RESEARCH ARTICLE OPEN ACCESS

Treatment of municipal and industrial wastewater by reed bed technology: A low cost treatment approach

Bansari M. Ribadiya*, Mehali J. Mehta**
* (Student, M.E Environmental Engineering, Sarvajanik College of Engineering & Technology, Gujarat, India-395001)
** (Assistant Professor, Department of Civil Engineering, Sarvajanik College of Engineering and Technology, Gujarat, India-395001)

ABSTRACT
Reed bed system for wastewater treatment has been proven to be effective and sustainable alternative for conventional wastewater treatment technologies. Use of macrophytes to treat wastewater is also categorized in this method. This new approach is based on natural processes for the removal of different aquatic macrophytes such as floating, submerged and emergent. Macrophytes are assumed to be the main biological components of wetlands. These techniques are reported to be cost effective compared to other methods. Various contaminants like total suspended solids, dissolved solids, electrical conductivity, hardness, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, nitrogen, phosphorous, heavy metals, and other contaminants have been minimized using aquatic microphytes. In this paper, role of these plant species, origin and their occurrence, ecological factors and their efficiency in reduction of different water contaminants have been presented.

***Keywords* -** contaminants, microphytes , reed bed, root zone, Wastewater.

I. Introduction

Out of many example of sustainable or environmentally sound management or use of natural entities, the focus in the paper is on performance evaluation of different types of aquatic microphytes for wastewater treatment. Reeds are coarse grasses growing in wet places. Reed bed is one of the natural and cheap methods of treating domestic, industrial and agricultural liquid wastes[1]. Reed bed is considered as an effective and reliable secondary and tertiary treatment method where land area is not a major constraint. Generally reed bed is made in shallow pits, installed with a drain pipe in a bed of pieces of lime stones and filled up with pebbles and graded sand. In this sandy body, reed plants generally with hollow root which bring oxygen into the filter bed are planted.

Reed bed is a biological wastewater treatment technology designed to processes found in natural wetland ecosystems. These systems use wetland plants, soils and their associated microorganisms to remove contaminants from wastewater[5]. The plant within the constructed wetland is the major component for the treatment process. The type of macrophyte chosen will vastly influence the efficiency and quality of wastewater. Plants provide an environment for microbes to live, they oxygenate the wastewater, providing nutrients for the microbes to survive, they stabilize the soil and they also partake in the reduction of nutrients[4].

Reed bed treatment system utilizes the active treatment capabilities of soil to biologically treat effluents such as sewage, industrial wastewater, run-off and leachates[8]. Reed beds are suitable for treatment of organic contaminants either natural or synthetic and some inorganic contaminants are also withheld or converted to safe products within the substrate of the reed bed system.

II. Types of reed beds

2.1. Reed bed based on type of macrophytic growth

2.1.1. Reed beds with free floating macrophytes

Free- floating plants have most of their photosynthetic parts above the surface of the water and their root below it. Typical plant species that have been used in the large scale applications are water hyacinth and duckweed species (*Lemna, Spirodela, and Wolffiela*). Free floating plants can be used as raw sewage as well as for primary or secondary treated effluents. The use of temperate climates of reed beds with water hyacinth, one of the most productive plants in the world, is limited, because hyacinth needs high temperature for its growth. The major disadvantage of duckweed compared to water hyacinth is their shallow root system and sensitivity towards wind, however, major advantage is their lower sensitivity towards colder climates [2].

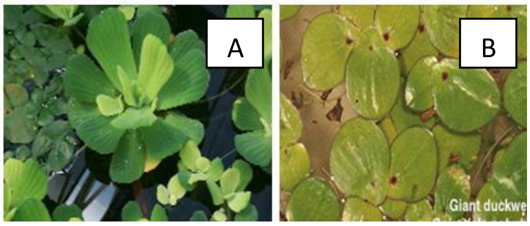

Figure 1:Free floating macrophytes
(A) Lemna, (B) Spirodela [15]

2.1.2. Reed beds with floating- leaved macrophytes

Floating leaved macrophytes includes plant species that are rooted in the substrate, and their leaf floated on the surface. Water lily, yellow pond lily and lotus are the typical representative of this group. So far, only a few systems have been used this type of vegetation and the use of reed beds with floating leaved species for wastewater treatment are considered questionable.

