International Journal of Applied Engineering and Technology ISSN: 2277-212X (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jet.htm
2015 Vol. 5 (1) January-March, pp.69-77/Arushai
Research Article

CONSTRUCTED WETLANDS AS A SUSTAINABLE SOLUTION FOR MUNICIPAL WASTEWATER

***Arushai Sheoran**
Department of Civil Engineering, Birla Institute of Technology & Science
Vidya Vihar, Pilani, 333031, Rajasthan, India
**Author for Correspondence*

ABSTRACT
Constructed wetlands are gaining importance as an effective passive treatment and low-cost alternative for treatment of municipal wastewater. Such systems have certain advantages over the conventional treatment systems: they can be established in the same place as where the wastewater is produced; they can be maintained by relatively untrained personnel; they have relatively lower-energy requirements and are low-cost systems. This paper presents a thorough review of passive treatment of municipal wastewater by constructed wetland.

Keywords: *Municipal Wastewater, Treatment, Passive Method, Constructed Wetland*

INTRODUCTION
The primary renewable source of freshwater is continental rainfall, which generates a global supply of 40 000–45 000 km^3 per year. This more or less constant water supply must support the entire world population, which is steadily increasing by roughly 85 million per year. Thus, the availability of freshwater per capita is decreasing rapidly. About 80 countries and regions, representing 40% of the world's population, are experiencing water stress, and about 30 of these countries are suffering water scarcity during a large part of the year. Apart from the natural scarcity of freshwater in various regions and countries, the developing country in particular, the quality of the available freshwater is also deteriorating due to pollution, hence intensifying the shortage. It is estimated that today throughout the world, more than 5million people (mostly children) die annually from illnesses caused by drinking poor quality water (Stikker, 1998).

Untreated sewage is the major sources of pollutants in developing countries. Municipal sewage containing readily biodegradable organic matter, inorganic and organic chemicals, toxic substances and disease causing agents are frequently discharged into aquatic environments (oceans, rivers, lakes, wetlands) without treatment. In rural areas and unplanned high density urban settlements, contamination of surface and groundwater by domestic wastewater occurs through infiltration and surface run-off of poorly placed pit-latrines especially during the rainy-season. The situation is getting worse with rapid urbanization and a continuing lack of proper sanitation in developing areas.

The most sustainable solutions for wastewater recycling will be passive, self-adaptive living systems. One such promising technology for wastewater treatment is the constructed wetland. The wetlands have potential for organic, nutrient (nitrogen and phosphorus), suspended solids and pathogen removal. A constructed wetland, like any other biological wastewater treatment process, will exhibit variability in the level of contaminant removal (Crites and Tchobanoglous, 1998). For example, Bastian and Hammer (1993) compiled pollutant removal results for a number of North American constructed wetland systems and reported a wide range of efficiencies for organic (50–90%), suspended solids (40–94%), nitrogen (30–98%) and phosphorus (20–90%) contaminant removal. This paper reviews the various aspects of constructed wetland for the treatment of municipal wastewater.

Municipal Wastewater: Indian Scenario
India supports more than 16% of the world's population with only 4% of the world's fresh water resources (Singh, 2003). The total wastewater generated by the 299 class I cities is 16,662 MLD approximately 81% of the water supplied. The state of Maharashtra alone contributes about 23%, while Ganga river basin contributes about 31% of the waste generated. Only 74% of the total wastewater

generated is collected. Out of 299 class I cities 160 cities have sewerage coverage for more than 75% of the population and 92 cities have between 50 and 75% of population coverage. On the whole 70% of the population of class I cities are provided with sewerage facility.

The type of sewerage system is either open or closed or piped. As per the latest estimate out of 22,900 MLD of wastewater generated, only about 5900 MLD (26%) is treated before letting out, the rest i.e., 17000 MLD is disposed of untreated. Twenty-seven cities have only primary treatment facilities and forty-nine have primary and secondary treatment facilities. The level of treatment available in cities with existing treatment plant varies from 2.5% to 89% of the sewage generated (CPCB, 2013).

