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POTENTIAL OF CONSTRUCTED WETLANDS TO REDUCE AND ASSIMILATE TOTAL ORGANIC CARBON FROM MUNICIPAL WASTEWATERS

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ABSTRACT

Wetlands present an important opportunity for carbon sequestration and greenhouse gas offsets by virtue of their potential for restoration using known and innovative land management methods. Because inherently they are highly productive and accumulate large below-ground stocks of organic carbon, wetlands are major carbon sinks. While vegetation traps atmospheric CO_2 in wetlands and other ecosystems alike, the net-sink of wetlands is attributed to low decomposition rates in anaerobic soils. Carbon fluxes and pool sizes vary widely in different wetlands.

Recently, artificially created constructed wetlands to treat wastewater has been in common usage in Europe, USA and developed Asian countries for ecosystem-based ecotechnology. Thus, wastewater treatment and protecting these wetland ecosystems clearly represent an immediate and large opportunity for enhancing terrestrial carbon sequestration too. Experiments were conducted to measure the rate of photosynthesis in the key planted macrophytic plant species of the constructed wetland: the *Phragmites karka* (Reed grass, the local plant species) using the Li-Cor 6400. The uptake of carbon-di-oxide by the plants could be measured at different CO_2 levels in the atmosphere. It was found that the reed grass shows maximum photosynthesis at levels as high as 500 ppm of CO_2. Thus, it can prove ideal for plantation at industrial sites emitting higher concentration of CO_2, capable of treating the wastewater, thus purifying water as well as fixing CO_2 and thus purifying ambient air in the industrial campus. Further it was found that the constructed wetlands have a good capacity to maintain the organic stocks in its medium as well at the anchoring gravel medium and the floor. Present study focused on the 'subsurface flow constructed wetlands' that have a smaller water column around the anchoring gravel bed as compared to the natural systems. Hence they have a greater carbon sequestration potential when compared to the natural systems. Constructed wetlands are a wise option to treat industrial wastewaters efficiently when compared to the energy intensive conventional (engineering-based) treatment plants. Moreover they not only help to develop green belt around the industry but also serve to absorb the atmospheric carbon in a beneficial manner. The present study focuses on the carbon sequestration potential of two constructed wetlands.

Key Words: Subsurface flow constructed wetland, *Phragmites karka*, Carbon sequestration, BOD, COD, Microbial biomass

INTRODUCTION

Historical changes in the quasi–steady state of the carbon system are clearly reflected in ice core and isotopic records, which also record the unprecedented changes caused by anthropogenic CO_2 emissions (Raynaud et al. 2000). Global warming is amongst the most dreaded problems of the new millennium. Carbon emission is supposedly the strongest causal factor for global warming. So, increasing carbon emission is one of today's major concerns, which is well addressed in Kyoto Protocol (1997).

In brief, a constructed wetland is a water treatment facility. Duplicating the processes occurring in natural wetlands, constructed wetlands are complex, integrated systems in which water, plants, animals, micro organisms and the environment—sun, soil, air—interact to improve water quality. Whereas geology, hydrology and biology create natural wetlands, constructed wetlands are the result of human skill and technology. Humans design, build and operate constructed wetlands to treat wastewater. By utilizing, and even attempting to optimize the physical, chemical and biological processes of the natural wetland ecosystem, constructed wetlands also are, to various extents, natural environments. *In sum, there is a broad and growing consensus that wetlands are critically important ecosystems that provide globally significant social, economic and environmental benefits.*

The major factors affecting carbon cycling in wetlands are inputs, outputs, and storage capability. Inputs can occur as gas (photosynthesis, algae and macrophytes), solids (dust, water and soil erosion, and animal biomass), and dissolved substances (dissolved organic carbon, dissolved inorganic carbon). Outputs also occur in these three states: as gas through respiration (carbon dioxide, methane and nitrous oxide); as solids (e.g., harvesting of vegetation such as hay cropping); and as dissolved substances in water through surface and groundwater flow (dissolved organic carbon and dissolved inorganic carbon).

Subsurface flow constructed wetlands have a smaller water column when compared to the natural systems which has stagnant water and larger sediments. Hence they have a greater carbon sequestration potential when compared to the natural systems. Moreover they not only help to develop green belt around the industry but also serve to absorb the atmospheric carbon in a beneficial manner. Wetlands as ecology are more productive in biomass production than any other environment except the rain forests (Campbell and Odgen 1999). Since one of the treatment goals is to remove carbon from wastewater, passive treatment technologies such as constructed wetlands should be considered because they offer significant savings in atmospheric carbon. Conventional, energy intensive, wastewater treatment plants discharge four pounds of carbon into the air, generating the electricity to remove one pound of carbon from the wastewater.

Carbon Sequestration is defined as either the net removal of CO_2 from the atmosphere or the prevention of CO_2 net emissions from the terrestrial ecosystems into the atmosphere. There are two fundamental approaches to sequester carbon in terrestrial ecosystems: (1) protection of ecosystems that store carbon so that carbon stores can be maintained or increased; and (2) manipulation of ecosystems to increase carbon sequestration beyond current conditions.

MATERIALS AND METHODS

In the present study, sub-surface constructed wetlands at two sites were selected to study the carbon dynamics. Both the sites are geographically located in Ujjain city (23º 11´N latitude and 75º 43´ E longitude).

