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Short Communication

Bioremediation of Yamuna Water using Algae

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This study illustrates the efficiency of microalgae-based treatment system for the bioremediation of Yamuna water. Organic and Inorganic substances that are released into the water because of domestic, agricultural and industrial activities leads to heavy pollution of rivers. Many times it becomes inconvenient that this pollution cannot be treated by primary and secondary treatment process. In such cases, the tertiary treatment becomes necessary for remediation of river water. Microalgae are one of the effective agents to carry out the tertiary treatment. Microalgae grow by using their necessary nutrients from the wastewater by absorption leading to tertiary water treatment and finally produce biomass of great worth. In the present study, we checked all the physicochemical parameters like pH, dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) during our 20 days of study and observed a significant change in all these parameters, specifically ~37% reduction in both Biological oxygen demand and Chemical oxygen demand was achieved while the DO was increased by 116% during study.

Keywords: Algae growth condition, Green technology, Microalgae, Nutrient removal, Wastewater treatment

Introduction

The Yamuna river is the largest tributary of river Ganga and is considered as one of the most prominent and sacred rivers of India through the ages. The River Yamuna originating from Yamunotri which is situated in the north of Hardwar in the Himalayan Mountains, flows through parts of Uttar Pradesh, Uttaranchal, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh, and National Capital Territory (NCT) Delhi. The entire Yamuna river right from its origin to confluence with the Ganga becomes pilgrimage site and famous for its temples and natural hot springs. Therefore, these places become the main tourist spots causing human activities to rise, in turn affecting the water quality directly or indirectly.

Today water resources have become the most exploited natural systems. Yamuna River is one of the main sources of water supply to Delhi and plays a crucial role in its growth. Because of the extensively uses of theYamuna River water for varous purposes, it becomes one of the most polluted rivers of India whose pollution level has risen mainly due to both industrial and domestic effluent discharge into the river through drains.[1,2] Due to rapid industrialization, increasing population and urbanization, the National Capital- Delhi are facing the major problems and challenges for proper sanitation and environmental degradation. Delhi alone produces around 3296 MLD/day of sewage and about half of it's dumped daily in to the River due to its poor management in waste treatment. India is having almost 300 sewage treatment plants but mostly are unutilized or poorly managed. Undoubtedly Delhi is the largest contributor of pollution to the river.

Algae for Bioremediation

It is universally acknowledged that the microorganisms play a significant role in the water purification process.[3–6] For the wastewater treatment, the use of algae is more advantageous than the conventional wastewater treatments. Interestingly, no chemicals are used for Algal technology and the whole effluent treatment procedure is simple resulting in minimum sludge formation.[7,8] Whereas, conventional wastewater treatment processes needs aeration, which is energy intensive. But algae-based wastewater treatment produces oxygen which supports the aerobic bacteria. Algae is having an efficient process for nutrient consumption and provides oxygen through photosynthesis to aerobic bacteria.[9] When compared to sludge processes and other secondary treatment procedure, algal technology is a cost-effective technique for the removal of nitrogen, phosphorus and pathogens.[10,11] Algae absorbs and uses the nutrients present in the wastewater for its own growth and increase growth rate along with interval.[12]

Factors Affecting the Growth of Algae

The presence of light helps in the growth of algae; it should not be too strong or weak. In most cases of algal cultivation, algae need only about 1/10 of direct sunlight. The growth temperature varies with algae species. Temperature of 20–30°C is the optimal range

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for phytoplankton cultures. If temperatures go beyond 35°C, it can be harmful to some algal species, especially green microalgae. Also, the lower temperatures like lower than 16°C will slow down the algal growth. Mixing is another important factors which influence algal growth and therefore agitation or circulation is must to mix algal cultures. For deep photo reactor systems an agitator is normally used, while paddle wheels are used for open pond systems. In addition, also pump circulation may be used for a photo-tube system. For good and effective growth of algal cultures, proper nutrient and pH are very important parameters. Carbon, hydrogen, oxygen, nitrogen, phosphorous, sulfur, iron, and trace elements are necessary for autotrophic growth.

Materials and Methods

Collection of Wastewater

The water samples were collected in sterilized plastic bottles about 6 Liters, from Delhi segment that is allocated in Yamuna River. The Najafgarh drain receives water from seventeen sewage drains of Delhi. It is considered as the most polluted segment of Yamuna River. It also receives the enormous loads of industrial, agricultural and domestic wastes resulting in large-scale deterioration of the water quality and affects the physicochemical parameters of water.