The Emergence of Constructed Wetland

A serious problem facing the cities presently is the enormous volume of municipal wastewater discharged per day. Wetlands seem to be a good remedy to this threatening problem. Wetlands commonly known as biological filters have emerged as a viable option for helping to solve a wide range of environmental and water quality problems (Greenway and Simpson, 1996; 1997a,b). The use of constructed wetlands is a relatively new technology but the system is gaining popularity due to its low tech system for treating wastewater (DeBusk *et al.*, 1996).

In the past several decades, CWs have become a popular option for wastewater treatment and have been recognized as attractive alternatives to conventional wastewater treatment methods. This is due to their high pollutant removal efficiency, easy operation and maintenance, low energy requirements, high rates of water recycling, and potential for providing significant wildlife habitat.

The Constructed wetlands are man-made systems that are designed, built and operated to emulate functions of natural wetlands.

They are created from a non-wetland ecosystem or a former terrestrial environment, mainly for the purpose of pollutant removal from wastewater. The constructed wetland treatment system is a cheaper alternative for wastewater treatment using local resources and is an energy-efficient technology (Collins *et al.*, 2005).

Types of Constructed Wetlands

There are two major types of constructed wastewater wetlands. The first is called a free water surface wetland (FWS). A FWS wetland encompasses shallow water flowing over plant media and water depths that vary through the wetland as shown in Figure 1.

Typically these wetlands resemble natural wetlands and include mineral or organic soil underneath vegetation. Vegetation includes reeds and cattails but can also include floating plants which are also known as macrophytes. The second type of constructed wetland is Sub-Surface flow constructed treatment wetlands as shown in Figure 2.

A Sub-Surface flow constructed treatment wetlands contains coarse substrate media such as gravel which the water travels through. The top of the water level is below the surface of the media and plant roots are allowed to grow in the coarse media.

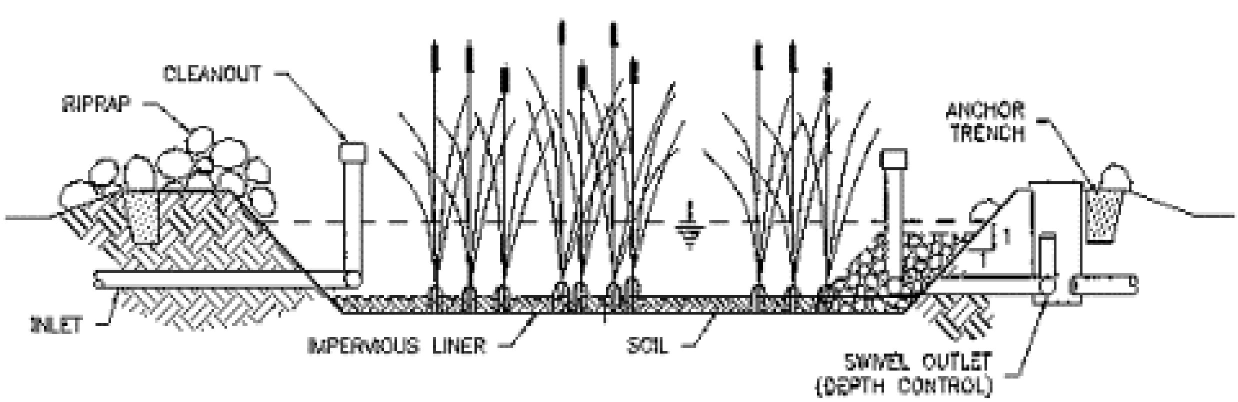

Figure 1: Surface flow constructed treatment wetlands (USEPA, 1999)

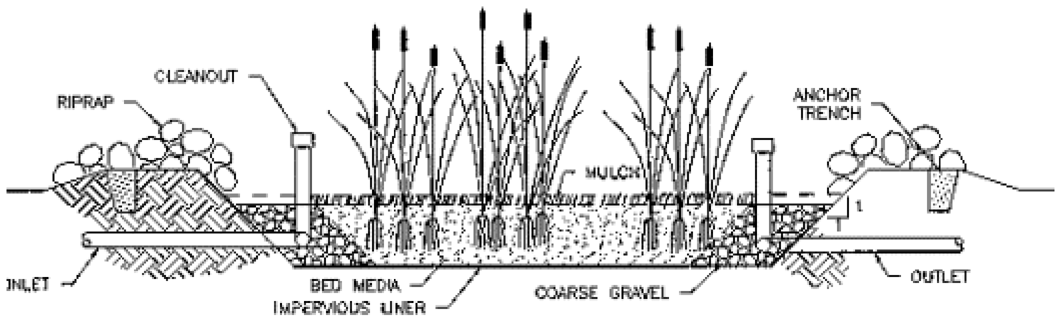

Figure 2: Sub-Surface flow constructed treatment wetlands (USEPA, 1999)