(1) Details of constructed wetland in Ravindra nagar (8 year old)

- Location: Ravindra Nagar , Ujjain
- Area:30 m length x 10m width = 300m^2
- Gravel Depth: 0.85 m
- Gravel Size: 0.8-2.5 cm
- Treatment capacity: 40 m^3/Day
- Water Retention capacity: 120 m^3
- Retention period: 3 days

(2) Details of constructed wetland on the Nala near Harijan thana (2yr. old Reed bed)

- Location: wastewater channel near the M.R.–11 road of Mahakal Commercial Area, Ujjain
- Dimension: (Length: 70m, Width: 15m, Depth: 0.60m, Effective surface area: 1050m^2)
- Retention Capacity: 221 m^3
- Lean treatment capacity: 75m^3 /day
- Retention time : Approx 3 Days
- Bed Lined with 0.05 mm LDPE
- Gravel Bed Depth:0.60 m
- Treated water collection: via PVC pipe (Dia 20 cm)
- Plantation : 2 Plants per m^2

Plants: The Constructed wetlands are grown with *Phragmites karka* (Reed grass), which is a perennial grass used to treat the wastewater entering the two Wetland sites, planted on the gravel bed. Besides, common reed roots reach deeper than any other hydrophyte (root depth up to 3 m) what helps the plant to take up water and first of all wetland nutrients (Kohzu et al. 2003). Field studies were carried out during December 2007 to December 2009.

Evaluation of the parameters: The water samples from the inlet and outlet regions and the bio-film rich gravel was evaluated seasonally for the different physico-chemical and the biological parameters. Water samples were collected from the inlet and outlet regions of each constructed wetland site and analysed in the laboratory for physico-chemical parameters such a **Dissolved Oxygen (**Winkler's Azide modification method), **COD**-(Open Reflux method), **BOD$_5$** (APHA 1992), **Total Organic Carbon** (Walkey and Black method). º%The gravel from the Reed bed was collected to analyse **Microbial Biomass** – (Fumigation method of Jenkinson and Powlson), Organic carbon (wet oxidation method). The **Plant Biomass** was calculated for the carbon content in the reed grass by gravimetric method (Harvest and dry wt.).

Seasonal loads and retention efficiencies for each parameter was examined. Retention efficiencies were calculated as the percent difference between input and output quarterly loads for each Constructed Wetland (Ravindra Nagar & the Nala at MR10).

RESULTS AND DISCUSSION

The results indicate that CWs trap a variety of constituents from the wastewaters. The CWs are particularly efficient at interacting and removing sediments, organic matter, total organic carbon, atmospheric carbon-dioxide, microbial carbon etc. Concentration of the constituents varied between years and between months.

The overall quarterly efficiency of TOC removal for both the years was recorded to be 29.67 % and 44.14 % respectively at Ravindra Nagar and Nala. The CW at Nala is showing a remarkably higher efficiency (Fig 1).

The TOC in Bf Gravel media at Ravindra Nagar was 3.94 % in 2008 and 3.98 % in 2009 simultaneously recording a quarterly average value of 3.96 % for both the years. Whereas the value of TOC in Bf Gravel at the Nala fluctuated widely during the 2 years of the study it was 5.85 % in 2008 and 1.99 % in 2009 amounting to a value of 3.92 % for both the years (quarterly average).

At the Nala the Bf gravel media had higher amount of TOC as compared to that at Ravindra nagar (Fig. 1)

Relationship between TOC and BOD_5 was drawn by plotting individual values percentage efficiency of both the CWs to remove BOD_5 against concurrent percentage efficiency of the CWs to remove TOC values. A significant positive correlation (pd"0.05) was noticed with r^2 value of 83.5% at Ravindra nagar and r^2 value of 40.9% at the Nala (Plot no: 1&2).

