Issue 9 vol 3 ISSN: 2321-8134

IJFEAT

INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

APPLICATIONS OF CONSTRUCTED WETLAND FOR INDUSTRIAL WASTEWATER TREATMENT

Shivani Hatgaonkar[1], Neha Patil[2], Kartik Shire[3]

[1]*S.J.Hatgaonkar, Civil Engineering Department, J.D.I.E.T Yavatmal, Maharashtra, India,* ***shivanihatgaonkar@gmail.com***
[2]*N.S.Patil, Civil Engineering Department, J.D.I.E.T, Yavatmal, Maharashtra, India,* **nehap29995@gmail.com**
[3]*K.S.Shire, Civil Engineering Department, J.D.I.E.T, Yavatmal, Maharashtra, India* **kartik.shire@gmail.com**

Abstract

Constructed Wetlands (CWs) were initially used for treating domestic wastewater. But in the last two decades, industrial wastewater has been treated with hybrid CWs, both surface and subsurface flow. CWs started treating industrial effluents like petrochemical, dairy, meat processing, abattoir, and pulp and paper factory effluents. Brewery, tannery and olive mills wastewaters have been recently added to CWs applications. So, CWs can be applied to several and different kinds of industrial wastewaters, including acid mine wastewater with low organic matter content and landfill leachate. Industrial wastewater can be treated with hybrid flow CWs systems with influent concentrations up to 10,000-24,000 mg COD/L and up to 496 mg NH_4^+/L. But there are not general rules to select the most suitable type of CW for a certain industrial wastewater or even urban wastewater. Every single case must be studied particularly due to several conditions: type of wastewater, land availability, the amount of flow and pollutant load, outlet discharge limits, etc.

Keywords: *Constructed wetland, Industrial wastewater, Leachate.*

--- *** ---

1. INTRODUCTION

CWs are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to achieve wastewater treatment."Modern treatment wetlands are man-made systems that have been designed to emphasize specific characteristics of wetland ecosystems for improved treatment capacity .Besides treatment wetlands, constructed and engineered wetlands can cover a broad range of objectives such as improving biodiversity and environmental conditions related to, wildlife use, irrigation of agriculture lands, improving river water quality, or river in restoration. Some misleading names have been given to the technology including green filters, bio filters and even sand filters or artificial wetlands. As CWs have evolved with time and applications, other terms like engineered wetlands have appeared that might include the use of devices that upgrade the performance using energy input. CWs are low-cost and eco friendly technologies, that take advantage of natural processes to remove pollutants from the water, generally avoiding the use of chemical products and the input of high amounts of external energy. On the other hand, CWs may require a large surface, which is its major drawback. As a result; they are included in the group of extensive technologies for wastewater treatment. The first research into CWs for wastewater treatment took place in Germany, in the 1950s, with special focus on phenols removal. From the beginning, the first applications of CWs dealt with urban wastewater, but in the last two or three decades, they have been applied for industrial and agricultural wastewater, as well as storm water runoff and the treatment of landfill leachates.

2. LITERATURE SURVEY

There are variety of industrial wastewaters which have been treated in HF constructed wetlands. The quality of industrial wastewaters varies widely with many wastewaters having very high concentrations of pollutants. Therefore, treatment of industrial waste waters nearly always requires one or more pretreatment stages.

2.1 Petrochemical Industry

Wallace (2002) used aerated HF constructed wetland to treat petroleum contact wastewater at Williams Pipeline Company terminal facility in Watertown, South Dakota ,USA.The 1,486 m^2 wetland was designed to receive 1.5 m^3d^{-1} on a seasonal (May-October) basis. To provide adequate oxygen transfer, a Forced Bed Aeration TM system was built (Wallace, 2001).The system was initially planted with *Phragmites*