Components of Constructed Wetland

To understand the wastewater treatment processes and nutrient removal processes in the wetland, it is important to know the main components of the wetland and the factors that influence the wetland performance. The main components of the wetland are wetland vegetation, soil or substrate or media, water column and living organisms in the wetland.

A constructed wetland is a shallow basin filled with substrate and planted with vegetation tolerant of saturated condition. Water is introduced at one end and flows on the substrate and discharged at the other end though a weir or other structure, which controls the depth of water. So wetland is a complex assemblage of Water, Basin, Substrate and Plants. Sometimes a liner is also included beneath the substrate. The different interacting processes are responsible for the removal of pollutants from wastewater in wetlands. The main processes are: settling, sedimentation, sorption, co-precipitation, cation exchange, photo degradation, phytoaccumulation, biodegradation, microbial activity and plant uptake. It is, however, difficult to illustrate what actually occurs or which reactions takes place in the wetland. The entire processes are dependent on each other, thus making the whole process of pollution removal mechanisms in wetlands very complex. More or less, the extent to which these reactions occur depends on the composition of the substrate, sediment pH, nature of wastewater and plant species.

Wetland Vegetation: Plants used in wetlands should be able to adapt to water logged conditions and local climatic conditions. Such emergent plants should be resistant to high pollutant levels. Commonly used hydrophytes in the constructed wetland are reed canary grass, soft stem bulrush, sedges, wild rice, soft rush, etc. Some of the important functions of vegetation in the wetlands are: to produce oxygen (needed for aerobic reactions) during photosynthesis, reduce velocities of inflowing water and thereby create better conditions for sedimentation of suspended solids, improve hydraulic conductivity of the substrate or media, and uptake nutrients from wastewater, stabilize substrate and enhancing its permeability.

Soil or Substrate: Substrates for wetland include soil, sand, gravel, rocks, etc. Constructed wetlands generally use gravel as the substrate as it provides a larger surface area for biological and chemical processes to take place and also provide site for suspended solids and removed pollutants. Course gravel as opposed to soil or fine gravel will provide high hydraulic conductivity in the wetland, which is required to stabilize the hydraulic retention time of the wetland.

Water Column: Water in the wetland is required for the occurrence of the biochemical reactions. It also acts a medium of transport for organic solids, nutrients, gases, etc.

Living Organisms: Of all the living organisms found in a wetland, microorganisms like bacteria, fungi, protozoa, etc play an important role in the treatment of wastewater. These microorganisms help in biochemical reactions taking place in the wetland as a part of the treatment process.

Pollutants Removal Mechanism in Wetlands

The various pollutants found in domestic waste water are total suspended solids, colloidal solids, dissolved solids, chlorides, nitrogen contents in the form of ammonia, organic nitrogen, nitrites and nitrates, fats, grease and oils, surfactants from synthetic detergents, pesticides and herbicides, gases such as hydrogen sulphide, ammonia, methane, BOD, COD, microorganisms, metals, pathogens faecal colliforms etc.

The removal mechanisms of pollutants occur in the three main compartments of a wetland, i.e. (1) Soil and substrate, (2) Hydrology, (3) Vegetation. The principal soils considerations in siting and implementing a FWS constructed wetland are the infiltration capacity of the soil and its suitability for berm construction. Soils with high humic and sand components result in rapid plant colonization and growth. Substrate for wetland vegetation should be agronomic in nature and well loosened. Water is usually present at the surface or within the root for extended periods of time. Hydrology is probably the single most important determinant for the establishment and maintenance of specific types of wetland and wetland processes. It is the permanent or periodic saturation of a wetland area that results in the anaerobic conditions in the soil under which typical wetland bio-geochemical processes occur. These processes cause the development of characteristic wetland soils, which support a dominant plant community adapted to living in saturated soils (ITRC, 2003).