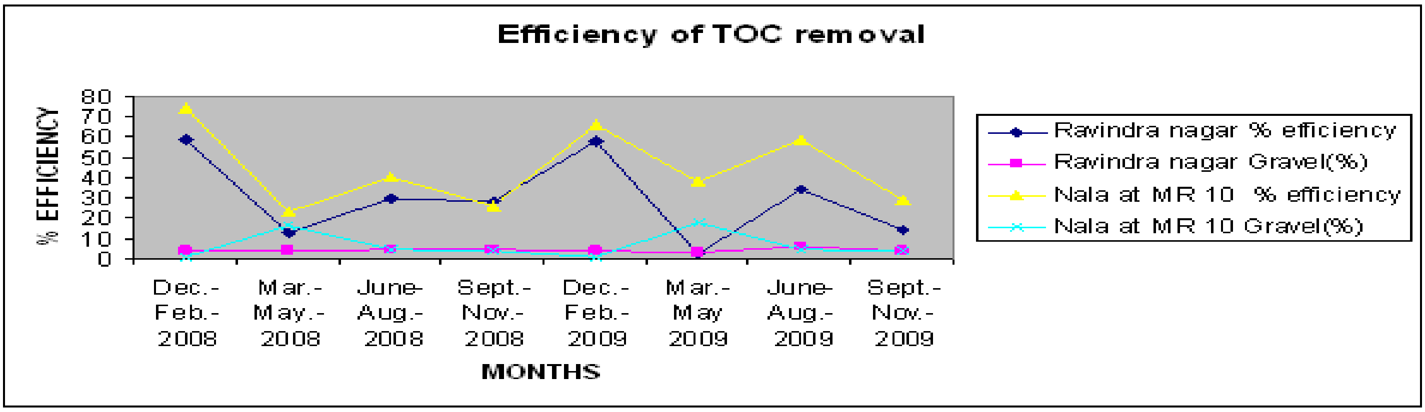
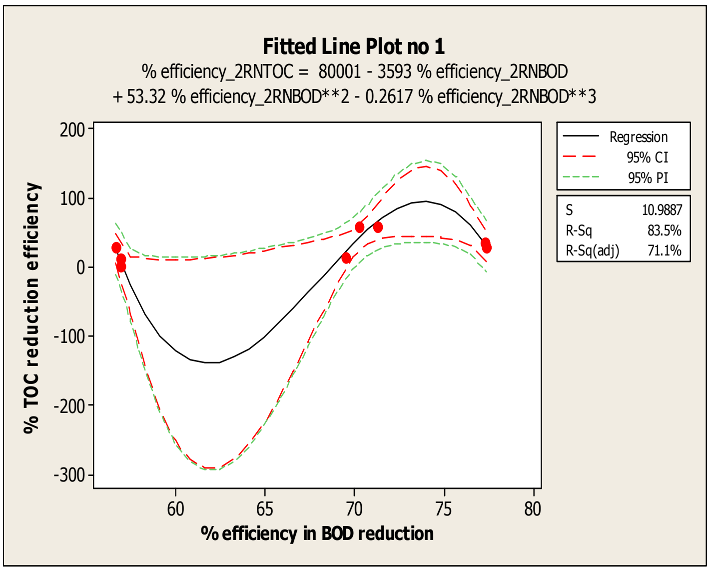
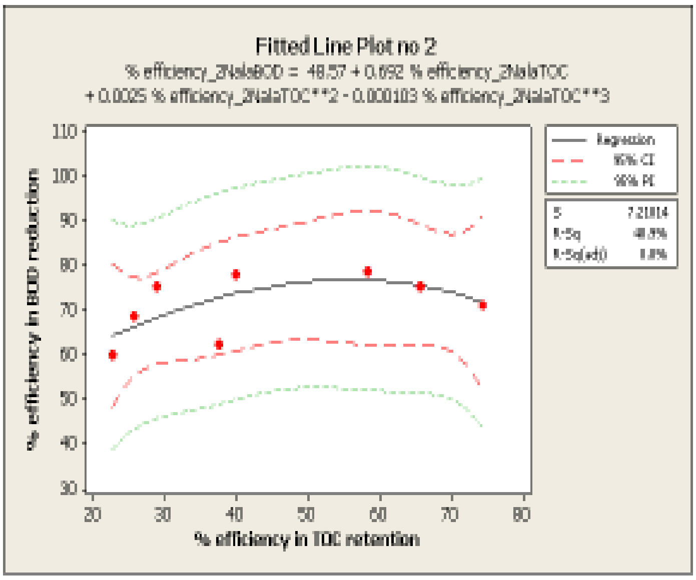


Fig 1. Comparison of the seasonal trends in retention of Total Organic Carbon(TOC) (%) from waste water and Bf gravel between the two CW sites measured from Dec 2007-Dec 2009.





Fitted line plot 1&2 exhibiting relationship between efficiency of BOD_5 reduction versus efficiency of TOC retention in the CW at Ravindra nagar (plot no1) and that at Nala (plot no 2) during the study period.

Total Carbon (TC)

The constructed wetland at Ravindra Nagar was found to exhibit a slightly higher total carbon sequestration capacity than that at the Nala region (Fig. 2).

OM in wastewater: The CW at Nala was observed to sequester or retain higher quantity of organic matter when compared to that at the Ravindra Nagar (Fig 3).

The average plant biomass carbon value studied during both the study years of 2008 & 2009 was 3334 g/m^2 oven dry wt. at Ravindra Nagar and 3814 g/m^2 oven dry wt. for the Nala region. The plant biomass at the Nala was observed to be slightly higher than that at Ravindra Nagar (Table 3, Fig. 4).

Ravindra nagar CW was found to exhibit a slightly higher value of microbial biomass carbon as compared to that at the Nala (Fig. 5).

