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ijirset@gmail.com



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# Natural Treatment of Wastewater Using Constructed Wetlands

Dr.Arif Khan<sup>1</sup>, Atul B. Bondre<sup>2</sup>

Registrar, National Institute of Technology Raipur, Raipur, Chattishgarh, India<sup>1</sup>

PG Student (M.Tech Environmental Engineering), Department of Civil Engineering, Nuva College of Engineering & Technology, Kalmeshwar, Nagpur, Maharashtra, India<sup>2</sup>

**ABSTRACT:** Soil biotechnology (SBT) is a green engineering approach for wastewater treatment and recycling. In the present study institutional waste water characterization has been performed followed by the design of Soil Biotechnology plant. Water is a very versatile resource and hence it is used for numerous domestic as well as industrial purposes. As water is a free resource and 70% of earth's surface is covered in water, Man has used it rapidly subsequently contaminating it with domestic as well as industrial wastes. Now, as we understand the importance of water and how we are contaminating it, we know that there is a need to reuse the water again and again so as to ease the pressure on the fresh water available on earth's surface. To reuse the contaminated water, it has to be treated so that the harmful impurities can be separated and removed. Depending upon the quality of waste water, volume of water to be treated and the use of the treated water, number of processes have been developed and implemented. One of such process is known as Soil Bio Technology which is a green technology wherein there is a minimum use of power for treatment without compromising the quality of treated water. The waste water is first passed through tube settlers and then through Tanks known as Bio-Reactors which are filled with Aggregates, Brick Bats and Bio Media (earthworms). Waste water flows through this layers which acts as filters by gravity and is treated through a natural and harmless process. This process has number of benefits over the conventional processes but also has its own limitations. Soil biotechnology (SBT) is a modern technology to treat the wastewater effectively, less costly, eco-friendly which uses the granular media like soil, gravels and sand, biological media like earthworms, bacteria and plants. This technology is useful where there is no sewer transportation is available. In this paper analysis of the domestic wastewater and treated water is being done by IS: 3025 methods and the parameters are pH, TDS, TSS, BOD, COD and Ammonical, Nitrogen.

**KEYWORDS:** Soil Biotechnology (SBT), Sewage, Earthworms, BOD, COD, TDS, TSS

## I. INTRODUCTION

### 1.1 GENERAL

Globally, most of the developing countries are geographically located in those parts of the world that are or will face water shortages in the near future. Moreover, the existing water sources are contaminated because untreated sewage and industrial wastewater is discharged into surface waters resulting in impairment of water quality. The treatment of wastewater using Constructed Wetland (CW) is one of the suitable treatment systems, used in many parts of the world. Wetlands are defined as land where the water surface is near the ground surface long enough each year to maintain saturated soil conditions, along with the related vegetation. Marshes, bogs, and swamps are all examples of naturally occurring wetlands.

A "constructed wetland" is defined as a wetland specifically constructed for the purpose of pollution control and waste management, at a location other than existing natural wetlands. Wetlands can be used for primary, secondary, and tertiary treatments of domestic wastewater, storm wastewater, combined sewer overflows (CSF), overland runoff, and industrial wastewater such as landfill leachate and petrochemical industries wastewater. The most common systems are designed with horizontal subsurface flow (HF CWs) but vertical flow (VF CWs) systems are getting more popular at present. The most commonly used species are robust species of emergent plants, such as the common reed, cattail and bulrush.

In this paper the inlet and outlet wastewater physico-chemical parameters were analysed during the retention period. The parameters studied were pH, BOD, COD, DO, Total Suspended Solids, Total Dissolved Solids, Nitrogen

and Phosphorus. The percentage removal of the parameters were analysed and studied until the percent removal rate gets stabilized.

## 1.2 ADVANTAGES OF CONSTRUCTED WETLANDS

- Wetlands can be less expensive to build than other treatment options
- Utilization of natural processes,
- Simple construction (can be constructed with local materials),
- Simple operation and maintenance,
- cost effectiveness (low construction and operation costs),
- Process stability.
- Low energy demand.
- Low environmental impact

## 1.3 LIMITATIONS OF CONSTRUCTED WETLANDS

- large area requirement
- wetland treatment may be economical relative to other options only where land is available and affordable.
- Design criteria have yet to be developed for different types of wastewater and climates.

## 1.4 NATURAL WETLANDS VS. CONSTRUCTED WETLANDS

A natural wetland is an area of ground that is saturated with water, at least periodically. Plants that grow in wetlands, which are often called wetland plants or saprophyte, have to be capable of adapting to the growth in saturated soil.