Soils consist of unconsolidated natural material that supports or is capable of supporting plant life. Under wetland conditions, soils are considered to be hydric, i.e. saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper portion of the soil. Hydric soils are developed under conditions sufficiently met to support vegetation typical to wet areas (hydrophytic vegetation). Wetland plants are autotrophic organisms, creating a biomass of reduced carbon compounds that serves as food for a variety of organisms, both micro and macroscopic. Plants also have the ability to remove trace metals from the water through biological uptake and surface adsorption (ITRC, 2003; Collins *et al.*, 2005). The most significant functions of wetland plants (emergents) in relation to water purification are the physical effects brought by the presence of the plants.

Performance of Constructed Wetlands

Constructed wetlands are among the recently proven efficient technologies for wastewater treatment and have a strong potential for application in developing countries, particularly by small rural communities. However, these systems have not found widespread use, due to lack of awareness, and local expertise in developing the technology on a local basis. Treatment technology using wetlands has been under development, with varying success, some of the case studies are given.

In Estonia many natural/semi-natural wetlands have been used for municipal or agricultural wastewater. During the last 6 years twelve constructed wetlands for wastewater purification were established. BOD, total-N and total-P of three systems, located in southern Estonia, are analyzed. Except for nitrogen, the efficiency of the sand/plant filter was found satisfactory: 82%, 36%, and 74% for BOD, total-N, and total-P, respectively. The poor performance with respect to nitrogen may be caused by weak vegetation (Mander and Mauring. 1997).

A constructed wetland was used to remove nitrate from the municipal drinking water supply of two million people in Orange County, southern California, USA. The source water was the effluent-dominated Santa Ana River and up to 1.5 m3 s-1 (33-106 gallon day-1) was treated prior to groundwater recharge. The influent was mostly highly treated, nitrified municipal wastewater containing 3.1–10.9 mg l-1 NO3–N and was applied to 170 ha (425 acres) of shallow, open water and vegetated marsh in the Prado Basin. Nitrate removal rates as high as 1,000 mg NO3–N m-2 d-1 were observed in some portions of the marsh and exiting nitrate concentrations sometimes fell to as low as 0.1 mg l-1 NO3–N with residence times of less than 10 days. High nitrate removal rates were observed at loading rates higher than comparable systems; hydraulic surface areas ranged from 0.04 to 0.55 ha per m-3 s-1 (2–33 acres per 106 gal d_1) and hydraulic detention times ranged from 0.3 to 9.6 days. Average nitrate removal was 522 mg NO3–N m-2 d-1 (range 4–1071), average efficiency for the entire wetland was 79% (range 14–100). Nitrate loading rates averaged 1458 mg NO3–N m-2 d-1 (Reilly *et al.*, 2000).

The nitrate removal efficiency was compared of two constructed wetlands receiving ambient river water to one constructed municipal wastewater treatment wetland over the same 2-year period in central Ohio, USA. The wastewater wetland represents a high-nutrient system, with an average nitrate plus nitrite load of 12.3 kg N ha-1day-1 and an average nitrate and nitrite inflow concentration of 12.5 mg N l-1. The riverine wetland loadings and concentrations were approximately 60% lower (4.6–4.7 kg N ha-1day-1 and 4.6 mg N l-1). Percent nitrate removal by mass ranged from 29% in the wastewater wetland to 37–

40% in the wetlands, although differences in retention varied widely by season and were not statistically significant among the wetlands (Spieles and Mitsch, 2000).

The use of constructed wetlands for wastewater treatment is an emerging technology in the Czech Republic. Wetlands have been intensively studied in the Czech Republic for wastewater treatment. The size of CWs ranges between 18 and 4500 m2 and between 4 and 1100 population equivalent (PE). Most frequently used filtration media are gravel and crushed rock with size fractions of 4/8 and 8/16 mm and Phragmites australis is the most commonly used plant. The treatment efficiency is high in terms of BOD (88.0% for vegetated beds) and suspended solids (84.3% for vegetated beds). The removal of nutrients is lower for vegetated beds, and averages 51 and 41.6% for total phosphorus and total nitrogen, respectively (Vymazal, 2002).