ISSN: 2321-8134

australis and over seeded with *Phalaris arundinacea*. Average influent BOD5 and ammonia concentrations (at 20% of the bed length) were approximately 10,000 mg $l^{-1}$and 100 mgl^{-1} with respective effluent concentrations (at 80% of the bedlength) averaging approximately 6 mg l^{-1} and 0.5 mg l^{-1}. Also BTEX was removed in the first 40% of the bed length due to enhanced volatilization as a result of the aeration system (Wallace, 2002a). Ji et al. (2002) reported the use of HF constructed wetlands to treat heavily oil-contaminated water produced in Liaohe Oilfields, China. Wood and Hensman (1989) reported the use of 2,000 m^2 and *Phragmites* at the outlet for the treatment of petrochemical effluents. Chapple et al. (2002) reported on the use of HF constructed wetlands for reducing the dissolved hydrocarbons in the runoff from a decommissioned oil refinery. Two out of four pilot wetlands (300 m^2 each) were filled with soil and two were filled with gravel. All beds were planted with *Phragmites australis*. The study focused on diesel range organics (typically reported as C10-C40). Both types of beds were successful in removing hydrocarbons but soil-based beds suffered substantially from surface flow. The authors pointed out, however, that because of the much higher cost of gravel it is likely that any future full scale system will contain a mixture of soil and gravel beds.

2.2 Chemical Industry

One of the largest HF constructed wetlands in Europe was built in 1990 at the Air Products chemical works at Billingham, Teeside, United Kingdom (Sands et al. 2000). The plant is producing alcohols for the plastics and Detergent industries, phenol/acetone and derivatives for plastics, detergents, Pharmaceuticals and flame-retardant purposes and amines and derivatives for drugs, detergents, paper treatment, agrochemicals and animal feedstock additives. Seven beds planted with *Phragmites australis* with a total area of 49,000 m^2 is filled with soil. Types of wastewater treated in HF constructed wetlands HF CW filled with waste and coarse ash and planted with *Typha* at the inlet. HF constructed wetland at Heglig, Sudan planted with *Phragmites australis* treating hydrocarbon contaminated water from the oil fields.

Dias et al. (2006) mentioned that in 1998, HF CW (1,500 m^2) was added to existing vertical flow constructed wetland to treat wastewaters rich in nitrates from the production of nitric acid in Estarreja, Portugal.

Industrial wastewater including those from chemical industry is treated in hybrid system including HF wetland in Yantian Industry Area in Baoan District, Shengzhen City. HF constructed wetland at Estarreja, Portugal treating wastewaters from nitric acid production.

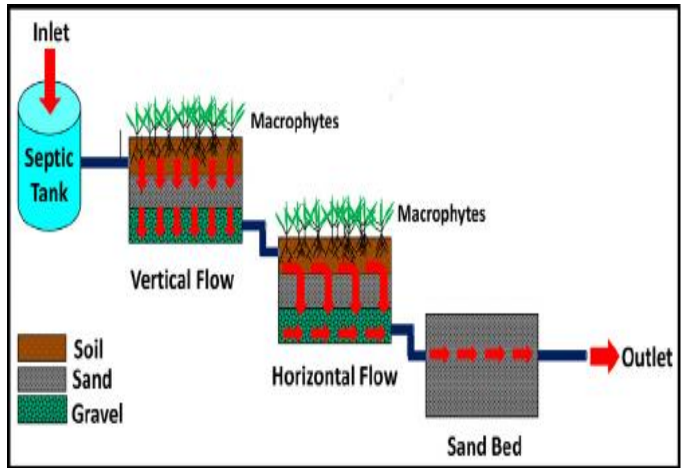

Fig. 1: Hybrid system of constructed wetland.

