



CONSTRUCTED WETLANDS: AN ECOFRIENDLY APPROACH TO WASTE WATER MANAGEMENT

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ABSTRACT

Rapid urbanization results in the depletion and degradation of natural resources. Untreated waste water from urban drainage as well as runoff leads to pollution of receiving water bodies. So there is need of sustainable urban waste water management. The present paper is an overview of working and performance level of constructed wetlands as an ecological method to remove different pollutants from urban waste water. This technology is well adopted in developed countries while not yet popular in India. Keeping in consideration its advantages it is suggested that there is need to rely upon natural ecological processes in preference to the energy and chemical intensive systems currently in use.

KEYWORDS: Urbanization, Constructed wetlands.

INTRODUCTION

Urbanization is now a global trend as it enhances economic development opportunities but unfortunately it is a poorly managed process in most of the developing countries. Moreover, mankind exploits the natural resources with little regard for conservation and economy. So it put excessive pressure on natural resources and basic services like water and sanitation. Mismanagement of urban growth resulted in land and water pollution. When areas are urbanized, much of the vegetation and top soil is replaced by impervious surfaces, the rainfall that used to be absorbed into ground now moves as runoff. The receiving water bodies can not handle large amount of runoff, so can be flooded. Moreover, runoff picks up gasoline, oil, heavy metals and other pollutants from roadways and parking lots, as well as pesticides and fertilizers from lawns.

Untreated wastewater from urban areas is polluting the receiving water bodies. It causes eutrophication of water which degrades the ecosystem. The urban drainage affects the biological community performance, water quality and biotic interactions in the aquatic system. Decomposition of organic materials produces large quantities of malodorous gases causing air pollution. Some nutrients and chemicals in wastewater decrease soil fertility reducing crop production and growth of aquatic plants. This waste water may contaminate ground water sources and drinking water supply sources producing imbalance of eco-system. So, immediate nuisance free removal of waste water from its sources of

generation followed by treatment and disposal is necessary. As the conventional treatment methods are of high cost and need technical manpower, so wetlands are the most suitable natural methods to treat waste water.

WETLANDS

Wetlands are defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas". In a wetland, physical, chemical and biological processes combine to remove contaminants from waste water. They contain specialized vegetation types with aerenchyma to transport atmospheric gases through leaves and stems down to roots to provide oxygen for respiration. This enables them to grow in an otherwise hostile environment. Wetlands are among the most productive ecosystems in the world. The high primary productivity in wetlands results in high microbial activity which in turn leads to a high capacity of decomposing organic matter. Microbial nitrification and denitrification released nitrogen as a gas to atmosphere. Phosphorus is co precipitated with compounds in root bed medium. Suspended solids are filtered out by sedimentation.

So, wetlands are natural water purification systems acting as a filter for contaminants and excessive nutrients thus improving water quality. They act as giant natural

sponges, absorbing run off from rain and melting snow and slowly releasing the stored water during drier periods preventing flooding of rivers. But the pollutant loads of urban drainage waters tends to be highly variable due to a dependence on factors such as land use, characteristics of the drainage system and catchment area, the nature and frequency of storms and the weather conditions between storms. Moreover natural wetlands may never receive wastewater from urban runoff. So the alternative is to use constructed wetlands for treatment of urban waste water and storage of urban runoff.

Constructed Wetland Systems (CWS) are artificially engineered wetlands specifically constructed for wastewater treatment at selected site utilizing particular combinations of plants, soil, bacteria to optimize the physical, chemical and microbiological processes present within root-zone of plants.

CONSTRUCTED WETLAND SYSTEMS (CWS)

Types of constructed wetlands according to macrophytes

Wetland treatment systems use different water tolerant plant species. The systems may be classified according to the life form of the dominating macrophytes into:

- Free-floating macrophyte-based system
- Submerged macrophyte-based system
- Rooted emergent macrophyte-based system

Types of constructed wetlands according to flow type

The basic types of constructed wetland treatment systems include

1. Surface flow (SF) wetlands
2. Subsurface flow (SSF) wetlands

Surface flow wetlands (SF) are densely vegetated by a variety of plant species and typically have water depths less than 0.4 m. In this the effluents move above the soil in a planted marsh or swamp, and can be supported by a wider variety of soil types including bay mud and other silty clays.

Subsurface flow wetlands (SSF) use a bed of soil or gravel as a substrate for the growth of rooted emergent wetland plants. The bed depth in SSF wetlands is typically between 0.6 and 1.0m. Subsurface-flow wetlands can be further classified as horizontal flow and vertical flow constructed wetlands. Subsurface-flow wetlands move effluent (agricultural runoff, wastewater from sewage or storm drains) through a gravel lavastone or sand medium on which plants are rooted. In subsurface-flow systems, the effluent may move either horizontally, parallel to the surface, or vertically, from the planted layer down through the substrate and out.