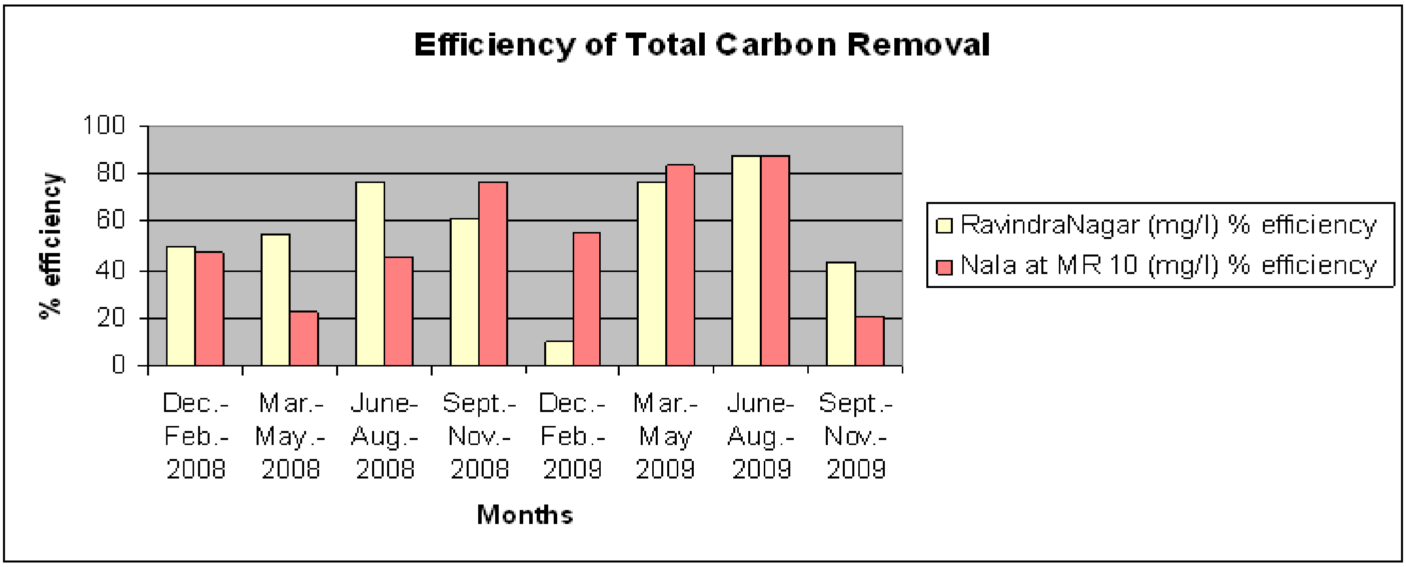


Fig. 2. Comparison of the seasonal retention of Total Carbon (TC) (mg/L) between the two CW sites measured from Dec 2007-Dec 2009.

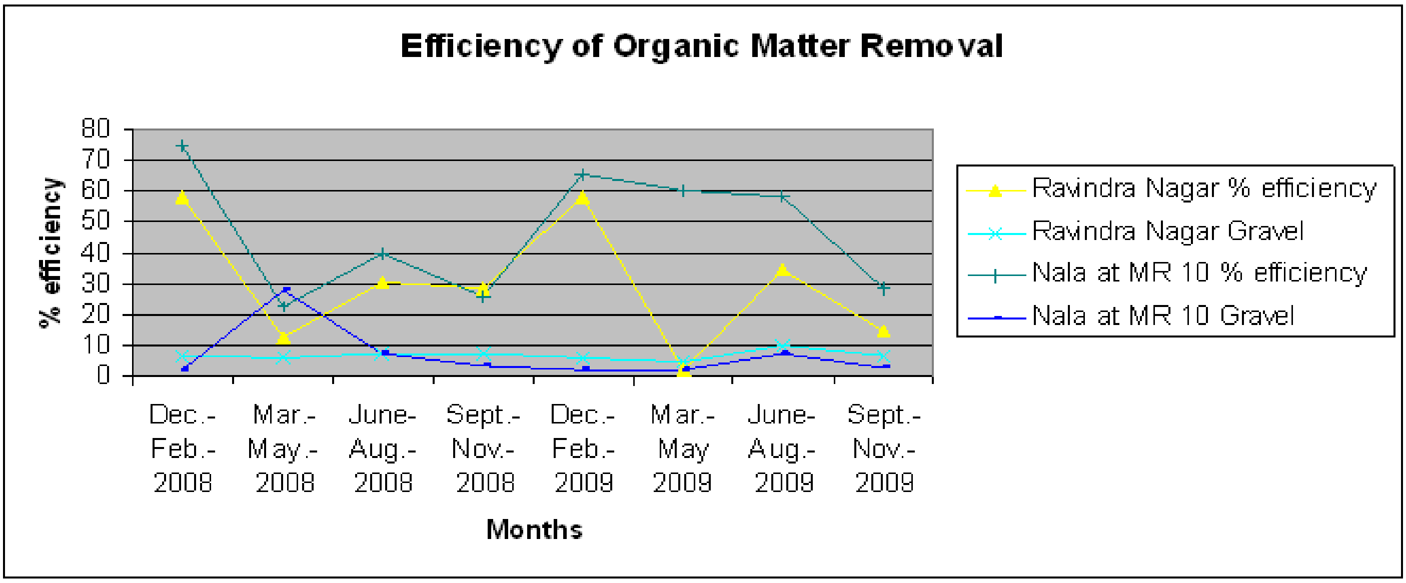


Fig.3. Comparison of the seasonal trends in the removal of Organic Matter (OM)(%) from the wastewater and the gravel between the two CW sites measured from Dec 2007- Dec 2009.

