J. Indian Chem. Soc.,
Vol. 96, April 2019, pp. 523-526

A comparative analysis of treating urban wastewater using bioremediation method in Kolkata, India

Susmita Mukherjee[a]*, Sonali Paul[a], Ranjana Das[b], Chiranjib Bhattacharya[b] and Abhishek Dutta[c]

[a]Department of Biotechnology, University of Engineering and Management, Action Area-III, B/5, New Town, Kolkata-700 156, India

[b]Department of Chemical Engineering, Jadavpur University, Kolkata-700 032, India

[c]KU Leuven, Campus Groep T Leuven, Faculteit Industriële Ingenieurswetenschappen, Andreas Vesaliusstraat 13, B-3000 Leuven, Belgium

E-mail: susmita.mukherjee@uem.edu.in

Manuscript received online 31 January 2019, accepted 25 March 2019

Wastewater generation is an explicit factor of urbanization. Urban expansion has imposed a pressure on wastewater management across world and Kolkata is no exception. Wastewater in Kolkata is treated by four Sewage Treatment Plants (STP) and the vast wetlands at the eastern fringe of the city, the East Kolkata Wetlands (EKW). The wastewater treatment by STPs is insufficient both in quality of treatment and quantity of water treated. To compound the problem EKW area is shrinking due to rapid urbanization. To deal with the wastewater management in Kolkata, an effective treatment process is presented in this study. Wastewater treatment by natural process or bioremediation is considered as an efficient and environmentally safe technology for inexpensive decontamination of polluted water. This study has been designed to understand the efficiency of cyanobacteria treated wastewater compared to the conventional stabilization pond system followed at EKW fish ponds and also to propose for reuse of these important nutrients to return them to the environment. In the course of this study, it has been found that the wastewater treated with blue-green algae *Anabaena* sp. shows improved water quality than the water treated by conventional system at stabilization pond. Thus bioremediation by blue-green algae offers a good opportunity to deal with the problem of wastewater management in Kolkata.

Keywords: Cyanobacteria, stabilization pond, East Kolkata Wetlands, bioremediation, wastewater.

Introduction

Wastewater generation is a factor of human activities. As with major cities in the world, rapidly increasing urban population has imposed a pressure for wastewater management of Kolkata. Treatment of wastewater is a basic mandate prior discharge into any natural water body. A considerable portion of the wastewater in Kolkata is treated by a vast stretch of wetlands on the eastern part of the city, the East Kolkata Wetlands (EKW), a Ramsar site, an area of 12,500 hectares, consisting of 264 fish ponds[1]. It helps the Kolkata Municipality to save almost Rs. 1,300 million per year for treating wastewater and for the fish farmers an expenditure of Rs. 60 million is averted every year for buying fish feed[2].

Bioremediation is considered as an efficient and environmentally safe technology for inexpensive decontamination of polluted water[3,4] indicated that cyanobacteria have immense potential in the remediation of polluted environments. Although nitrogen and phosphorous are the key elements for algal growth, they are also serious pollutants in many water bodies as because excess of nitrogen and phosphorus lead to fast ageing of any water body and ultimate death of the system. Blue-green algae can thrive in nitrogen and phosphorus-rich conditions common to many water bodies and this feature can be utilized to not only remove but also capture these important nutrients to return them to the terrestrial environment for reuse[5]; Markou and Georgakakais (2011) reviewed the environmental factors that affect the biomass generation of filamentous cyanobacteria in agro-industrial wastewater.

The wastewater treatment at EKW is done by stabilization pond method, where the waste gets converted into nutrients and in turn supports production of fish, consumed by local people on a daily basis[7], thus the natural resource recovery. Though EKW contributes in a big way in cleaning the city wastewater, it has got some problems which are posing a threat on its existence[8].

Under such circumstance to address the waste management problem of Kolkata, this study has been planned to understand and compare the bioremediation potential of conventional stabilization pond system with an algal pond. As in the process of remediation, the algae leach nutrients from waste water, hence also to propose the possible utilization of these nutrient-rich algae by distributing them as fish food in the stabilization ponds of EKW area, especially in the further downstream section. In the present study, photosynthetic nitrogen fixing cyanobacterium, *Anabaena* sp. was used to find out their efficacy in remediating the wastewater of Kolkata city, which contains both domestic and industrial effluent.