2.1.3. Reed beds with submerged macrophytes

The photosynthetic tissue of submerged aquatic plant is entirely submerged. Sea moss (*Cladophora sp), green weed (Enteromorpha sp),* pond weed (*Potomogeton sp), hornwort (Ceratophyllum sp), giant duck weed (Myriophyllum sp), Elodea canadensis and Egeria muttalli, sea lettuce (Ulva lacytuca) and E. densa*, have been studied for wastewater treatment, but the use of submerged macrophytes for wastewater treatment is still in the experimental stage. The development of epiphytic communities on the leaves of vascular plants may reduce photosynthesis in submerged macrophytes[2].

Figure 2: Submerged macrophytes

(A) Phragmites australis (B) Oenanthe javanica [15]

2.1.4. Reed beds with emeragent macrophytes

Various emergent macrophytes species can be used in constructing wetlands, including cattails, bulrushes, reeds, rushes. Constructed wetland for wastewater treatment with emergent macrophytes can be constructed with different design. In general these can be categorized into two major groups according to their flow pattern: free water surface systems (FWS Wetlands) and system with subsurface flow (SSF wetlands); subsurface flow wetland further categorized into horizontal subsurface flow systems (HSSF or HF Wetlands) and vertical subsurface flow systems (VSSF Wetlands).

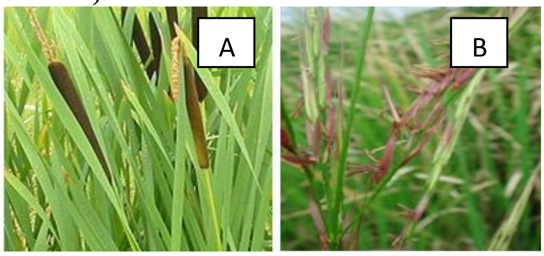

Figure 3: Emergent Macrophytes
(A) Typha angustifolia (B) Zizania latifolia [15]

2.2. Reed bed based on type of Construction

2.2.1. Surface Horizontal Flow (SHF)

This design allows water to flow over the surface of the bed between the stems of the reed plants which are planted in earth. The water is visible, usually to a depth of around 150mm. The design is effective for settling out solids prior to further treatment, or to balance flows into further reed bed stages.

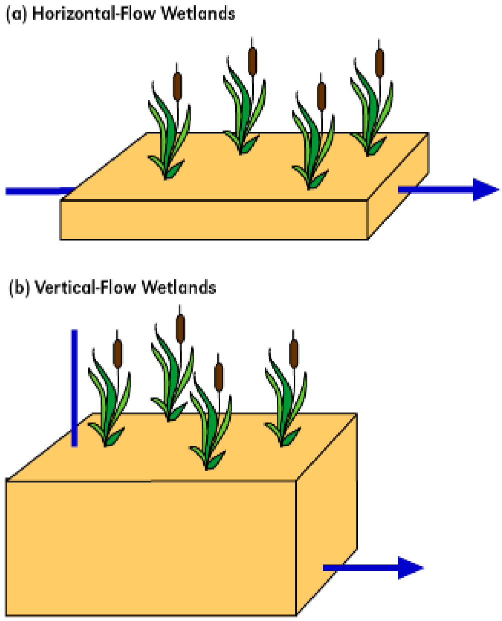

Figure 4: Types of reed beds based on its construction

2.2.2. Subsurface Horizontal Flow (SSHF)

This design allows water to flow below the surface of the reed bed through gravel media. The reed plants are planted in the gravel. There is no visible water in the bed and as such presents no public safety of odour problems. The reed plants are allowed to dieback in winter and form a warm composted layer which protects the biofilm below. This design if effective in reducing SS, BOD, COD and partial ammonia removal. It is also effective in removal of hydrocarbons, some heavy metals and nitrates.