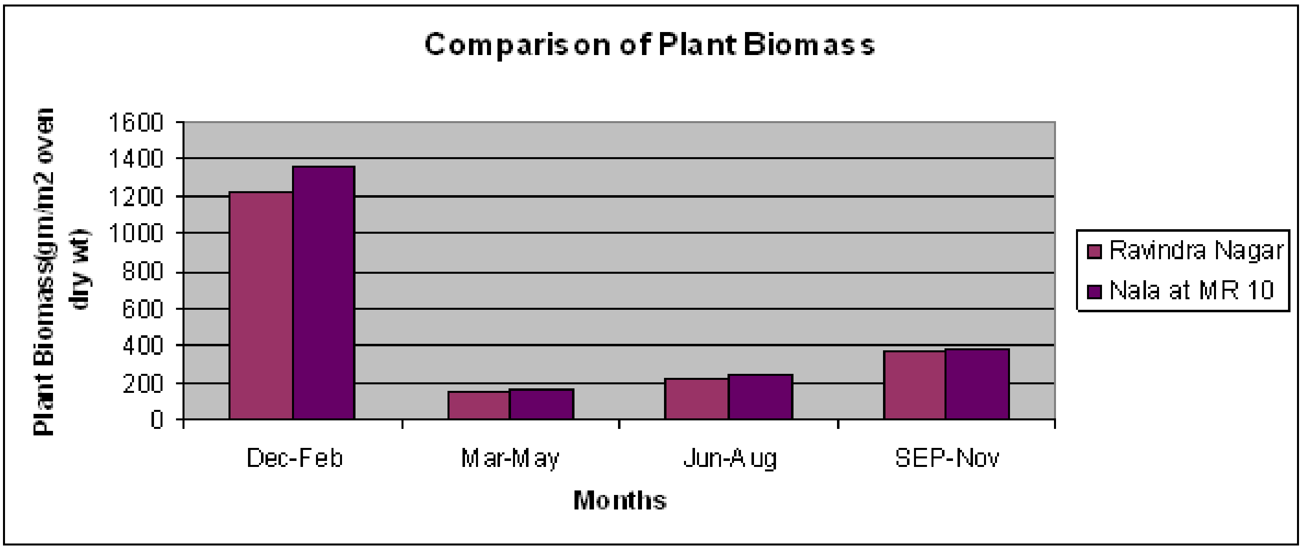


Fig. 4. Comparison of Plant Biomass at the two CW sites of Ravindra nagar and Nala measured from Dec 2007-Dec 2009.

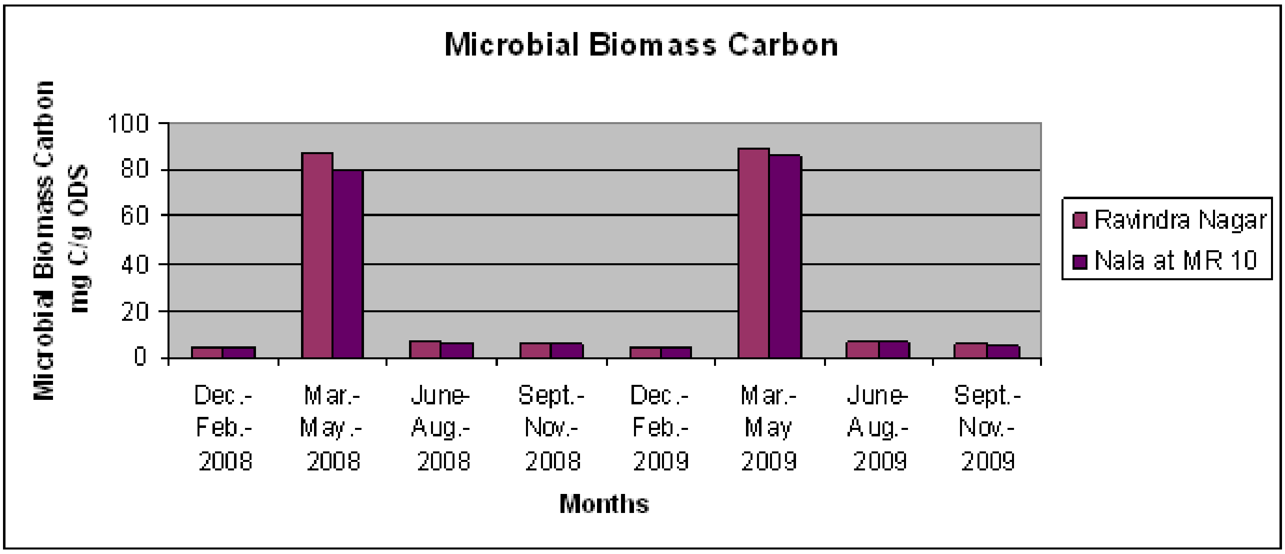


Fig. 5. Comparison of Microbial Biomass Carbon between the two CW sites of Ravindra nagar and Nala measured from Dec 2007-Dec 2009.

Carbon content in the Constructed Wetlands (CW): Both the CWs were sinks of carbon measured in terms of total organic carbon, organic matter, total carbon, plant biomass carbon, microbial biomass carbon, biological oxygen demand, chemical oxygen demand and inorganic carbon measured in terms of photosynthesis or carbon assimilation. The values of the above mentioned parameters were evaluated experimentally at the inlet and outlet locations of each CW site regularly for two consecutive years (i.e. 2008-2009). The seasonal averages and percentage efficiencies were calculated and reported.

The difference between the inlet and outlet quarterly (seasonal) loads was calculated as the amount of carbon assimilated or sequestered by the particular CW. The CW at Nala was found to sequester greater amount of carbon in terms of TOC, organic matter, BOD_5 and plant biomass carbon. Whereas the CW at Ravindra Nagar exhibited better efficiency in sequestering carbon in terms of total carbon, COD, microbial biomass carbon.