Constructed wetlands, in contrast to natural wetlands, are man-made systems or engineered wetlands that are designed, built and operated to emulate functions of natural wetlands for human desires and needs. Engineered to control substrate, vegetation, hydrology and configuration. It is created from a non-wetland ecosystem or a former terrestrial environment, mainly for the purpose of contaminant or pollutant removal from wastewater (Hammer). These constructed wastewater treatments may include swamps and marshes. Most of the constructed wetland systems are marshes. Marshes are shallow water regions dominated by emergent herbaceous vegetation including cattails, bulrushes, and reeds.

## II. LITERATURE REVIEW

**ATIF MUSTAFA (2013)** conducted treatment performance of a pilot-scale constructed wetland (CW) commissioned in Karachi, NED University of Engineering & Technology, was evaluated for removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), ammonia-nitrogen ( $\text{NH}_4\text{-N}$ ), ortho-phosphate ( $\text{PO}_4\text{-P}$ ), total coliforms (TC) and faecal coliforms (FC) from pretreated domestic wastewater. Monitoring of wetland influent and effluent was carried out for a period of 8 months. NED wastewater treatment plant (WWTP) treats wastewater from campus and staff colony. The wastewater contains domestic sewage and low flows from laboratories of various university departments. The constructed wetland is planted with common wetland plant (*Phragmites karka*). The key features of this CW are horizontal surface flow. Treatment effectiveness was evaluated which indicated good mean removal efficiencies; BOD (50%), COD (44%), TSS (78%),  $\text{NH}_4\text{-N}$  (49%),  $\text{PO}_4\text{-P}$  (52%), TC (93%) and FC (98%).

**YADAV and JADHAV (2011)** construct wetland unit combined with surface flow and planted with *Eichhornia crassipes* was built near Technology Department, Shivaji University, Kolhapur (Latitude 16° 40' N, Longitude 74° 15' S). Maharashtra situated in Western part of India. The campus wastewater was let into the constructed wetland intermittently over 30 days. The study was performed in two sets A and B which were run in the months of December and January respectively. The parameters analysed for the study were pH, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Total Dissolved Solids, Nitrogen and Phosphorus. Only quality of wastewater was analysed during the study period of 2 months i.e. December and January. The sampling took place daily at both inlet and outlet of constructed wetland system. Treatment effectiveness was evaluated which indicated good mean removal efficiencies; BOD (95%), COD (97%), TSS (82%),  $\text{NH}_4\text{-N}$  (43%),  $\text{PO}_4\text{-P}$  (49%).



### III. WETLAND CONSTRUCTION

Wetlands, either constructed or natural, offer a cheaper and low-cost alternative technology for wastewater treatment. A constructed wetland system that is specifically engineered for water quality improvement as a primary purpose is termed as a 'Constructed Wetland Treatment System' (CWTS). In the past, many such systems were constructed to treat low volumes of wastewater loaded with easily degradable organic matter for isolated populations in urban areas. However, widespread demand for improved receiving water quality, and water reclamation and reuse is currently the driving force for the implementation of CWTS all over the world. The ability of wetlands to transform and store organic matter and nutrients has resulted in a widespread use of wetland for wastewater treatment worldwide.

Recent concerns over wetland losses have generated a need for the creation of wetlands, which are intended to emulate the functions and values of natural wetlands that have been destroyed. Natural characteristics are applied to CWTS with emergent macrophyte stands that duplicate the physical, chemical and biological processes of natural wetland systems. The number of CWTS in use has very much increased in the past few years. The use of constructed wetlands in the United States, New Zealand and Australia is gaining rapid interest. Most of these systems cater for tertiary treatment from towns and cities. They are larger in size, usually using surface-flow system to remove low concentration of nutrient (N and P) and suspended solids. However, in European countries, these constructed wetland treatment systems are usually used to provide secondary treatment of domestic sewage for village populations. These constructed wetland systems have been seen as an economically attractive, energy-efficient way of providing high standards of wastewater treatment.

Typically, wetlands are constructed for one or more of four primary purposes: creation of habitat to compensate for natural wetlands converted for agriculture and urban development, water quality improvement, flood control, and production of food and fiber (constructed aquaculture wetlands).

Constructed wetlands are based upon the symbiotic relationship between the micro organisms and pollutants in the wastewater. These systems have potential to treat variety of wastewater by removing organics, suspended solids, pathogens, nutrients and heavy Metals.

