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Constructed wetland as an ecotechnological tool for pollution treatment for conservation of Ganga river

U.N. Rai, R.D. Tripathi, N.K. Singh, A.K. Upadhyay, S. Dwivedi, M.K. Shukla, S. Mallick, S.N. Singh, C.S. Nautiyal *

Plant Ecology and Environmental Science Division, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow 226 001, India

HIGHLIGHTS

- Constructed wetland (CW) efficiently decreased up to 90% BOD from sewage in 24 h.
- *P. australis*, *T. latifolia* and *C. esculenta* (HGR) were main components of CW.
- CW efficiently removed nutrients and metals from sewage.

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ABSTRACT

With aim to develop an efficient and ecofriendly approach for on-site treatment of sewage, a sub-surface flow constructed wetland (CW) has been developed by raising potential aquatic macrophytes; *Typha latifolia*, *Phragmites australis*, *Colocasia esculenta*, *Polygonum hydropiper*, *Alternanthera sessilis* and *Pistia stratoites* in gravel as medium. Sewage treatment potential of CW was evaluated by varying retention time at three different stages of plant growth and stabilization. After 6 months, monitoring of fully established CW indicated reduction of 90%, 65%, 78%, 84%, 76% and 86% of BOD, TSS, TDS, NO_3–N, PO_4–P and NH_4–N, respectively in comparison to inlet after 36 h of retention time. Sewage treatment through CW also resulted in reduction of heavy metal contents. Thus, CW proved an effective method for treatment of wastewater and may be developed along river Ganga stretch as an alternative technology. Treated water may be drained into river to check further deterioration of Ganga water quality.

1. Introduction

Safe disposal of domestic and industrial wastewater is an essential requirement under the Environmental Protection Act, which established maximum permissible limits of various pollutants for discharge into the lotic and lentic water bodies (EPA, 1986). Thus, proper treatment of sewage/wastewater is mandatory prior to its final disposal, however, sewage treatment in most of the developing countries is not yet fully operational, partly due to power failure or improper maintenance.

The Ganga, the most important river system in India originates from the Gangotri glacier in the Himalaya Mountain at an elevation of 7138 m above mean sea level in the Uttar Kashi district in the state of Uttarakhand and travels a distance of 2510 km before it merges into Indian Ocean. Already half a billion people almost one tenth of the world's population live within the river basin at an average density of over 500 people per sq km. This population is projected to increase over 1 billion people by the year 2030. A stretch of 2510 km long of river supports 29 class I cities, 23 class II cities, 48 towns, and thousands of villages. According to an estimate over 1.3 billion liters per day domestic sewage goes directly into the river (Singh et al., 2004). Further, various point sources of common effluent treatment plants and other anthropogenic activities in water shed have deteriorated the water quality by discharge of low quality effluent into the river (Rai et al., 2011). On the other hand, direct discharge of sewage into the river without treatment or partial treatment affect the quality of Ganga water, which contribute to 75% of total river pollution. Sewage contains heavy metals such as Cd, Zn, Ni, Pb, Cr, Co and Cu, which are released into the river water and sediments and their persistence in the aquatic environment leads to bioaccumulation and biomagnification into the food chain affecting the aquatic flora and fauna (Gochfeld, 2003). Conventional methods and other steps such as treatment by STPs have been taken by the Government to treat the sewage, could only treat 1/4 of the sewage produced, while 3/4 of untreated

* Corresponding author. Address: CSIR-National Botanical Research Institute, Lucknow 226 001, Uttar Pradesh, India. Tel.: +91 522 2205848; fax: +91 522 2205836/39.

E-mail addresses: csnnbri@yahoo.com, nautiyalnbri@lycos.com (C.S. Nautiyal).

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sewage is being released into the river, which affects water quality severely.

Conventional wastewater treatment systems have inherent limitation as they employ chemicals, emit foul odors, require technical skills to operate, and required high cost for construction and maintenance and moreover they are not environment friendly (Carty et al., 2008). However, ecological technologies are particularly important as the best innovative solutions for environmental protection and restoration due to their sustainable nature. Constructed wetlands (CW) are engineered wastewater treatment systems that encompass a plurality of treatment modules including biological, chemical and physical processes, which are all akin to processes occurring in natural treatment wetlands. The constructed wetlands have been successfully used for mitigation of environmental pollution by treatment of a wide variety of wastewaters including industrial effluents, urban and agricultural, stormwater runoff, animal wastewaters, leachates, sludges, pharmaceutical waste and mine drainage (Scholz and Lee, 2005; Zhang et al., 2012). However, there is a pressing need to develop a low-cost affordable technology in which plant based management needs a special attention to remediate and conserve river ecosystem. Construction of wetland along the bank of river Ganga may act as biofilter and can remove high load of nutrients and other pollutants including heavy metals from the river water. Macrophytes are considered to be the main biological component of constructed wetlands which play an important role in the treatment process. Several workers (Breitholtz et al., 2012; Wu et al., 2011) demonstrated the use of CW in many developed countries for the nutrient removal from sewage, storm water and river water and also applied for the treatment of industrial wastewater (Hadad et al., 2006). However, use of CW in India remains largely unexplored. Present investigation was conducted to evaluate sewage treatment efficiency and feasibility of a sub-surface flow constructed wetland as a model using efficient aquatic macrophytes *viz.*, *Phragmites australis*, *Typha latifolia*, *Polygonum hydropiper*, *Alternanthera sessilis*, *Colocasia esculenta* and *Pistia stratoites* in order to implement this approach at a large scale to improve Ganga water quality.