In Ireland constructed wetland systems are increasingly being used to perform tertiary treatment on municipal waste effluent from small towns and villages located in areas whose receiving waters are deemed sensitive. This study examines the waste treatment performance, in terms of nutrient (P and N) reduction, of a recently constructed surface-flow wetland system at Williamstown, County Galway, Ireland. Performance evaluation is based on more than two years of water quality and hydrological monitoring data. The N and P mass balances for the wetland indicate that the average percentage reduction over the two-year study period is 51% for total N and 13% for total P. The primary treatment process in the wetland system for suspended solids (between 84 and 90% reduction), biological oxygen demand (BOD). (On average, 49% reduction), N, and P is the physical settlement of the particulates. However, the formation of algal bloom during the growing season reduces the efficiency of the total P removal (Healy and Cawley, 2002). In Canada, municipal sewage treatment systems have been installed to treat 75% of the wastewater produced. Therefore, there is still a large portion of untreated wastewater being discharged directly to receiving waters. Further efforts must be made to encourage the treatment of wastewater before discharge to surface waters. A pilot constructed wetland system has been built in Alfred, Ontario and was evaluated as an effective means to treat municipal lagoon wastewater for the municipality. This research project was initiated to refine the knowledge available on the treatment of rural municipal wastewater by constructed wetlands. To determine the treatment capacity of a constructed wetland system receiving municipal lagoon effluents, the wetland was monitored over one treatment season, from May 19 to November 3, 2000. The wetland system consisted of a three-cell free-surface wetland, phosphorus adsorption slag filters and a vegetated filter strip. Bimonthly water samples at the inlet and outlet of each component of the wetland system were analyzed for biochemical oxygen demand, nitrate and nitrite, ammonia and ammonium, total Kjeldahl nitrogen (TKN), total suspended solids (TSS), total phosphorus (TP), ortho-phosphate (ortho-PO4), fecal coliforms (FCs) and Escherichia coli. The free-surface wetland cells treating the lagoon effluents achieved removals as follows: biochemical oxygen demand (34%), ammonia and ammonium (52%), TKN (37%), TSS (93%), TP (90%), ortho-PO4 (82%), FCs (52%) and E. coli (58%). The wetland cells reduced total nitrogen, TP and biochemical oxygen demand to levels below the maximum permissible levels required for direct discharge to nearby receiving waters. The vegetated filter strip treating the effluents from the wetland cells achieved removals as follows: biochemical oxygen demand (18%), ammonia and ammonium (28%), TKN (11%), TSS (22%), TP (5%), FCs (28%) and E. coli (22%). It may therefore serve as an additional treatment stage further reducing the concentrations of these mentioned parameters. The slag filters reduced TP in the lagoon effluents by up to 99%, and, in this study, were concluded to be effective phosphorus absorbers (Cameron, 2003). Forested wetlands have been used to provide advanced secondary and tertiary treatment for municipal wastewater for a number of cities in southern Louisiana. The City of Breaux Bridge, LA, has discharged secondarily treated municipal wastewater into a forested wetland since 1950, and wetland assimilation was permitted by the Louisiana Department of Environmental Quality and the US Environmental Protection Agency (US EPA) in 1997. We compared benefits and costs of utilizing forested wetlands and conventional sand treatment using money-based and energy-based cost–benefit analyses (CBA). The wetland method had a higher benefit–cost ratio than conventional treatment by 6.0 times based on dollar based CBA, and by 21.7 times from the energy analysis (Ko *et al.*, 2004).

With the aim of solving the wastewater treatment problem in small villages, treatment performance of a pilot scale subsurface-flow constructed wetland (SFW) was evaluated for removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total and faecal coli form and faecal streptococci bacteria from raw municipal wastewater. Studies of the composition and thermal behavior of the harvested biomass were achieved in order to assess their possible utilisation as a fuel. Two different hydraulic application rates (150, and 75mmday-1) and two macrophytes, cattail (Typha sp.) and reed (Phragmites sp.), were assayed. High levels of BOD, COD and TSS removal for all treatments were obtained. The best removals were obtained in those beds with the lowest hydraulic application rate. With regard to the type of plant, no significant differences were found between cattail and reed performance; however, cattails showed to be by far (almost a factor of 2) the greatest producer of biomass (22 t [d.m.] ha-1). Both cattails and reeds presented high heating values (17–20MJ kg-1).According to these results, it can be concluded that the wetland system utilized in this research could be a suitable solution for raw wastewater as a stand-alone treatment, although a previous pre-treatment in order to remove grit, heavy solids and floatable materials would be necessary. Besides, the obtained biomass could be utilized as fuel in a small boiler for domestic uses. No seasonal differences were found in the performance of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and pathogens, except in winter. During that season, the removal of those parameters was significantly lesser, although the removal percentages have never been below 40% (Solano *et al.,* 2004).