A constructed wetland is a shallow basin filled with some sort of filter material (substrate), usually sand or gravel, and planted with vegetation tolerant of saturated conditions. Wastewater is introduced into the basin and flows over the surface or through the substrate, and is discharged out of the basin through a structure which controls the depth of the wastewater in the wetland. A constructed wetland comprises of the following five major components:

- Basin
- Substrate
- Vegetation
- Liner
- Inlet/Outlet arrangement system

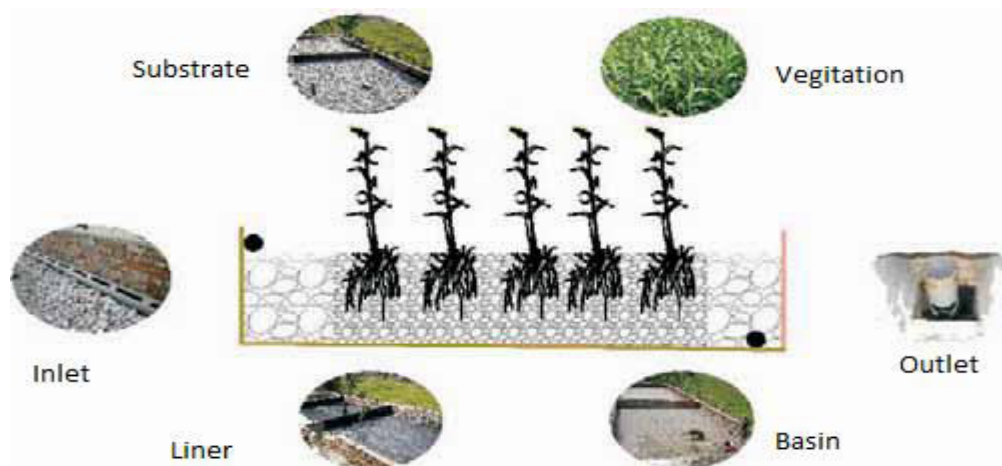


Fig 3.1 Components of constructed wetland(UN-HABITAT, 2008.)

### Basin

Systems have been designed with bed slopes of as much 8 percent to achieve the hydraulic gradient. Newer systems have used a flat bottom or slight slope and have employed an adjustable outlet to achieve the hydraulic gradient.

### Substrate

Many different media sizes have been tried for the bed, but gravel less than 4 cm diameter seems to work best. Larger diameters increase the flow rate, but result in turbulent flow. Smaller media gives a reduced hydraulic conductivity, but has the advantage of more surface area for microbial activity and adsorption. Soil is sometimes used to remove certain materials due to the ability of reactive clays to adsorb heavy metals, phosphates, etc..

### Vegetation

Three types of plants are normally used

- Cattails, which are a favorite food of muskrats and nutria.
- Bulrush is also high on the mammals food list, but they should not be attracted to the wetland if the water surface is kept below the media.
- Reeds are used most often in Europe because they are not a food source for animals. However, they are not allowed in some areas due to their tendency to spread and push out native vegetation.

The type used will also depend on the local climate and the substances to be removed. In some instances decorative plants are used, but results show them to be less effective and require more maintenance. Control of the water level can be used to increase root penetration and control weeds.

### Liner

The liner goes under the entire system and can be a manufactured liner or clay. This prevents the wastewater from infiltrating into the ground before it is treated. A berm around the system prevents runoff from entering the system.

### Inlet

The inlet can be a manifold pipe arrangement, an open trench perpendicular to the flow, or weir box. The manifold arrangement can be a pipe with several valve outlets or a simple perforated pipe. Coarse gravel allows rapid infiltration of the water. The inlet purpose is to spread the wastewater evenly across the treatment bed for effective treatment.

### Outlet

The outlet structures used are similar to the inlet structures. One preferred addition is making the outlet adjustable to allow the control of water level. The level could be lowered when a large amount of rainfall is expected or raised for maximum cross-sectional use of the media.

## IV. WETLANDS PLANTS

The larger aquatic plants growing in wetlands are usually called macrophytes. The term includes aquatic vascular plants (angiosperms and ferns), aquatic mosses, and some larger algae that have tissues that are easily visible. Although ferns like *Salvinia* and *Azolla* and large algae like *Cladophora* are widespread in wetlands, it is usually the flowering plants (i.e. angiosperms) that dominate. Macrophytes, like all other photoautotrophic organisms, use the solar energy to assimilate inorganic carbon from the atmosphere to produce organic matter, which subsequently provides the energy source for heterotrophs (animals, bacteria and fungi). As a result of the ample light, water and nutrient supply in wetlands, the primary productivity of ecosystems dominated by wetland plants are among the highest recorded in the world. Associated with this high productivity is usually a high heterotrophic activity, i.e. a high capacity to decompose and transform organic matters and other substances.

