Towards Enhancement of Water Sovereignty by Implementing the 'Constructed Wetland for Reuse' Technology in Gated Community

Rahul S. Sutar, B. Lekshmi, Dilip R. Ranade, Yogen J. Parikh, and Shyam R. Asolekar

Abstract The eco-centric wastewater treatment technology entitled 'CW4Reuse' (Constructed Wetland for Reuse) for treatment of domestic wastewaters employing horizontal subsurface-flow constructed wetland (CW) beds has been developed and demonstrated in India. A case study of treatment of wastewater using CW is presented in this paper based on our current research and demonstration of the developed technology. The CW4Reuse technology has been demonstrated in the Town of Katel, District of Buldhana, State of Maharashtra, India. The CW4Reuse technology has evidently shown the high treatment efficiency for the wastewater treatment in Katel. It is hoped that the CW4Reuse technology will potentially play a significant role to strengthen the country's agricultural economy on one hand and will also improve the rural and peri-urban sanitation on the other hand. Additionally, it will enhance the 'ecosystem restoration and rejuvenation' of urban as well as rural waterfronts in India. Moreover, the CW4Reuse technology is utilizing the skills of rural people—which will ultimately fortify the inclusive growth of the community.

Keywords Constructed wetland · Wastewater treatment · Water reuse

1 Introduction

In India, by and large, the discharge of large volumes of untreated or partially treated sewages into lakes, rivers, ponds, creeks and on the coast has led to their contamination. Additionally, there exists a huge difference between the generation and treatment of wastewaters. Hence, there is a huge potential for the application of natural treatment systems, in particular, constructed wetlands (CWs) in the developing economies such as Asia or Africa in general and India in particular due to their innate strength [1]. For the treatment of sewages and sullages from communities all over the Country, intensive efforts have been made by the Government of India during the past two

R. S. Sutar · B. Lekshmi · D. R. Ranade · Y. J. Parikh · S. R. Asolekar (✉)
Environmental Science and Engineering Department, Indian Institute of Technology Bombay, Powai, Mumbai, India
e-mail: asolekar@gmail.com

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decades. Therefore, the new recent sewage treatment plants in small rural and peri-urban communities have nominated CW as the 'favoured' technology for treatment of sewages and sullages due to their favourable economics (ecological and economic benefits) or their social acceptability among communities [1–7].

The CWs seem to be a sustainable alternative for the conventional sewage treatment technologies due to several advantages such as low power requirements, higher efficiency for the removal of pollutants, ease of operation and maintenance, simplicity of construction and eco-friendliness [8–12]. Furthermore, wetlands are known for their unique place in urban ecosystems by the virtue of the multiple functions performed by them including storage and purification of wastewater, transformation of nutrients and ecosystem biodiversity. In recent times, CWs are also being employed for treatment of wastewaters from urban and rural communities.

The 'CW4Reuse', an eco-centric wastewater treatment technology using horizontal subsurface-flow CW beds has been developed at Indian Institute of Technology Bombay (IIT Bombay), Mumbai for treatment of domestic wastewaters. CW4Reuse is proved to be eco-friendly, lower in energy consumption, easy to operate and manage. Owing to remarkably lower capital as well as operation and maintenance costs, it is gaining more acceptance in gated communities, academic campuses, peri-urban and rural habitats.

The objective of this paper is to evaluate the CW4Reuse technology for improving sanitation in gated communities as well as in rural and peri-urban settings in India. Furthermore, the performance of CW4Reuse technology for treatment of domestic wastewater in gated pilgrimage community in the Town of Katel has been evaluated.

2 Materials and Method

A horizontal subsurface constructed wetland (HSSF CW), based on CW4Reuse technology, has been employed for the treatment of domestic wastewater generated from a toilet block comprising of 22 toilets and 22 bath units as well as effluent from kitchen of the dining hall at the pilgrimage site (Sant Gulab Baba Sansthan) in the Town of Katel, District of Buldhana, State of Maharashtra, India as shown in Fig. 1 (latitude:21°03′17.2″N; longitude: 76°44′54.6″E). Reportedly, on a daily basis, about 500 devotees use the toilet block. However, this toilet block is used by nearly 6,000 devotees during the designated days for religious services and events.