Wastewater Analysis

The wastewater analysis was carried out after every five days interval and the following parameters were analyzed: biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and total dissolved solids (TDS) of the wastewater. The parameters were also analyzed before and after the bioremediation treatment and the data were recorded.[12]

Isolation of Algae

The algae were collected from the old water tank. The collected was centrifuged at 5000×g to separate the algae in pellet form, which was used as inoculums. The inoculums were mixed with sterilized algae culture broth (Bold's Basal Medium) that was used as media for the growth of algae. The flasks were incubated in growth chamber in the presence of artificial light (12 h on and 12 h off) and were shaken manually to avoid algal sedimentation.

Algal Biomass Study

The algal biomass was measured after every five days interval by withdrawing the ~50 ml sample in 200 ml flask. The flasks were kept in hot air drier for the removal of excess water. By using gravimetric method the dry biomass was measured and the total biomass productivity was also calculated.

Experimental Setup

The 50 ml of inoculums (20 days old in Bold basal media) was mixed with 200 ml of wastewater and incubated for 20 days at 27±2°C in a growth chamber in the presence of light (12 h on and 12 off). Samples were periodically (every 5th day) analyzed for physicochemical parameters such as pH, phosphate, nitrate, BOD and COD using standard methods (APHA, 1998). All the experiments were conducted in triplicates.

Results and Discussion

For comparison, the physicochemical characteristics of Yamuna water is calculated before treatment along with the data of treated water and all the data are presented in Table 1. The untreated water sample showed dark colour and the foul odour was reduced after treatment with algae. The pH and DO after treatment increased from 7.7 and 1.89 to 9.0 and 4.1, respectively. After algal treatment, BOD and COD also decreased significantly, as shown in Table 1. The result indicates that the algae have the potential to be used for wastewater treatment at a large scale. Further studies are required to optimize the processing conditions and scale-up of the operation.

An alga was successfully isolated and the algal growth was recorded from the 10th day in Yamuna water sample. The data were shown in Table 2. The

Table 1 — Analysis of Physicochemical characteristics of Yamuna Water

Parameters	Untreated water	Treated water	%Change
Colour	Black	Colorless	—
PH	7.7	9.0	16%
DO	1.89	4.1	117%
BOD	137	86	37%
COD	164	105	36%

Treatment was carried out for 20 Days

Table 2 — Analysis of Physicochemical Characteristics five times after Treatment of Algae

Physicochemical characteristics	Day 5	Day 10	Day 15	Day 20
PH	7.7	7.9	8.4	9.0
DO	2.34	2.95	3.8	4.1
BOD	137	128	110	86
COD	164	147	121	105

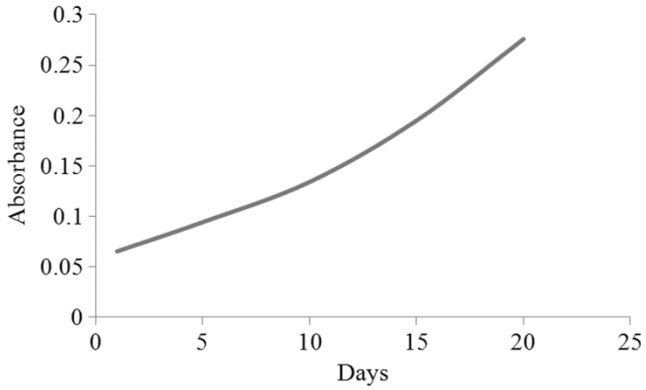

Fig. 1 — Algae Growth Curve

algal growth curve was recorded and showed to be exponential from 15th day (Fig. 1). Algal species was studied morphologically using light microscope at 40X magnification. The morphology of the algal species like its color, shape of cell and its motility was observed.

Conclusions

Phyco-remediation is one of the options for reducing the impact of pollution on environment, which is produced from domestic, and industries. From this experimental study we observed that the growth rate of algae in the Yamuna River when increases, the rate of reduction of different pollutants of the river increases. Therefore, it is accepted that for the wastewater remediation, using algae is the most favorable cost-effective, eco-friendly option. Thus we can conclude that algae are one of the significant agent of wastewater treatments. It can provide a cheapest and cost effective way for biological treatment of polluted water.

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