Experimental

The water samples were collected from three sampling locations, on the same day, listed in Table 1. The sample collected from Keshtopur canal (location #1) was used for treatment with algae. The second sample was collected from the fishery feed canal at Bantala (location #2) and the final sample was collected from Goltala fishery (location #3), a state-owned fishery and is listed under State Fisheries Development Corporation. Locations #2 and #3 were chosen to understand the efficiency of stabilization pond system at EKW.

The city waste enters into EKW area through Dry Weather Flow Canal (DWF) and gets distributed into different fish ponds lying on both sides of it by many secondary canals known as fishery feed canals. Wastewater on its way through DWF canal gets diluted; hence the estimation of the parameters gives a wrong impression about the quality of water in a place away from the source. But for example, in Bantala area, selected for sample collection to get the actual value of the parameters is because a new canal carrying wastewater joins the DWF at this area. Goltala fishery is selected because wastewater from DWF canal in Bantala area enters into the Goaltala fish pond 1.5 km away from it, for treatment by stabilization pond method.

Table 1. Sampling locations (marked with GPS coordinates)

Sampling point #1 (Keshtopur canal)	Sampling point #2 (fishery feed canal at Bantala)	Sampling point #3 (Goltala fishery)
Keshtopur canal (GPS: 22.58^{o}N; 88.41^{o}E)	Bantala tannery effluent (GPS: 22.54^{o}N; 88.43^{o}E)	Goltala fishery (GPS: 22.54^{o}N; 88.43^{o}E)

Immediately after water collection, the samples were taken for analysis. All estimations were done following the standard regulations from APHA[9]. All parameters were tested in triplicate.

Blue-green algae *Anabaena* sp. is found in shallow water area. For the present study, *Anabaena* sp. was collected from rice field in Burdwan district (23.23 latitude and 87.86 longitude) and was identified under microscope (Olympus, MLX-B Plus). The collected algal species was cultured in BG11 broth for 2 weeks. Then it was incubated in waste water for 10 days, as the minimum residence time in a digester is 10 days[10] at 27^{o}C temperature. The culture was introduced into the wastewater in a ratio of 1.5 g in 1 L. The experimental set-up was done in duplicate with same dilution of wastewater to have repeatability of the test experiments.

Results and discussion

National River Conservation Directorate (NRCD) under Ministry of Environment and Forest, Government of India, established effluent standard parameters with priority placed in order of (1) removal of organic matter and suspended solids, (2) pathogenic bacteria and (3) removal of nutrients[11]. Based on this the water quality parameters were chosen as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids, Total Nitrogen and Total Phosphorus for estimation and comparison.

The urban wastewater at EKW is treated by stabilization pond method where primarily symbiosis of bacteria and phytoplankton like *Oscilatoria*, *Microcystis*, *Firmicutes*, *Nitrosomonas* sp., *Theobacillus* sp. play the major role[12]. Bacteria degrade the organic matter (expressed as BOD and COD) releasing nutrients and these nutrients through food chain become available to fish as food.

In blue-green algae mediated bioremediation, the degraded organic matter i.e. the inorganic nutrients are consumed as food completely by the algae *Anabaena* sp. whereas in the stabilization pond by the fish, being at the top of the food chain.

The sampling location considered in the study for treatment with blue-green algae is from the canal and not from

Table 2. Water quality parameters before and after microbial treatment

Parameters	Location # 1		Location # 2	Location #3
	Prior algal treatment	After algal treatment		
pH	6.43	6.56	6.33	7.08
Total suspended solids (g)	0.03	Below detection limit	0.08	0.02
Total dissolved phosphate (mg/L)	286.67	8	200	86.67
BOD5 (mg/L)	19.05	3.2	24.7	19.04
COD (mg/L)	32	7	44.80	29.92
TKN (mg/L)	56	4.03	84	56

the fish pond; whereas in the other case the sampling locations were both from the canal and the fish pond. This was done to understand the difference in waste treatment efficiency between both the systems.

The selected parameters were estimated for comparing the efficiency between an algae mediated system and a traditional system and listed in Table 2. The efficiency was calculated by applying the following formula:

Efficiency (%) = [(Value at Inlet – Value at Outlet)/Value at Inlet]×100

Table 2 shows that the pH of the wastewater remains almost same and TSS content is negligible in both the cases. One reason for low level of TSS is that the sample collection was done during monsoon. Another interesting observation is that the initial value of all the parameters, except total phosphate (TP) is higher in location #2, compared to the initial value in location #1; reason being Bantala area connects a fresh wastewater stream in the DWF canal.

