertiary treatment process appears to perform well when compared to the chemical processes which are in general too costly to be implemented in most places and which may lead to secondary pollution. In addition, each additional treatment step in a wastewater system greatly increases the total cost ***(Oswald., 1988*).**

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