The presence or absence of aquatic macrophytes is one of the characteristics used to define wetlands, and as such macrophytes are an indispensable component of these ecosystems. In spite of the fact that the most important removal processes in constructed treatment wetlands are based on physical and microbial processes, the macrophytes possess several functions in relation to the water treatment.

Vegetation and its litter are necessary for successful performance of constructed wetlands and contribute aesthetically to the appearance. The vegetation to be planted in constructed wetlands should fulfill the following criteria:

- Application of locally dominating macrophyte species;
- Deep root penetration, strong rhizomes and massive fibrous root;
- Considerable biomass or stem densities to achieve maximum translocation of water and

assimilation of nutrients;

- Maximum surface area for microbial populations;
- Efficient oxygen transport into root zone to facilitate oxidation of reduced toxic metals and support a large rhizosphere.

Two species, *Phragmites* sp. and *Typha* sp., widely used vegetation in constructed wetlands. *Phragmites* sp. and *P. australis* (Common Reed) is one of the most productive, wide spread and variable wetland species in the world. Due to its climatic tolerance and rapid growth, it is the predominant species used in constructed wetland.



Fig 4.1 *Phragmites* sp. (common reed)

#### 4.1 SELECTION OF WETLAND PLANTS

Floating and submerged plants are used in an aquatic plant treatment system. A range of aquatic plants have shown their ability to assist in the breakdown of wastewater. The Water Hyacinth (*Eichhornia crassipes*), and Duckweed (*Lemna*) are common floating aquatic plants which have shown their ability to reduce concentrations of BOD, TSS and Total Phosphorus and Total Nitrogen. However prolonged presence of *Eichhornia crassipes* and *Lemna* can lead to deterioration of the water quality unless these plants are manually removed on a regular basis. These floating plants will produce a massive mat that will obstruct light penetration to the lower layer of the water column that will affect the survival of living water organisms. This system is colonised rapidly with one or only a few initial individuals. The system needs to be closely monitored to prevent attack from these nuisance species. Loss of plant cover will impair the treatment effectiveness. Maintenance cost of a floating plant system is high. Plant biomass should be regularly harvested to ensure significant nutrient removal. Plant growth also needs to be maintained at an optimum rate to maintain treatment efficiency.

**Fig 4.2 The Water Hyacinth *Eichhornia crassipes*****Fig 4.3 The Common Reed *Phragmites karka***

The Common Reed (*Phragmites* spp.) and Cattail (*Typha* spp.) are good examples of emergent species used in constructed wetland treatment systems. Plant selection is quite similar for SF and SSF constructed wetlands. Emergent wetland plants grow best in both systems. These emergent plants play a vital role in the removal and retention of nutrients in a constructed wetland. Although emergent macrophytes are less efficient at lowering Nitrogen and Phosphorus contents by direct uptake due to their lower growth rates (compared to floating and submerged plants), their ability to uptake Nitrogen and Phosphorus from sediment sources through rhizomes is higher than from the water.

## 4.2 EXAMPLES OF WETLAND PLANTS

There is a variety of marsh vegetation that is suitable for planting in a CWTS (see Table 4.1). These marsh species could be divided into deep and shallow marshes.

Table 4.1: List of emergent wetland plants used in constructed wetland treatment systems (Lim *et al.* 1998)

Planting zones	Common name	Scientific name
Marsh and deep marsh (0.3-1.0m)	Common Reed	<i>Phragmites karka</i>
	Spike rush	<i>Eleocharis dulcis</i>
	Greater Club Rush	<i>Scirpus grossus</i>
	Bog Bulrush	<i>Scirpus mucronatus</i>
	Tube Sedge	<i>Lepironia articulata</i>
	Fan Grass	<i>Phylidrium lanuginosum</i>
	Cattail	<i>Typha angustifolia</i>
Shallow marsh (0-0.3m)	Golden Beak Sedge	<i>Rhynchospora corbosa</i>
	Spike rush	<i>Eleocharis variegata</i>

	Sumatran Scieria	<i>Scieria Sumatran</i>
	Globular Fimbristylis	<i>Fimbristylis globulosa</i>
	Knot Grass	<i>Polygonum barbatum</i>
	Asiatic Pipewort	<i>Eriocaulon longifolium</i>