The efficiency of pollution removal from municipal sewage in two vertical flow constructed wetlands consisting of gravel filters with a surface area of 4x5 m, depth 60 cm, planted with reed (Phragmites) was assessed over a period of about two years. The flow of wastewater was 50 mm per day. Wastewater underwent only primary treatment before application to reed bed B, but reed bed A was supplied with wastewater after mechanical and biological treatment. Measurements were taken of sewage supply and discharge, precipitation and wastewater temperatures. The main indicator of efficiency was the elimination of suspended solids, BOD, nitrogen and phosphorus from the wastewater during treatment. The elimination of the pollution load was 2–25 g O2 per square meter per day for the BOD5 and 0–3.5 g per square meter per day for so-called “total nitrogen”. Rates of pollution removal were between 2 and 4 times as high in bed B (after primary treatment) as in bed A (after biological treatment), but the loading rate of bed B was also substantially higher. The rate of BOD removal and the coefficient k for BOD were greatly dependent on temperature for reed bed B (primary tretament); less so for bed A (biological treatment). The difference between summer and winter temperatures indicates that the surface area of constructed wetland B with wastewater after mechanical treatment should be about 3 times greater during winter, to obtain the summer rate of BOD pollution removal in the climatic conditions of Northern Poland (Kowalik *et al.,* 2004).

Constructed wetlands have been identified as a potentially important component of animal wastewater treatment systems. Continuous marsh constructed wetlands have been shown to be effective in treating swine lagoon effluent and reducing the land needed for terminal application. Constructed wetlands have also been used widely in polishing wastewater from municipal systems. Constructed wetland design for animal wastewater treatment has largely been based on that of municipal systems. The objective of this research was to determine if a marsh-pond-marsh wetland system could be described using existing design approaches used for constructed wetland design. The marsh-pond-marsh wetlands investigated in this study were constructed in 1995 at the North Carolina A&T University research farm near Greensboro, NC. There were six wetland systems (11m × 40 m). The first 10-m was a marsh followed by a 20-m pond section followed by a 10-m marsh planted with bulrushes and cattails. The wetlands were effective in treating nitrogen with mean total nitrogen and ammonia-N concentration reductions of approximately 30%; however, they were not as effective in the treatment of phosphorus (8%). Outflow concentrations were reasonably correlated ($r2 \geq 0.86$ and $r2 \geq 0.83$, respectively) to inflow concentrations and hydraulic loading rates for both total N and ammonia-N. The calculated first-order plug-flow kinetics model rate constants (K20) for total N and ammonia- N (3.7–4.5 m/day and 4.2–4.5 m/day, respectively) were considerably lower than those reported in the limited literature and currently recommended for use in constructed wetland design for animal wastewater treatment (Stone *et al.*, 2004).

There is severe degradation of the water quality of the Texcoco River in central Mexico as a result of discharges of raw sewage from communities into the watershed.. To assess the removal of pollutants from wastewater, we constructed a pilot scale treatment wetland in the small community of Santa Marıa Nativitas in the Rio Texcoco watershed. The system, consisting of sedimentation terraces, stabilization pond, subsurface flow wetland (SSFW) and vertical flow wetland (VFW), removed >80% of TSS, COD and nitrate from domestic sewage. Removal of ammonium was less efficient at about 50%. This study also showed that ornamental flowers with high economic value planted in the SSFW performed as well as cattail (Typha angustifolia) in removing TSS and nitrogen.

The treated water was suitable for irrigation, which could help to alleviate the scarcity of water in the Rio Texcoco watershed (Belmont *et al.*, 2004).