2.2.3. Down Flow or Vertical Flow (VF)

This design requires dosing of the bed's surface using a network of pipes using either a pumping or a siphon system. The idea is to flood the surface of the reed bed a number of times per day. As the water flows down through the bed, it draws air in, creating the right bacterial environment. VF reed beds are very effective in removal of BOD, ammonia and some heavy metals and take up less area for similar treatment compared to SSHF.

The efficiency of SSHF and VF reed beds may be improved by adding certain chemicals to the water during the treatment. This dosing technique can be used for COD or phosphorous removal in industrial process water, for example.

Water can be treated progressively through multiple reed bed stages and some or all of the above systems can be incorporated into a complete treatment system.

III. Macrophytes and its role

The three types of macrophytes are emergent, free- floating and submerged which have been discussed above. SF- reed beds have all three types where as SSF- reed beds will only have emergent species. Macrophytes play a major role in reed beds, influencing biological, chemical and physical treatment processes. The most important function of macrophytes in reed beds has been categorized by as physical and metabolic. Physical effects include: Filtration of suspended material, protection against erosion by reducing turbulence and flow velocities stabilization of sediments and providing the surface area for micro-organisms. Metabolic functions of macrophytes include nutrient uptake and O2 release from roots into the rhizosphere. Macrophytes have adapted to anaerobic conditions by developing internal air spaces which transport O2 to the root zone. These air spaces form an extensive system throughout the plant and can occupy 60% of the total tissue volume. Research differs on the potential for macrophytes to release O2 from roots to the surrounding rhizosphere thus providing aerobic conditions for plant nitrification to occur. A study by concluded that internal O2 movement not only supplied to buried plant tissues but also leaked O2 into the rhizosphere. Macrophytes can also provide habitat for flora and fauna and increase aesthetic appeal. Research differs on the significance of plant uptake in nutrient removal with nutrient loading is an important part in the proportion of nutrient removal by plant uptake [6].

IV. Reed bed as an On-site Systems for disposal of wastewater effluent

A constructed reed bed is an option for the treatment of on-site wastewater. The term is used to describe different categories of the generic process, differentiated according to media selection and the direction of effluent flow, as follows:

• Horizontal free surface flow constructed reed bed (with soil).
• Horizontal subsurface flow reed beds (with gravel).
• Vertical subsurface flow reed beds (with gravel or sand).

The most common type of reed bed is the subsurface horizontal flow reed bed with gravel as the chosen media where the wastewater is maintained below the surface of the media. Such reed beds are generally regarded as effective in terms of organics, suspended solids and pathogenic organism removal but will not nitrify any ammonia to nitrate due to oxygen limitations.

Vertical flow reed bed systems are more effective than horizontal flow reed beds in not only reducing organics and suspended solid levels, but also in nitrifying ammonia nitrogen to nitrate. Hybrid reed bed systems, normally incorporating one or two stages of vertical flow followed by one or more stages of horizontal flow in series, may be designed to achieve higher treatment efficiency and in particular target total nitrogen removal, as well as organic reduction and pathogen removal. Free water surface based constructed reed bed need to be much larger than their subsurface counterparts to achieve the same level of treatment as the surface of the wastewater is at or above the surface of the soil support media. These systems however, can promote superior ecological diversity and aesthetics. There is a scarcity of reliable long-term performance data relevant to Ireland and its climate for such systems, and reluctance exists amongst some local authorities to permit the use of reed bed as stand-alone secondary treatment syatem.

V. Concluding Remarks

It has been observed that reed beds system for treatment of wastewater using the floating plant system is a predominant method which is economic to construct requires little maintenance and increase the biodiversity. The removal efficiency of contaminants like TSS, TDS, BOD, COD, EC, hardness, heavy metals, etc varies from plant to plant. Plant growth rate and hydraulic retention time can influence the reduction of contaminants. Therefore, an available knowledge and techniques for removal of water contaminants and advances in waste water treatment can be integrated to assess and control water pollution.