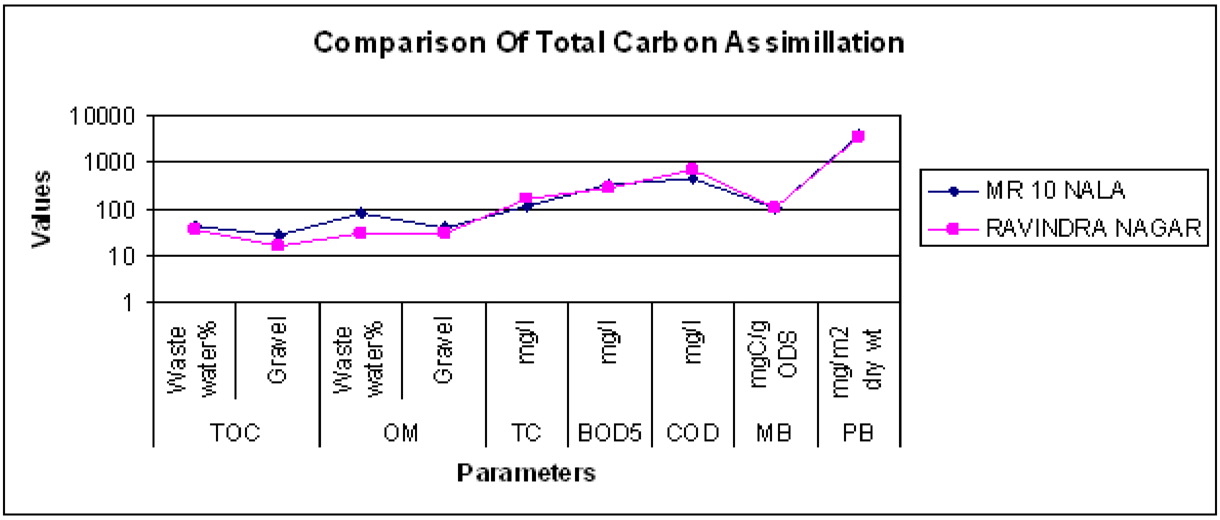


Fig. 6. Comparison of the Carbon Sequestration potential of the two CW sites namely Ravindra nagar and Nala at MR 10 observed during the study period of Dec-2007 to Dec-2009.

Carbon Sequestration by CW at Ravindra Nagar: The amount of total organic carbon (TOC) from the wastewater entering the system for treatment was found to be maximum in the summer months (March-May). 21.55% of TOC was assimilated by the system including the macrophytes and the microbioata. It was lowest (2.55%) in the months of September-November. The overall average value of TOC for both the study years amounted to 34.9%. The TOC estimated from the gravel media of the CW was consistent throughout the year with a slight increase in the months of June-August. The value was 4.86%. The average value for both the years was recorded to be 15.43%. The organic matter assimilated by the wetland system from the wastewater was again maximum in the summer months, the value being 13.5%, followed by the winter months (Dec-Feb), the value being 6.64%. The overall average for both the years amounted to 29.03%. The organic matter present in the gravel media of the CW was maximum in the month of Jun-Aug, the value being 9.74%, followed by Sept-Nov, the value being 7.55%. The overall average of the organic matter assimilated by the CW at Ravindra Nagar was 29.85%. The total carbon sequestered by the CW at Ravindra Nagar was highest during the months of September-November. The value was 55.84 mg/L. The value was consistent throughout the year. The overall average of TC for the two years was 159.1 mg/L. Ravindra Nagar exhibited greater sequestration of TC as compared to the CW at Nala (118.08 mg/L). Similarly the average value of COD reduced by the CW at Ravindra Nagar was recorded to be 656 mg/L for the two study years, though it fluctuated seasonally.

Microbial biomass Carbon for the study years amounted to 106.47 mg C/g ODS. The microbial biomass C sequestered by the CW at Ravindra Nagar was significantly high during the summer months (March-May). The value being 89.42 mg C/g ODS. The plant biomass carbon in the CW at Ravindra Nagar averaged to 3334 g/m^2 oven dry wt. measured from Dec 2007-Dec 2009.

Carbon Sequestration at the MR 10 Nala CW: The amount of TOC from the wastewater absorbed by the CW at Nala was found to be significantly higher than that at Ravindra nagar. The average value of TOC for the study period was 44.35%. The highest C assimilation was observed during the summer months, the value being 22.8% followed by the winter months (December-February) with a value of 10.25%. TOC sequestered by the gravel media was also higher than that at Ravindra Nagar. The yearly average value for TOC in the gravel media was recorded to be 27.05%. The highest absorption of TOC was recorded in the summer months of March-May (18%). During the rest of the year the rate of assimilation of TOC by the CW had been consistent throughout. The organic matter removed by the CW from the wastewater was significantly high. The yearly average value of the same was recorded to be 82.6%, which was significantly higher than that of the CW at Ravindra Nagar (29.03%) The highest quarterly (seasonal) average was observed in the summer months (March-May), the value being 39.3% followed by winter months of December-February (23.1%). The organic matter present in the gravel media of the wetland was 27.9% during the months of Mar-May. The yearly average value of organic matter present in the gravel was 40.3% which was remarkably higher than that of CW at Ravindra Nagar 29.8%). This is most probably due to the young emergent wetland vegetation at the Nala.

Total carbon value was calculated from the value of BOD_5. CW at the Nala assimilated an yearly average value of 118.08 mg/L of total carbon. The seasonal average was maximum during the winter months (Dec-Feb), the value being 67.56 mg/L. During the consecutive months, the rate of sequestration was consistent with a value of 12.94 mg/L, 19.38 mg/L and 18.2 mg/L for the months of March-May, June-August and September-November respectively. The rate of removal of BOD_5 from the wastewater entering the CW at the Nala amounted to 312.1 mg/L to an yearly average. This value was higher than that at Ravindra Nagar. The rate of reduction of BOD_5 from the wastewater was directly dependent on the activity of the micro organisms present on the gravel media and in the rhizosphere and the efficiency of the vegetation in pumping the oxygen in to the rhizosphere.