The main reasons for the establishment of CW4Reuse technology at the Town of Katel were treatment of wastewater at this pilgrimage site and utilize the treated water for beneficial uses such as irrigation, gardening, etc. In septic tanks, the wastewater from toilets is first pre-treated (Fig. 2). Further, the overflow from these septic tanks is carried to the wetland bed having dimensions of 17 m length, 3 m width, 0.7 m depth, porosity of 0.5 and vegetation of *Canna indica* as shown in Fig. 3. The CW bed treats approximately 18 m^3/d wastewater on a daily basis. Furthermore, the additional treated water from the CW bed is deposited into the nearby river—where the untreated

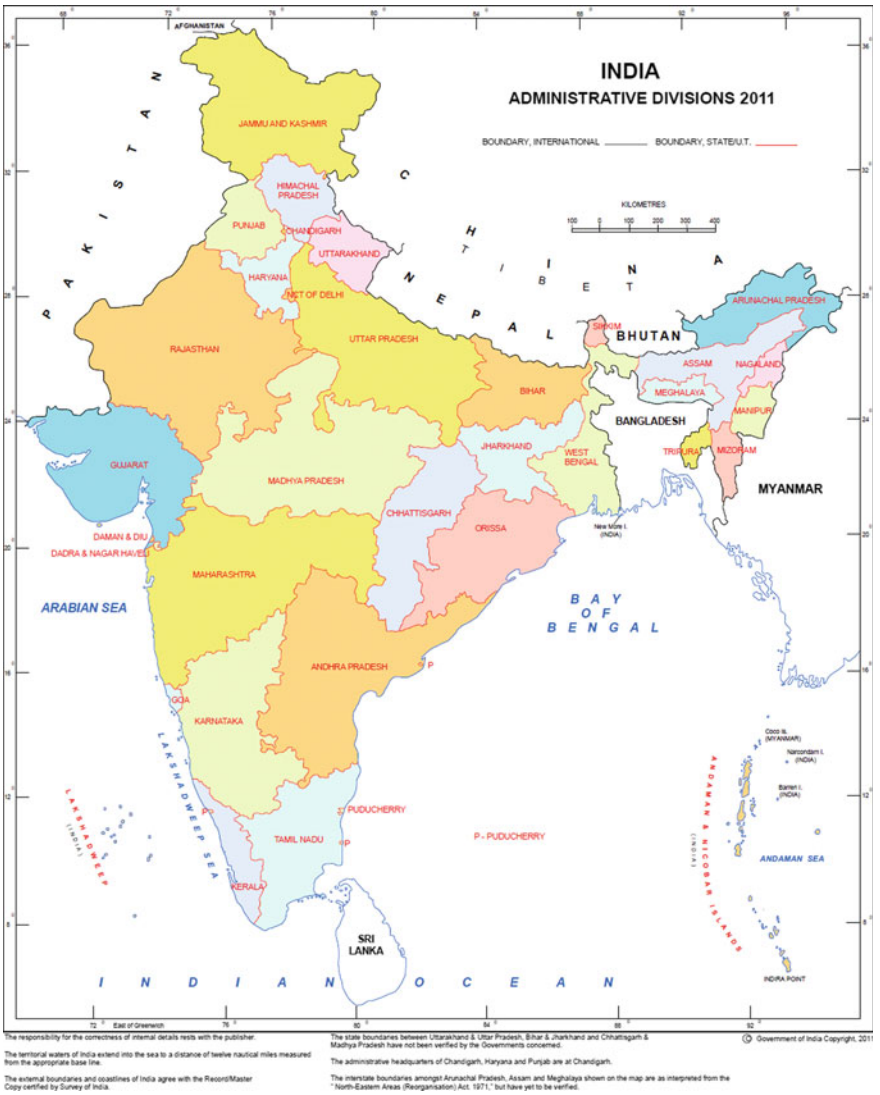

Fig. 1 The location of Katel in the State of Maharashtra in India. *Source* Administrative Atlas—2011, Government of India [13])

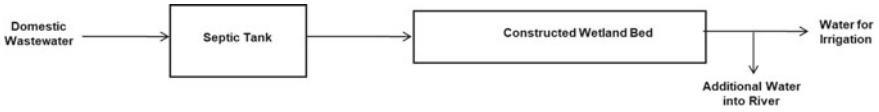

Fig. 2 The flow diagram of wastewater treatment in the Town of Katel, State of Maharashtra

Fig. 3 The CW bed in the Town of Katel, State of Maharashtra

water was discharged earlier in absence of CW-based wastewater treatment at the Town of Katel.