2.3 Pulp and Paper Industry

Pulp mill effluents are complex mixtures of wood-derived organics as well as some inorganic ions and compounds. In untreated effluents, the BOD_5 is high (generally in the range of 200 to 800 mg l^{-1}). Secondary treatment (by aerated lagoon or activated sludge) can be quite effective, Industrial wastewaters reducing the BOD_5 to about 10 to 100 mg l^{-1}. The compounds responsible for the BOD_5 of untreated effluents are primarily simple sugars, organic acids (e.g., acetic) and alcohols (e.g., methanol). After treatment, the residual BOD_5 is largely caused by biological solids and some more refractory organic compounds (Thut, 1993). Thut (1990b, 1993) used a 3,750 m^2 CW planted with *Phragmites australis* to treat pulp mill effluent. The system was very effective in removing BOD with removal being consistently between 80 and 90%. Because the secondary-treated effluent delivered to the wetland was of a high quality with an average of about 10 mg l^{-1}, this resulted in the 1 to 2 mg l^{-1} range in the wetland effluent throughout much of the study period. Removal of TSS and ammonia was variable but in general, quite high. However, the wetland had no beneficial effect on color or adsorbable organic halide (AOX). Hammer et al. (1993b) reported on the use of HF constructed wetlands for color removal from pulp mill wastewaters. The early color removal results were encouraging despite the concomitant export of BOD5. The authors suggested that a treatment system for tannins and lignins should be designed to optimize environmental conditions and retention times to enhance fungal decomposition of complex organics, and incorporate similar components for further decomposition by bacterial populations. Since fungal populations require an attachment substrate, a vegetated sand or porous soil substrate is likely to simulate natural soil conditions and provide aerobic environment and hydraulic conductivity needed to enhance fungal growth. Removal of phenol from pulp and paper mill wastewaters was studied by Abira et al. (2005) in Webuye, Kenya. The HF wetland with an area of 30.7 m2 was filled with gravel to a depth of 0.3 m and planted with Cyperus immensus ,Cyperus papyrus, Phragmites mauritianus.

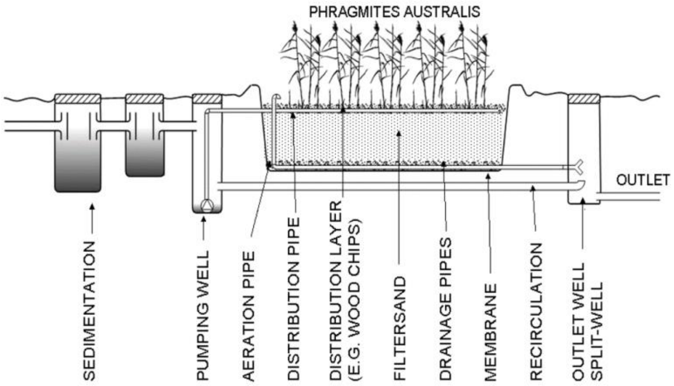

Fig.2: Secondary treatment system of constructed wetlands (Horizontal flow)

2.4 Tannery Industry

Calheiros et al. (2007) evaluated the use of HF constructed wetlands for the treatment of tannery wastewaters in Portugal. Five experimental units were planted with *Canna indica*, *Typha latifolia*, *Phragmites australis*, *Iris pseudacorus* and *Stenotaphrum secundatum* and filled with Leca (Filtralite MR 3-8). The units were loaded with two HLR, 3 and 6 cm d^{-1}. COD was reduced by 41-73% for an inlet organic loading varying between 332 and 1,602 kg ha-1 d-1 and BOD_5 was reduced by 41-58% for an inlet organic loading between 218 and 780 kg ha^{-1} d^{-1}. No significant differences in removal performance were observed among planted units. Also, an unplanted unit did not differ significantly from planted units. The use HF constructed wetlands for tannery wastewaters has also been evaluated by Küçük et al. (2003), Daniels (1998, 2001 a ,b) and Dotro et al. (2006).