The reduction of COD by the CW has been recorded to be 428 mg/L (yearly average). In the winter months of December-February the seasonal average was observed to be 246 mg/L which was remarkably highest among the rest of the quarterly averages recorded during the entire period of the study.

Microbial Biomass Carbon sequestered by the CW was 102.19 mg C/g ODS (yearly average). The seasonal average Microbial Biomass Carbon was 85.68 mg c/g ODS for the summer months, the value being highest when compared to the rest of the seasons. The value was consistently low during the rest of the year with a sudden increase in the summer season.

The yearly average of Plant Biomass Carbon was recorded to be 3813 g/m^2 oven dry wt. which was significantly higher than that at Ravindra Nagar. The highest value of the same was recorded in the winter months of December-February (1865 g/m^2 oven dry wt). It was remarkably higher than the Plant Biomass recorded during the rest of the seasons. It may be due to the dense growth of vegetation in the winter months. During the summer, reed grass had totally dried up due to the hot weather including drought in the year 2009. The vegetation again revived after the rains. Therefore, there was a noticeable increase in the Plant Biomass after the showers.

NUTRIENT RETENTION: The earlier studies, the present study as well as the scientific literature have proved that these manmade wetlands have been fairly significant in removing nutrients over the past decade. These planted, engineered and more diverse wetlands have removal rates which are consistently improving from year to year. The average organic carbon removal by the wetlands was the maximum (58% reduction seen in Ravindra nagar and 74% at the Nala) in the winter months during the last five years of the study (Table 1-3). COD retention in the constructed wetland basins continued to be significant at around 80% at Ravindra nagar and 85% at the Nala in the summer months throughout the two years of the study. In the 10th year after wetland construction, the constructed wetland at Ravindra nagar retained 63% of COD (quarterly average) while the CW at Nala (2 years old) retained 61%. The sediments discharged from the wetlands had significantly very low COD. It was as low as 8 mg/L in the outlet treated water of the Nala in the rainy season and the efficiency of reduction was as high as 89%. This is mainly because of the complex interaction between the aquatic microbiota and the macrophytes which is due to a very dynamic pattern of pH change through the wetland basins, similar to that seen for dissolved oxygen.

MODELLING CARBON FLUXES IN CONSTRUCTED WETLAND

View Within Article

CW treatment systems effectively treat organic matter and pathogens. Water plants (macrophytes) have several relevant properties, the most important being their physical effects (Brix1997, Kadlec 2000). The amount of nutrients, removed by plant harvesting, is generally insignificant compared to yearly loadings with wastewater. If plants are not harvested, the nutrients will be returned to the water during plant decomposition (Brix 1997, Tanner et al. 2002). In general, the use of CWs provides a relatively simple, inexpensive, and robust solution for treatment. As natural treatment systems, CWs require a larger specific surface area compared to technical solutions such as activated sludge. However, CWs usually have lower operation and maintenance expenses and other additional benefits, including tolerance against fluctuations of flow and pollution load, ease of water reuse and recycling, provision of habitat for many wetland organisms, and a more aesthetic appearance than technical treatment options (Kadlec 2000, Haberl et al. 2003).

Wetlands of several types have been shown to be currently accumulating carbon (Gorham 1991, Trunen and Toloven 1996) at rates that average about 30g C m^{-2} yr^{-1}. These are higher than C accumulation rates of 3-20 g C m^{-2} yr^{-1} observed in upland boreal forest sites between fires (Harden et al. 1997, Rapalee et al. 1998). Little was known about how the carbon balance of wetlands varies with factors such as vegetation or nutrient status (Camill and Clark 1998). Carbon accumulation rates were maximum at the wetland site largely due to slower decomposition rates of C in the upper layers of medium. Increases in light levels and nutrient availability result in an increase in the biomass production of reed-grass. The thick mats of reed-grass are beneficial in controlling soil erosion, contributing large amounts of soil organic matter to the site and excluding other competitive species. Daily carbon uptake rates increased from morning, attained peak around mid-day and declined towards the end of the day. It has been found that higher rates of carbon assimilation are attained when the moisture is adequate.

Organic matter is decomposed both aerobically and anaerobically, resulting in efficient removal. At Ravindra nagar CW, the removal of organic matter from the wastewater was observed to be as high as 58% and 9.8% from the gravel bed whereas the reduction efficiency was 74.4% from the wastewater and 7.5% from the gravel medium at the Nala CW. The Nala was found to be better in reducing the organic matter from wastewater than the CW at Ravindra nagar because the latter is older than the former. The Reed grass at the Nala is young and in the growing stage, thus they assimilate nutrients faster than the fully grown Reed grass. Whereas the gravel media of Ravindra nagar CW was found to sequester greater organic matter as compared to the one at Nala. This is because of greater litter fall at Ravindra nagar. Langergraber and Haberl (2001) have reported that the carbon cycle considers several state variables, including plant biomass, organic matter, total and particulate organic carbon and microbial biomass carbon. The transformation of organic carbon considered heterotrophic growth and die-off of bacteria, and mineralization & settling of organic matter. Mashauri and Kayombo (2002) concluded that the processes in the pond and CW system may well be defined by the fact that the transformation of organic carbon was found to be dominated by mineralization, which led to high growth of heterotrophic bacteria in the systems. This was also shown by the amount of organic carbon that accumulated in the system.