## ROLE OF PLANTS-

The main role of the aquatic plants (please be sure to select only aquatic plants because of the always water saturated environment that is a fundamental aspect in constructed wetlands) is to act as catalyzers in the purification process. This process, as seen before, is a combination of microbiological, chemical and physical processes. The plants haven't a significant action as direct removal (for some substances, like N and P or organic matter, we can talk of a contribution in the order of 10-20% during the vegetative season); they offer instead a very efficient support for the growth of aerobic bacteria colonies on their rhizomes. Air is pumped towards the root zone by several mechanisms, like convection. Another important plant's function is the maintenance and continuous re-establishment of the hydraulic conductivity inside the beds. Amongst all macrophytes, *Phragmites australis* or *communis* is the most used worldwide for its optimal performances, for its ability in developing deep roots (0.5-0.7 m), for its resistance to aggressive wastewaters and to diseases.

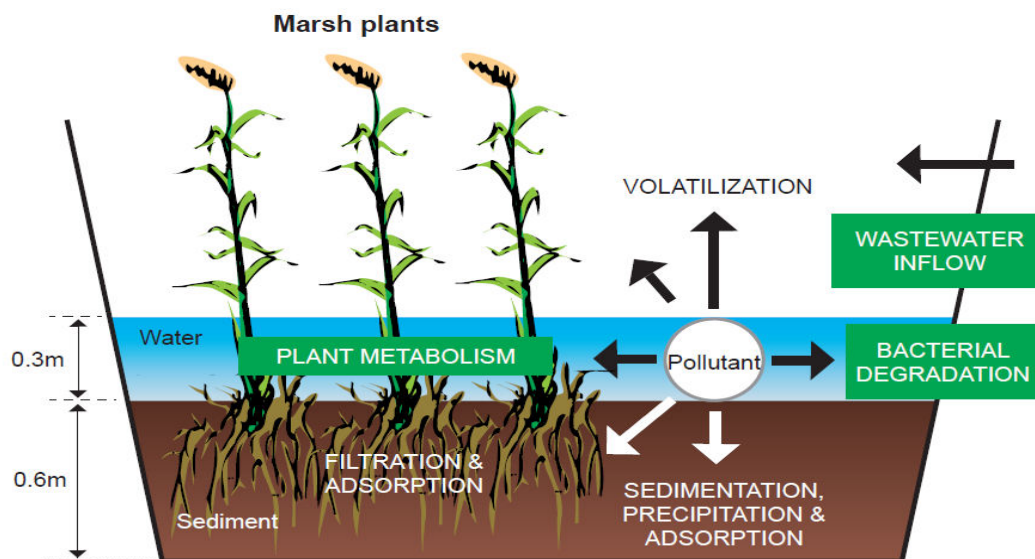
**Table 4.2 Role of plants (Brix, 1997)**

Macrophyte property	Role in treatment process
Aerial plant tissue	<ul style="list-style-type: none"> <li>• Light attenuation – reduced growth of phytoplankton</li> <li>• Reduced wind velocity – reduced risk resuspension</li> <li>• Aesthetic pleasing appearance of system</li> <li>• Storage of nutrients</li> </ul>
Plant tissue in water	<ul style="list-style-type: none"> <li>• Filtering effect-filter out large debris</li> <li>• Reduced current velocity – Increase rate of sedimentation, reduced risk of suspension</li> <li>• Provide surface area for attached biofilms</li> <li>• Excretion of photosynthetic oxygen – Increases aerobic degradation</li> <li>• Uptake of nutrients</li> </ul>
Roots and rhizomes in the sediment	<ul style="list-style-type: none"> <li>• Stabilizing the sediment surface-less erosion</li> <li>• Prevents the medium from clogging in VFS</li> <li>• Release of oxygen increase degradation(nitrification)</li> <li>• Uptake of nutrients</li> </ul>

## V. REMOVAL MECHANISMS

A constructed wetland is a complex assemblage of wastewater, substrate, vegetation and an array of microorganisms (most importantly bacteria). Vegetation plays a vital role in the wetlands as they provide surfaces and a suitable environment for microbial growth and filtration. Pollutants are removed within the wetlands by several complex physical (sedimentation, filtration, adsorption and volatilisation) chemical (precipitation, adsorption hydrolysis, oxidation/reduction) and biological (bacterial metabolism, plant metabolism, plant absorption, natural die-off) processes as depicted in Fig 5.1





**Fig 5.1 The pollutant removal mechanisms in constructed wetland (modified from Wetlands International, 2003)**

Settleable and suspended solids that are not removed in the primary treatment are effectively removed in the wetland by filtration and sedimentation. Particles settle into stagnant micro pockets or are strained by flow constrictions. Attached and suspended microbial growth is responsible for the removal of soluble organic compounds, which are degraded biologically both aerobically (in presence of dissolved oxygen) as well as anaerobically (in absence of dissolved oxygen). The oxygen required for aerobic degradation is supplied directly from the atmosphere by diffusion or oxygen leakage from the vegetation roots into the rhizosphere, however, the oxygen transfer from the roots is negligible (Figure 5.1).