A full-scale constructed wetlands system with a total area of 80 ha and treatment capability of 2.0×104 m3 d-1 was completed in Rongcheng, Shandong Province, China. To evaluate wastewater treatment effectiveness and seasonal performance of the system, water samples were collected and analyzed from January 1999 to December 2004. Comparison of mean inlet and outlet concentrations showed that the constructed wetland system could effectively reduce the output of SS (71.8±8.4%), BOD (70.4±9.6%), COD (62.2±10.1%), total coliform (99.7%) and fecal coliform (99.6%). However, the percent reduction of ammonia nitrogen was relatively low (40.6±15.3%), and total phosphorus showed the least efficient reduction (29.6±12.8%). BOD, COD, ammonia nitrogen, and total phosphorus removal efficiencies displayed seasonal variations. BOD and COD removal was more efficient in spring and summer than in autumn and winter whereas ammonia nitrogen and total phosphorus removal was more efficient in summer and autumn than in spring and winter (Song *et al.*, 2006).

Advantages of Constructed Wetlands

Constructed wetland treatment technology has emerged as a viable option for addressing a wide range of water quality problems specially in treating gray water. The treatment is often more economic than energy intensive engineered treatment plants. The constructed wetland treatment technology has the following advantages over the conventional treatment (Hillier *et al.*, 1994)

- Provides a high level of treatment – Properly designed, constructed, maintained and managed wetlands can provide very efficient treatment of waste water.
- Relatively inexpensive to construct – Each constructed wetland's design is site specific, taking into consideration such variables as topography, water supply, soil types etc. Selection of a site with accommodating specifications keeps establishment costs low.
- Inexpensive to operate and maintain – A constructed wetland requires little, if any, energy use and equipment needs are minimal. A well-designed wetland transfers water by gravity through the system. If topography limits the use of gravity, pumps will be necessary which increases the cost of operation. Once established, properly designed and constructed wetlands are largely self-maintaining. Operation and maintenance expenses are low (Energy & supplies are low). Operation and maintenance require only periodic, rather than continuous on site labor. The goal of this gray water treatment by constructed wetlands in to provide a long term, zero or low-maintenance method of abating acid mine drainage. Although some human intervention may be required.
- Able to handle variable waste water loadings – Property-designed wetlands have shown great tolerance for varying amount of wastewater loading. This is important because varying production levels again especially with mineral processing, changing climatic conditions, and modifications in management can alter loading rates significantly. They are more flexible and less susceptible to loading and able to tolerate fluctuations in flow.
- Reduces, if not completely eliminates, odor – Odor is a serious problem when handling and treating wastewater especially from mining and mineral processing and if the operation is located in close proximity to residential housing. Research, has shown that odors from wetlands are of very low intensity or are non-existent.

- Can be aesthetically pleasing – depending upon design, location and type of vegetation, constructed wetland can enhance the landscape with color, texture, and variety in plant materials. In addition they provide green space and educational areas.
- Provide wildlife habitat – Wetlands attract some types of wildlife and can add to the usefulness and attractiveness of the area. Passive recreation such as bird watching and photography.
- They facilitate water reuse and recycling.
- They are environmentally sensitive approach that is viewed with the favour by the public. They can be built to fit harmoniously into the landscape.
- The technology offers the added advantage of operational reliability while requiring minimal operational control.

CONCLUSION

Surface and ground water contamination due to municipal wastewater reported around the world has severe impacts on environment and human health. The constructed wetland is a passive method, which would function as biofiltration systems.

The water flows through these wetlands and plants absorb most of the pollutants. With the unwanted material thus removed, clean water can be released into the environment. This method is virtually self-sustaining and can operate unattended for many years. However, the efficiency of engineered wetland is limited in northern countries such as Canada because harsh winters prevent the use of engineered wetland during winter months.

But in countries like India the efficiency is activated because of the favorable climatic conditions. Biologically driven systems have activity in hot temperatures and drought also. .The use of constructed wetlands to control the water pollution due to municipal wastewater is considered to be technologically, economically and environmentally acceptable. The need for this new technology exists because current approaches are too expensive.

REFERANCES

Bastian RK and Hammer DA (1993). The use of constructed wetlands for wastewater treatment and recycling. In: *Constructed Wetlands for Water Quality Improvement*, edited by Moshiri GA (Lewis Publishers) Ann Arbor 59–68.

Belmont MA, Cantellano E, Thompson S, Williamson M, S´anchez A and Metcalfe CD (2004). Treatment of domestic wastewater in a pilot-scale natural treatment system in central Mexico. *Ecological Engineering* **23** 299–311.