Constructed Wetlands are major carbon sinks. While vegetation traps atmospheric CO_2 in wetlands and other ecosystems alike, the net-sink of wetlands is attributed to low decomposition rates in anaerobic soils. Enhancing carbon reserves in constructed wetlands, in the context of climate change, is consistent with reducing GHG emissions from the wetlands and restoring their carbon reserves. Protecting and creating treatment wetlands is a practical way of retaining the existing carbon reserves and thus avoiding emission of CO_2 and GHGs.

CONSTRUCTED WETLANDS IN THE LIGHT OF CLEAN DEVELOPMENT MECHANISM (CDM)

Making quick, drastic cuts in carbon emissions is extremely expensive. Instead the world should focus on efforts in making non-polluting green-energy research and development strategies. Saving the earth requires a smarter strategy than those being pursued dogmatically. CDM is a flexibility mechanism put forth by Kyoto Protocol (1997) according to which, a company in the developed world can pay money to a project or company in a developing world to buy the necessary technology and in turn own the carbon units generated by bringing a technology change and thus meet the targets set by their governments. Having to face the ill effects of climate change, any step big or small towards reduction of carbon emission would be a boon to our city as well as our nation.

Conventional treatment plants are one of the major avenues whereby a huge amount of electrical energy can be saved and carbon emissions that would have been caused by production of such electrical energy, can therefore be avoided. Electricity consumed by conventional treatment plants is high as against CWs, which are a boon and not only reduce carbon emissions by consuming way too little electricity but are also free from any type of emission of harmful rays and gases. Moreover they provide additional benefits of Carbon Sequestration in the ecosystem. By adopting these Biological CW treatment systems, we can not only achieve our plan of carbon emission reduction but also generate huge amount of savings and earn carbon credits too.

The CW at Ravindra nagar has been found to save 5721 Kg of C equivalent emissions /m^2/ year (14.44 Kg C/ m^2/ day). The CW at the Nala saves a significant amount of 9884 Kg of C equivalent emissions/ m^2/ year (27.07 Kg C/ m^2/ day). CH_4 flux is as low as 228 and 256 mg/m^2/d. Amount of C sequestered is 3741mg C/m^2 and 4673.7mgC/m^2.

Photosynthesis rate is found to increase at high concentrations of carbon dioxide (800ppm), sequestering more carbon into the biomass. CWs can be used to treat the wastewater from an industry or community development and also provide an additional benefit as green belts around the industries/ community development thus reducing a considerable amount of pollution (from air and water) they cause.

Table 1. Summary of Carbon Sequestration/annum at Ravindra nagar CW observed from Dec 2007-Dec 2009.

Months	TOC		Organic Matter		TC	BOD_5	COD	Microbial Biomass	Plant Biomass
	Waste water %	Gravel	Waste water%	Gravel	mg/L	mg/L	mg/L	mg C/g ODS	mg/m^2 oven dry wt
Dec-Feb	3.85	**3.7**	6.64	**6.51**	25.5	75.6	194	4.48	**1625**
Mar-May	21.6	3.17	13.5	6.05	25.4	71.3	88	89.4	310
Jun-Aug	6.95	4.86	3.2	9.74	52.3	61.2	170	6.72	525
SEP-Nov	2.55	3.7	5.69	7.55	55.8	73.2	204	5.85	874
Total	34.9	15.4	29	29.9	159	281	656	106	3334

Table 2. Summary of the Carbon Sequestration at the Nala/annum CW observed from Dec 2007-Dec 2009.

Months	TOC		Organic Matter		TC	BOD_5	COD	Microbial Biomass	Plant Biomass
	Waste water %	Gravel	Waste water %	Gravel	mg/L	mg/L	mg/L	mg C/ g ODS	mg/ m2 oven dry wt
Dec-Feb	10.3	1.05	23.1	1.81	67.56	75.1	246	4.32	**1865**
Mar-May	22.8	18	39.3	27.9	12.94	80.9	46	85.68	367
Jun-Aug	7	4.3	12	7.49	19.38	72.9	68	6.54	648
SEP-Nov	4.3	3.7	8.2	3.1	18.2	93.2	68	5.65	933
Total	44.35	27.05	82.6	40.3	118.1	322.1	428	102.2	3813

Table 3. Carbon Sequestration Potential of the two CW sites /annum measured from Dec 2007-Dec 2009.

Location of CW	TOC		Organic Matter		TC	BOD_5	COD	Microbial Biomass	Plant Biomass
	Waste water %	Gravel	Waste water %	Gravel	mg/L	mg/L	mg/L	mg C/g ODS	mg/m2 oven dry wt
MR 10 NALA	44.35	27.05	82.6	40.3	118.1	322.1	428	102.2	3813
RAVINDRA NAGAR	34.9	15.43	29.03	29.85	159.1	281.3	656	106.5	3334

CONCLUSION

Both the CWs have been found to be potential sinks of Carbon in terms of organic carbon. We face several significant questions regarding the potential for carbon sequestration in wetlands. Constructed wetlands can be managed as net carbon sinks over time. In the two years of the study it was found that the net carbon gain and the biomass was comparatively higher in the Constructed wetland system at the Nala than at Ravindra nagar. Though the Total Carbon value at the CW at Ravindra nagar was higher than that at the Nala. Tropical warm weather in Ujjain (Central India) is particularly beneficial for the growth of *Phragmites karka* (emergent macrophyte). CWs can be used to treat the wastewater from an industry or community development and also provide an additional benefit as green belts around the industries or the community development. By adopting these Biological CW treatment systems, we can not only achieve our plan of carbon emission reduction but also generate huge amount of savings and earn carbon credits too to ensure a Clean Development Mechanism.

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