**Table 5.1 the pollutant removal mechanism in constructed wetland**

Waste water constituents	Removal mechanism
Suspended solids	<ul style="list-style-type: none"> <li>• Sedimentation</li> <li>• filtration</li> </ul>
Soluble organics	<ul style="list-style-type: none"> <li>• Aerobic microbial degradation</li> <li>• Anaerobic microbial degradation</li> </ul>
Phosphorus	<ul style="list-style-type: none"> <li>• Matrix sorption</li> <li>• Plant uptake</li> </ul>
Nitrogen	<ul style="list-style-type: none"> <li>• Ammonification followed by microbial nitrification</li> <li>• Denitrification</li> <li>• Plant uptake</li> <li>• Matrix adsorption</li> <li>• Ammonia volatilization( mostly in SF system)</li> </ul>
Metals	<ul style="list-style-type: none"> <li>• Adsorption and cation exchange</li> <li>• Complexation</li> <li>• Precipitation</li> <li>• Plant uptake</li> <li>• Microbial oxidation/ reduction</li> </ul>
Pathogens	<ul style="list-style-type: none"> <li>• Sedimentation</li> <li>• Filtration</li> <li>• Natural die-off</li> <li>• Predation</li> </ul>

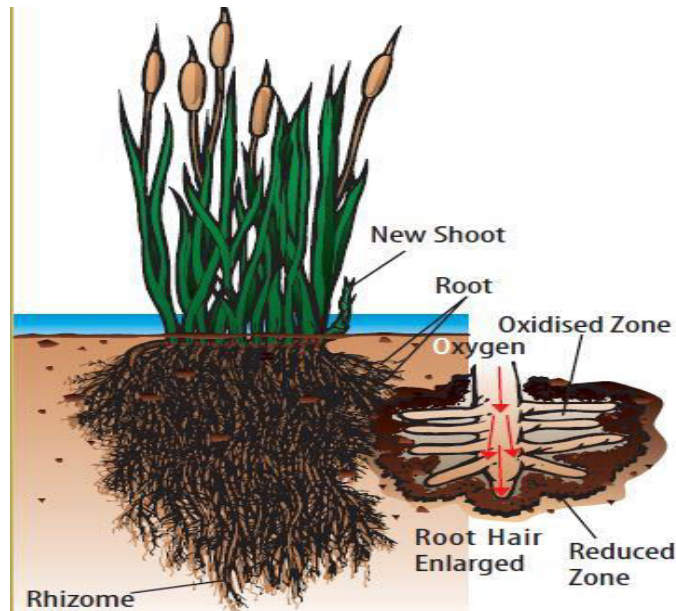


Fig 5.2 Oxygen transfer from roots(modified from Wetlands International, 2003)

### 5.1 NITROGEN REMOVAL MECHANISMS

There are sufficient studies to indicate some roles being played by wetland plants in Nitrogen removal but the significance of plant uptake vis-à-vis nitrification/denitrification is still being questioned. Nitrogen (N) can exist in various forms, namely Ammoniacal Nitrogen ( $\text{NH}_3$  and  $\text{NH}_4^+$ ), organic Nitrogen and oxidised Nitrogen ( $\text{NO}_2^-$  and  $\text{NO}_3^-$ ). The removal of Nitrogen is achieved through nitrification/denitrification, volatilisation of Ammonia ( $\text{NH}_3$ ) storage in detritus and sediment, and uptake by wetland plants and storage in plant biomass (Brix, 1993). A majority of Nitrogen removal occurs through either plant uptake or denitrification. Nitrogen uptake is significant if plants are harvested and biomass is removed from the system.

At the root-soil interface, atmospheric oxygen diffuses into the rhizosphere through the leaves, stems, rhizomes and roots of the wetland plants thus creating an aerobic layer similar to those that exists in the media-water or media-air interface. Nitrogen transformation takes place in the oxidised and reduced layers of media, the root-media interface and the below ground portion of the emergent plants. Ammonification takes place where Organic N is mineralised to  $\text{NH}_4^+\text{-N}$  in both oxidised and reduced layers. The oxidised layer and the submerged portions of plants are important sites for nitrification in which Ammoniacal Nitrogen (AN) is converted to nitrite N ( $\text{NO}_2\text{-N}$ ) by the *Nitrosomonas* bacteria and eventually to nitrate N ( $\text{NO}_3\text{-N}$ ) by the *Nitrobacter* bacteria which is either taken up by the plants or diffuses into the reduced zone where it is converted to  $\text{N}_2$  and  $\text{N}_2\text{O}$  by the denitrification process.