References

[1.] Ninad B. Bhalerao, A. R. Kambekar, analysis and design of zero sewage discharge systemfor model township, *international journal of research in engineering and technology eissn: 2319-1163 | pissn: 2321-7308.*

[2.] M. Bouali, M. Feki and A. Bakhrouf, Comparative study of two constructed wetlands for wastewater treatment, *Journal of Chemical, Biological and Physical Sciences, Vol. 4, No. 2; 1680-1691.*

[3.] David O. Olukanni and Kola O. Kokumo, Efficiency Assessment of a Constructed Wetland Using Eichhornia Crassipes for Wastewater Treatment, *American Journal of Engineering Research (AJER), Volume-02, Issue-12, pp-450-454.*

[4.] Ramprasad. C, Experimental study on waste water treatment using lab scale reed bed system using Phragmitis australis, *international journal of environmental sciences Volume 3, No 1, 2012.*

[5.] P. Pratik and D. Nishith, Phytoremediation of Sugar Industry Effluent Using *Typha angustata* and *Phragmites australis* through Constructed Wetland, *Journal of Chemical, Biological and Physical SciencesNovember 2013 – January 2014, Vol. 4, No. 1; 846-851.*

[6.] M. Sushil, Performance Evaluation of Reed Grass (Phragmites karka) in Constructed Reed Bed System (CRBs) on Domestic sludge, Ujjain city, India, *Research Journal of Recent Sciences, ISSN 2277 – 2502 Vol. 1(ISC-2011), 41-46 (2012).*

[7.] M. Rizwana, M. Darshan and D. Nilesh, Phytoremediation of Textile Waste Water Using Potential Wetland Plant: Eco Sustainable Approach, *International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS), 2014, Vol 1, No.4, 130-138.*

[8.] H. E. J. Deguenon, P. Hounkpe, M. P. Aina, J. Adounkpe, D. C.K. Sohounhloue, purification performances of common reed beds Based on the residence time: case of benin, *journal of applied biosciences 71:5682– 5691.*

[9.] Morari F., Giardini L., Municipal wastewater treatment with vertical flow constructed wetlands for irrigation reuse ecological engineering 35, 643–653.

[10.] A. Rana, J. Singh Laura, Removal efficiency of horizontal constructed wetland for treating domestic wastewater using local plant species, *International Journal of Environmental Biology*, ISSN 2277–386X.

[11.] Armstrong, J. and Armstrong, W. (1990). Pathways and mechanisms of oxygen transport in *Phragmites australis*. In: *The Use of Constructed Wetlands in Water Pollution Control. Ed*. Cooper, P. *Pergammon Press*, 529-533.

[12.] Armstrong, W., Armstrong, J. and Beckett, P.M. (1990).Measurement and modelling of oxygen release from roots of Phragmites australis. In: The *Use of Constructed Wetlands in Water Pollution Control.* Ed. Cooper, P. *Pergammon Press*, 41-51.

[13.] Schierup, H.-H., Brix, H., Lorenzen, B., (1990). Wastewater treatment in constructed reed beds in Denmark - state of the art. In: Cooper, P.F., Findlater, B.C. (Eds.), Constructed Wetlands in Water Pollution Control. *Pergamon Press*, London, 495-504.

[14.] Vrhovsek, D., Kukanja, V. and Bulc, T. (1996). Constructed wetland (CW) for industrial wastewater treatment. *Water Res.* 30, 2287-2292.

[15.] Tanner, C.C. (2000). Plants as ecosystem engineers in subsurface flow treatment wetlands. *In 7th Int. conf. on wetland systems for water pollution control*; University of Florida, 13-22.

Book

[16.] Sawyer CN, McCarty PL and Parkin GF. 1994. Chemistry for environmental engineers. McGraw-Hill, p.280-31O.