2.5 Textile Industry

Bulc et al. (2006) pointed out that the continuous dyeing of cotton and polyester fabrics or their blends of various ratios in the industrial production can be performed by pad-dry, pad-dry-bake, pad-steam and thermosol methods using reactive, vat and dispersed dyes (Shore, 1995). Colored wastewater, with high COD, TOC and pH values and low BOD_5 values, is aesthetically unpleasant. Several methods have been studied for purification of dye-house effluents, such as carbon adsorption, chemical precipitation and flocculation, oxidation, ozonation, ion extraction and membrane filtration, but each method has significant disadvantages: incomplete ion removal, high energy requirements, and production of toxic sludges (Golob and Ojstršek, 2005; Alkan et al., 2005). Davies and Cottingham (1992) used HF constructed wetlands planted with *Phragmites australis* for the treatment of complex wastewaters from a group of textile processing and dyeing facilities with a dark blue-blue coloration caused by dye residues. The experiments were carried out in Melbourne, Australia, in 150 m^2 wetlands which had been used for domestic wastewaters for three years. The hydraulic loading rate of 9.6 cm d^{-1} was the same as for domestic wastewater. The visible colorization of the textile wastewater was reduced very quickly as it passed through the bed and disappeared after only 6 m of travel. Also, the suspended solids inflow concentration of 80 mg l-1 quickly decreased to less than 10 mg l^{-1} after about 15 m of travel and then remained more or less unchanged. Bulc et al. (2006) reported the use of VF (40 m^2)-HF (40 m^2) constructed wetland to treat textile wastewaters in Slovenia. At the flow of 1 m^3 d^{-1} the 5% for TN, 77% for organic N, 62% for sulfate, 87% for anionic tenzides and 85% for color. The system exported ammonia-N. Also, the alkaline pH of the wastewater was lowered to neutral. Constructed wetlands showed buffering capacity due to acids produced by microbial action; this was also reported by Mbuligwe (2005). Bulc et al. (2006) pointed out that constructed wetlands have a significant performance advantage with respect to COD, mostly due to filtering, sedimentation, and aerobic/anaerobic processes, although the reductive biodegradation of azo-dyes produces aromatic amines that can be biodegraded more easily under aerobic than anaerobic conditions (Mbuligwe, 2005). Baughman et al. (2003) reported 20-34% efficiency for the COD inflow of 50 mg l-1 and Winter and Kickuth (1989) reached 65- 76% efficiency for the inflow of 1,400 mg l^{-1}. The BOD5/COD ratios between 0.19 and 0.43 indicates biologically the hardly-degradable nature of textile wastewater and therefore, high BOD_5 removal cannot be expected.

3. CONCLUSION

Constructed wetlands are now playing an important role in indirect potable reuse where they are part of the overall system. This role is providing a robust barrier to micro constituents as well as an environmental buffer that serves as a psychological separation of impurities from waste water of industries.

Constructed wetlands are a proven technology for removal of conventional pollutants in a variety of wastewaters and other impaired water streams of various industries worldwide. Thousands of wetland treatment systems have been constructed to reduce BOD, TSS, nitrogen, phosphorus, and trace metals. Best use of constructed wetlands is as the final step in an overall treatment train that includes primary and secondary pretreatment. Thus, by adopting all these stages industrial wastewater can be treated naturally without having to use external energy at low cost.

REFERENCES

[1] Álvarez, J. A., Ruíz, I., & Soto, M. (2008). Anaerobic digesters as a pretreatment for constructed wetlands. *Ecological Engineering*, *33*(1), 54–67. doi:10.1016/j.ecoleng.2008.02.001

[2] Brix, H., & Arias, C. A. (2005). Danish guidelines for small-scale constructed wetland systems for onsite treatment of domestic sewage. *Water Science and Technology*, *51*(9), 1–9.

[3] Chen, Y., Wen, Y., Zhou, Q., & Vymazal, J. (2014). Effects of plant biomass on nitrogen transformation in

subsurface-batch constructed wetlands: A stable isotope and mass balance assessment. *Water Research*, *63*, 158–167.

[4] Cui, L., Feng, J., Ouyang, Y., & Deng, P. (2012). Removal of nutrients from septic effluent with recirculated hybrid tidal flow constructed wetland. *Ecological Engineering*, *46*(0), 112–115

[5] De La Varga, D., Ruiz, I., & Soto, M. (2013b).Winery wastewater treatment in subsurface constructed wetlands with different bed depths. *Water, Air, and Soil Pollution*, *224*(4), 1–13.

[6] Dias, V. N., wastewater treatment in Portugal: a global review.*10th International Conference on Wetland Systems for Water Pollution Control*