The samples were collected at the inlet as well as outlet of wetland bed. The collected samples were analyzed for chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), pH and total suspended solids (TSS) at IIT Bombay laboratory in Mumbai using the methods and protocols given in the 'Standard Methods' [14].

3 Results and Discussion

This section provides brief information about the treatment performance of the CW bed as well as rural development and improvement in sanitation at the Town of Katel.

Table 1 Removal of pollutants in the CW bed at Katel Village

Sr. No.	Example	Inlet concentration* (mg/L)	Outlet concentration (mg/L)
1	Chemical oxygen demand	131*	45
2	Biochemical oxygen demand	60*	17
3	Total suspended solids	62*	20
4	pH	7.5*	7.9

*Inlet to CW bed was the overflow from septic tank

3.1 Treatment Performance of CW4Ruese Technology at the Town of Katel

The bathroom, toilet and kitchen water generated by the Katel Sansthan is treated in the CW along the nearby riverfront. Figure 3 depicts the CW bed in front of toilet block at the Katel. The treatment performance of the CW4Reuse technology at the Katel is shown in Table 1.

From the results, it can be seen that the removal of COD and BOD were 66% and 72%, respectively—which shows significant treatment efficiency of the CW bed. Furthermore, the first order rate constants for removal of COD and BOD were 0.044 h^{-1} and 0.052 h^{-1}, respectively [2]. The results are excellent in comparison with Indian standards for discharge of treated water into the inland surface water. The prime user of the treated water from the CW-based treatment plant is the agricultural irrigation and garden at the guesthouse of Sansthan.

3.2 Rural Development and Improvement in Sanitation

The CW4Reuse technology (Fig. 4) is playing a very significant role for the improvisation of the sanitation in the rural areas such as Katel. The treated wastewater from CW-based treatment plant is reused by local farmers for agricultural and gardening purposes which is another main aspect of CW4Reuse technology. Additionally, the job opportunities are created for the local people who are easily managing the operation and maintenance of CW-based treatment plant as no highly experienced specialists' or mechanized equipment's are required as compared to the conventional wastewater treatment technologies.

As the wastewater from the Sansthan is treated in CW-based treatment plant, there is no discharge of wastewater into the nearby river which will significantly minimize the river pollution. It is argued that the foul odour and mosquito breeding has been reduced to significant extent at the CW-site in Katel. Thus, treated water can be reused and water quality can be enhanced along with improvement of sanitation with the help of CW4Reuse technology. In addition, for composting and energy, the

Fig. 4 The reuse of treated water in the Town of Katel. *Source* Google Maps, India [15])

vegetative biomass produced from the wetland bed could be gainfully utilized by the rural communities. It is clear that the employment of CW4Reuse technology in Katel can fulfil all social, economic and environmental goals through several above mentioned benefits.

4 Conclusions

For rural and peri-urban communities, the CW-based eco-centric technologies can be employed for the treatment of wastewaters in India. The recyclable and reusable treated water could be utilized for valuable uses in the rural communities for agricultural irrigation and irrigation in urban landscapes. In addition, the inclusive growth of the community has been strengthened owing to the CW4Reuse technology which is utilizing the skill-set of rural people for operation as well as maintenance of CW-based wastewater treatment plant. For the implementation of CW4Reuse technology, there are several opportunities in India where such eco-centric technologies could be executed in real-life by co-operative societies or municipal councils and the recyclable and reusable treated water will be utilized for valuable uses in the respective rural communities. Additionally, this intervention is protecting the drinking water resource for downstream communities by preventing the discharge of untreated wastewater into the river. Thus, for the rural and peri-urban communities

in India, the CW4Reuse technology is of greater importance from the spectacles of community ownership and also, the social benefit through applications of technology.

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