Denitrification is the permanent removal of Nitrogen from the system; however the process is limited by a number of factors, such as temperature, pH, redox potential, carbon availability and nitrate availability. The annual denitrification rate of a surface-flow wetland could be determined using a Nitrogen mass-balance approach, accounting for measured influx and efflux of Nitrogen, measured uptake of Nitrogen by plants, and sediment, and estimated  $\text{NH}_3$  volatilisation.

The extent of Nitrogen removal depends on the design of the system and the form and amount of Nitrogen present in the wastewater. If influent Nitrogen content is low, wetland plants will compete directly with nitrifying and denitrifying bacteria for  $\text{NH}_4^+$  and  $\text{NO}_3^-$ , while in high Nitrogen content, particularly Ammonia, this will stimulate nitrifying and denitrifying activity.

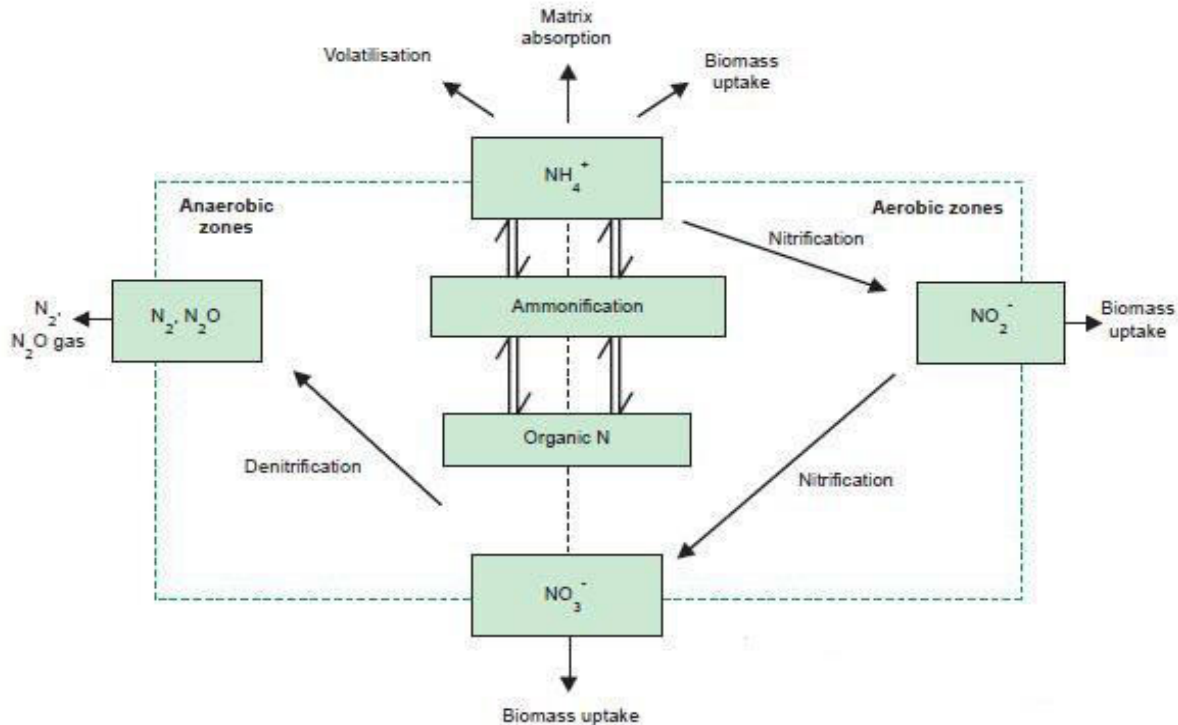


Figure 5.3: Nitrogen transformations in a constructed wetland treatment system (Cooper *et al.*1996)

## 5.2 PHOSPHORUS REMOVAL MECHANISMS

Phosphorus is present in wastewaters as Orthophosphate, Dehydrated Orthophosphate (Polyphosphate) and Organic Phosphorus. The conversion of most Phosphorus to the Orthophosphate forms ( $\text{H}_2\text{PO}_4^-$ ,  $\text{PO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ) is caused by biological oxidation. Most of the Phosphorus component may fix within the soil media. Phosphate removal is achieved by physical-chemical processes, by adsorption, complexation and precipitation reactions involving Calcium (Ca), Iron (Fe) and Aluminium (Al). The capacity of wetland systems to absorb Phosphorus is positively correlated with the sediment concentration of extractable Amorphous Aluminum and Iron (Fe). Although plant uptake may be substantial, the sorption of Phosphorus (Orthophosphate P) by anaerobic reducing sediments appears to be the most important process. The removal of Phosphorus is more dependent on biomass uptake in constructed wetland systems with subsequent harvesting.