Cameron K, Madramootoo C, Crolla A and Kinsley C (2003). Pollutant removal from municipal sewage lagoon effluents with a free-surface wetland. *Water Research* **37** 2803-2812.

Collins BS, Sharitz RR and Coughlin DP (2005). Elemental composition of native wetland plants in constructed mesocosm treatment wetlands. *Bioresource Technology* **96**(8) 937-948.

CPCB (2013). Performance evalution of swevage treatment plants under NRCD.

Crites R and Tchobanoglous G (1998). *Small and Decentralized Wastewater Management Systems* (McGraw-Hill) Boston.

Debusk AT, Laughlin RB and Schwartz LN (1996). Retention and Compartmentalization of Lead and Cadmium in Wetland Microcosms. *Water Research* **30**(11) 2707-2716.

EPA US (1999). *Constructed Wetlands Treatment of Municipal Wastewaters* **165**.

Greenway M and Simpson JS (1996). Artificial wetlands for waste water treatment, water reuse and wild life in Queensland, Australia. *Water Science and Technology* **33**(10-11) 221-229.

Greenway M and Simpson JS (1997a). Nutrient content of wetland plants in constructed wetlands receiving municipal effluent in tropical Australia. *Water Science and Technology* **35**(5) 135-142.

Greenway M and Simpson JS (1997b). Suitability of aquatic macrophytes for constructed wetlands receiving sewage effluent in Queensland, Australia. In: *BNR 3 conference on "AAWQ and AWWA*", Brisbane 1-9.

Healy M and Cawley AM (2002). Nutrient processing capacity of a constructed wetland in western Ireland. *Journal of Environmental Quality* **31** 1739-1747.

Hellier WW, Giovannitti EF and Stack PT (1994). Best Professional Judgment Analysis for Constructed Wetland as a Best Available Technology for the Treatment of Post-Mining Groundwater Seeps. *In the Proceedings of International Conference on the Abatement of Acidic Drainage, Pittsburgh, PA* 60-69.

ITRC (2003). Technical and regulatory guidance document for constructed treatment.

Knight RL, Payne Jr VWE, Borer RE, Clarke Jr RA and Pries JH (2000). Constructed wetlands for livestock wastewater management. *Ecological Engineering* **15**(1-2) 41-55.

Kowalik PJ, Mierzejewski M, Randerson PF and Williams HG (2004). Performance of Subsurface Vertical Flow Constructed Wetlands Receiving Municipal Wastewater. *Archives of Hydro-Engineering and Environmental Mechanics* **51**(4) 349–370.

Mander U and Mauring T (1997). Constructed wetlands for wastewater treatment in Estonia. *Water Science and Technology* **35**(5) 323-330.

Reilly JF, Horne AJ and Miller CD (1999). Nitrogen removal in large-scale free-surface constructed wetlands used for pre-treatment to artificial recharge of groundwater. *Ecological Engineering* **14**(1–2) 33-47.

Reilly JF, Horne AJ and Miller CD (2000). Nitrate removal from a drinking water supply with large free-surface constructed wetlands prior to groundwater recharge. *Ecological Engineering* **14** 33-47.

Singh AK (2003). Water resources and their availability. Proceedings of the National Symposium on Emerging Trends in Agricultural Physics, April 22-24, 2003, *Indian Society of Agrophysics* 18-29.

Song Z, Zheng Z, Li J, Sun X, Han X, Wang W and Xu M (2006). Seasonal and annual performance of a full-scale constructed wetland system for sewage treatment in China. *Ecological Engineering* **26** 272-282.

Spieles DJ and Mitsch WJ (2000). The effects of season and hydrologic and chemical loading on nitrate retention in constructed wetlands: A comparison of low- and high-nutrient riverine system. *Ecological Engineering* **14** 77-91.

Stikker A (1998). Water today and tomorrow. *Futures* **30** 43–62.

Stone KC, Poach ME, Hunt PG and Reddy GB (2004). Marsh-pond-marsh constructed wetland design analysis for swine lagoon wastewater treatment. *Ecological Engineering* **23** 127–133.

Vymazal J (2002). Constructed wetlands for wastewater treatment in the Czech Republic the first year's experience. *Water Science and Technology* **34**(11) 159–164.