Efficiency comparison between two systems in Fig. 1

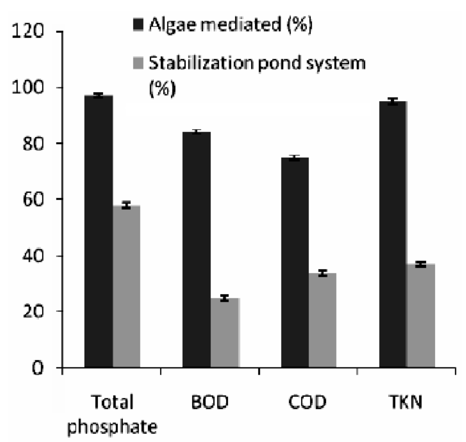

Fig. 1. Comparison in efficiency of treatment between the two systems.

shows that the efficacy in remediating the wastewater of Kolkata city is much more for *Anabaena* mediated system compared to conventional system of stabilization pond. Filamentous cyanobacteria have many advantages for using in wastewater treatment[13].

This process of bioremediation by *Anabaena* sp. has got two-fold benefits: treated water becomes good for disposal into any natural water body and also the algae grown can be utilized for other purposes like, as fertilizer or as fish food into the stabilization ponds which receive poor quality and quantity of wastewater.

Conclusions

This study initiates a work towards mitigating the problem of wastewater management of Kolkata city. A comparison between the conventional stabilization pond system and algae mediated system shows that the algae mediated system is around 48% more efficient compared to the stabilization pond system. The result shows that the quality of treated water in case of *Anabaena* treatment is good but from the stabilization pond is not that good. The wastewater in both the cases after treatment is finally disposed of to the surface water body, hence its quality has to be maintained. This study actually gives the opportunity for wastewater management of Kolkata, both qualitatively and quantitatively. Another important possibility is that the *Anabaena* which is used for wastewater treatment can be reused as fish feed in the stabilization ponds according to requirement. The result also indicates that further treatment of EKW effluent by the *Anabaena* can make the effluent better for discharge into the surface water body.

However, the only concern is that the results are the output of a lab-based study, which when exposed to real life environmental stresses might influence the efficiency. To test this concept, a pilot-scale study on bioremediation through algal pond (*Anabaena* sp.) would be needed as an answer to tackle one of the several problems of growing urbanization in a mega city like Kolkata.

References

1. Creative Research Group, East Calcutta Wetlands and Waste Recycling Region-Primary Data, Base line document for management action plan (As per Ramsar Convention Guidelines), Calcutta Metropolitan Water and Sanitation Authority, West Bengal, India, 1997.
2. D. Ghosh, *Worldview*, 2005, 1.
3. M. Megharaj, I. Singleton, N. C. Mc Clure and I. R. Naidu, *Arch. Environ. Contam. Toxicol*., 2000, **38**, 439.
4. S. Yoo, W. Carmichael, R. Hochn and S. Hrudey, American Water Works, Association Research Foundation, 1995, pp. 1-229.
5. J. K. Pittman, A. P. Dean and O. Osundeko, *Bioresource Technology*, 2011, **102**, 17.
6. G. Markou and D. Georgakakis, *Applied Energy*, 2011, **88**, 3389.
7. N. Kundu, M. Pal and S. Saha, Proceedings of TALL: The 12th World Lake Conference, 2007.
8. A. Hussan, *Aquaculture Times*, 2016, **2**, 011.
9. American Public Health Association (APHA), Standard Method for Estimation of Water and Wastewater, 22nd ed., Washington DC, 2012.
10. M. B. Pescod, Wastewater treatment and use in agriculture – FAO irrigation and drainage paper 47.
11. National River Conservation Directorate (NRCD), Ministry of Environment and Forest, Annual Report, 2005.
12. S. Sarkar, P. Tribedi, P. Ghosh and T. Saha, *Waste Biomass Valor*, 2016, **7**, 483.
13. S. K. Dubey, J. Dubey, S. Mehra, P. Tiwari and A. J. Bishwas, *African J. Biotech*., 2011, **10**, 1125.