## 5.3 BOD<sub>5</sub> REMOVAL

The physical removal of BOD<sub>5</sub> is believed to occur rapidly through settling and entrapment of particulate matter in the void spaces in the gravel or rock media. Soluble BOD<sub>5</sub> is removed by the microbial growth on the media surfaces and attached to the plant roots and rhizomes penetrating the bed. Some oxygen is believed to be available at microsites on the surfaces of the plant roots, but the remainder of the bed can be expected to be anaerobic.

## 5.4 PLANT UPTAKE

Nitrogen will be taken up by macrophytes in a mineralised state and incorporated it into plant biomass. Accumulated Nitrogen is released into the system during a die-back period. Plant uptake is not a measure of net removal. This is because dead plant biomass will decompose to detritus and litter in the life cycle, and some of this Nitrogen will leach and be released into the sediment. Johnston (1991) shows only 26-55% of annual N and P uptake is retained in above-ground tissue, the balance is lost to leaching and litter fall.

## 5.5 METALS

Metals such as Zinc and Copper occur in soluble or particulate associated forms and the distribution in these forms are determined by physico-chemical processes such as adsorption, precipitation, complexation, sedimentation,

erosion and diffusion. Metals accumulate in a bed matrix through adsorption and complexation with organic material. Metals are also reduced through direct uptake by wetland plants. However over-accumulation may kill the plants.

## 5.6 PATHOGENS

Pathogens are removed mainly by sedimentation, filtration and absorption by biomass and by natural die-off and predation.

## 5.7 OTHER POLLUTANT REMOVAL MECHANISMS

Evapotranspiration is one of the mechanisms for pollutant removal. Atmospheric water losses from a wetland that occurs from the water and soil is termed as evaporation and from emergent portions of plants is termed as transpiration. The combination of both processes is termed as evapotranspiration. Daily transpiration is positively related to mineral adsorption and daily transpiration could be used as an index of the water purification capability of plants. Precipitation and evapotranspiration influence the water flow through a wetland system. Evapotranspiration slows water flow and increases contact times, whereas rainfall, which has the opposite effect, will cause dilution and increased flow.

Precipitation and evaporation are likely to have minimal effects on constructed wetlands in most areas. If the wetland type is primarily shallow open water, precipitation/evaporation ratios fairly approximate water balances. However, in large, dense stands of tall plants, transpiration losses from photosynthetically active plants become significant.



**Fig 5.4 Experimental studies continue to be carried out in Florida and many other parts of the country as well as overseas to evaluate the performance of a variety of constructed wetlands systems.( United States EPA(2003)**

## VI. CONCLUSION

It is noted that CWs are now being increasingly used for environmental pollution control. Recent inventories have indicated that there are more than 7000 CWs in Europe and North America with the number increasing in Central and South America, Australia and New Zealand as well as Asia and Africa. Most of them are local soil/gravel based systems with either horizontal or vertical flow planted mostly with common reeds (*phragmitesaustralis*). Constructed wetlands were implemented in a wide range of applications, such as water quality improvement of polluted surface water bodies, wastewater on-site treatment and reuse in rural areas, campuses, recreational areas and green architectures, management of aquaculture water and wastewater, tertiary treatment, and miscellaneous applications.

Water monitoring results obtained from several demonstrations show that CWs could achieve acceptable wastewater treatment performances in removing major pollutants, including suspended solids, organic matters, nutrients, and indicating microorganisms, from wastewater influent. The results indicate that if constructed wetlands are appropriately designed and operated, they could be used for secondary and tertiary wastewater treatment under local conditions, successfully. Hence constructed wetlands can be used in the treatment train to upgrade the existing malfunctioning wastewater treatment plants, especially in developing countries. During hydraulic retention study, it was found that the BOD, COD was best removed in planted wetland than unplanted wetland. It is because of the oxygen diffusion from roots of the plants and the nutrient uptake and insulation of the bed surface. It is also found that the increases in the detention period of the wastewater the removal rate also increases.



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