VEGETATION

Plantings of reedbeds are popular in European constructed wetlands, and plants such as cattails (*Typha* spp.), sedges, Water Hyacinth (*Eichhornia crassipes*) and *Pontederia* spp. are used worldwide. Recent researches in use of constructed wetlands has shown that buckbeans (*Menyanthes trifoliata*) and pendant grass (*Arctophila fulva*) are also useful for metals uptake.

WORKING OF CONSTRUCTED WETLAND

Untreated or pretreated waste water is piped into the constructed wetland and flows through. The elimination processes take place during this passage; they are based on various complex physical, chemical and biological processes with the association of substrate, macrophytes and microorganisms:

- Settling of suspended particulate matter.
- Filtration and chemical precipitation through contact of the water with the substrate.
- Chemical transformation.
- Adsorption and ion exchange on the surfaces of plants, substrate, sediment and litter breakdown, and transformation and uptake, of pollutants and nutrients by microorganisms and plants.
- Predation and natural die-off of pathogens.

The principal pollutants in urban drainage and runoff are BOD, suspended solids, heavy metals, hydrocarbons, nutrients and faecal coliforms.

Table 1: Quality of urban runoff (Duncan, 1999).

Pollutants	Total suspended solids	Total phosphorus	Total nitrogen	Biological oxygen demand (BOD)	Oil and grease	Total lead	Total zinc
Value (mg/L)	150	0.35	2.6	14	8.7	0.14	0.24

Constructed wetlands are found responsible for pollutant removal and waste breakdown. The plants not only remove the pollutants but also act as the carbon source for the microbes when they decay. The removal mechanism and the removal efficiency of major waste water pollutant in macrophyte based constructed wetland is summarized as as: (Brix, 1993; Knight *et al.*, 1993).

Table 2: Removal mechanism and removal efficiency of pollutants in macrophyte based waste water systems.

S. No.	Pollutants	Removal mechanism	Removal efficiency
1.	Suspended solids	Sedimentation Filtration	69%
2.	Biological oxygen demand (BOD)	Microbial degradation (Aerobic and anaerobic) Sedimentation (Accumulation of organic matter/sludge on the sediment surface)	73%
3.	Nitrogen	Ammonification followed by microbial nitrification and denitrification Plant uptake	64%
4.	Phosphorus	Soil sorption (Adsorption or precipitation reactions with Al, Fe, Ca and clay minerals in the soil) Plant uptake	55%
5.	Pathogens	Sedimentation, Filtration Natural die off Excretion of antibiotics from roots of macrophytes	
6.	Trace metals	Adsorption Plant uptake Microbial transformation	Approximately 70%

ADVANTAGES

Constructed wetlands are of cost-effective and technically feasible approach to the treatment of wastewater for several reasons:

- Often be less expensive to build than other treatment options
- Operation and maintenance expenses (energy and supplies) are low
- Operation and maintenance require only periodic, rather than continuous, on-site labor.
- Able to tolerate high fluctuations in flow
- Able to treat wastewaters with very different constituents and concentration
- Facilitate water reuse and recycling

DEVELOPMENT OF CONSTRUCTED WETLANDS

In Florida, there are 21 constructed wetlands covering roughly 1618.4 km² area. The two wetland sites, North West waste water reclamation facility (NWRf) and Eastern water reclamation facility (EWRf) are combination of natural and constructed wetlands. Both projects work in response to the increasing need associated with urbanization. The EWRf has been functioning well over 20 years (Megic and Chang, 2010). Efforts are done at war level to promote constructed wetland as a method to treat urban runoff and storm water in Utopia (Shutes *et al.* 2008). In Nepal a community based constructed wetlands in Sunga has become successful in recycling and reuse of treated effluence hence enhancing receiving river quality (Rajbhandari, 2006).

Although developed countries have been using this technology, the use of these systems in treating waste water has not been very popular in developing countries like India. In India, some pilot projects are focussed on treatment of urban waste water and runoff by using

constructed wetlands. One such project is conceived for metropolitan city, New Delhi in order to achieve an optimal solution of treating sewage and urban runoff before going into water of river Yamuna (Mittal *et al* 2006). In Warangal city of Andhra Pradesh, a pilot project of constructed wetland was started. It is found that the system performs well and could be adopted as a viable alternative which would be low in cost and at the same time, environment and ecologically friendly in upcoming cities (Jayakumar and Dandigi 2003). A pilot project of constructed wetlands at Pipal Majra and Shekhupura villages of Punjab has been started where two ponds have been identified for implementing the project. The waste water from open drainage is treated to provide safe and cleaner water to the villagers.

CONCLUSION

Constructed wetlands are the ecological way to treat waste water from urban drainage and runoff. The city planners should design the urban areas giving due consideration to source control and treatment of waste water. As the conventional water treatment systems are expensive and need technical man power, so constructed wetlands can be used as an alternative or can supplement the existing systems. If this technology is implemented correctly, then these constructed wetlands would not only provide an ideal solution to help curbing the problem of water pollution in urban areas but also create a healthy natural ecosystem.

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