2. Methods

2.1. Experimental setup and designing

The constructed wetland was developed at Shantikunj, Haridwar (India) which is situated at 29.93 latitude and 78.13 longitude where temperature ranges between 6 and 36 °C. The sub-surface flow CW used in this study having lined gravel beds supporting aquatic plants (Fig. 1) and designed according to the USEPA (1993) guidelines under a sponsored project by National River Conservation Directorate, Ministry of Environment and Forests, New Delhi. The effective treatment area of wetland is 79.17 m^2 and it consisted of two chambers. Among them the rectangular planted zone (L = 7.8 m; W = 6.65 m; D = 1.8 m) was build after the settling tank (L = 7.8 m; W = 3.5 m; D = 1.8 m). Gravel beds were 0.75 m thickness with the gravel ranging from 6 to 25 mm diameter in equal proportion. Shantikunj has a huge residential complex with 5000 person visiting everyday and this CW is designed to treat the sewage generated from this complex which is about 5–6 MLD. The water depth, area, effective volume and the retention time of these two zones were described (Table 1).

The system size was based on organic load and hydraulic rates of 0.065 MLD sewage. The wastewater was allowed to flow 15 cm below the gravel surface through perforated pipes from settling tank. Sequencing fills- and draw-batch mode was applied to influent from February to June, 2012. The flow rate was controlled using a 12 mm diameter gate valve by regulating the inlet and outlet flow, using beaker and a stopwatch.

The selected macrophytes (15 d old) were transplanted in the month of November, 2011 and the study was carried out from November, 2011 to June, 2012 in which first 2 months were given for plant growth and establishment, however, another 6 months for operation and monitoring of CW for sewage treatment. The constructed wetland was monitored for influent and effluent at 12, 24 and 36 h retention time of sewage treatment by composite sampling, repeatedly at 2, 4 and 6 months (in the month of February, April and June, 2012) of plant growth and stabilization. After plantation in CW in the end of November,

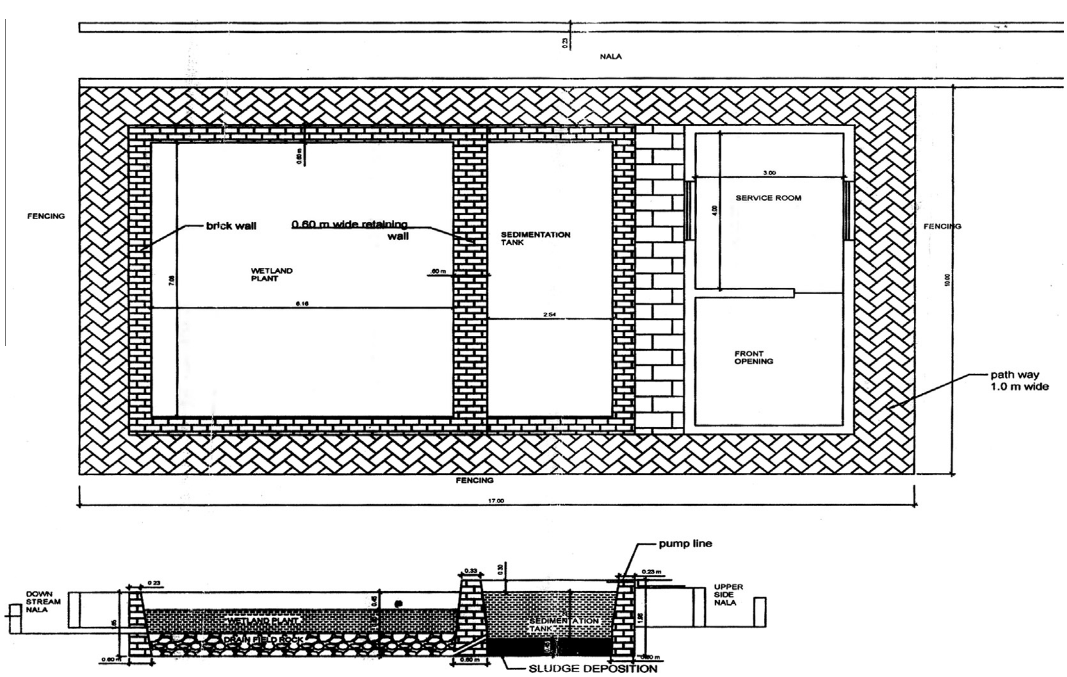

Fig. 1. Structural lay out of sub-surface flow constructed wetland (SSCW).