Paper No. 132

REUSE OF WASTEWATER IN AGRICULTURE RECOVERED FROM CONSTRUCTED WETLANDS

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Abstract

The reuse of treated wastewater in agriculture, in particular irrigation, is an increasingly common practice, fortified by government and official bodies worldwide. Irrigation with wastewater may have implications at two different levels: increase soil productivity by enhancing nutritional value or lead to the deposition of the chemical and biological contaminants on soil. Sustainable reuse of wastewater includes the holistic approach involving integrated risk assessment that would result in minimal pollutant transfer and sustainable agricultural system. Constructed Wetlands are the biological systems for removing chemical and biological pollutants from wastewater. The present study was conducted at NUST H-12 Sector Campus, Islamabad. The objective of the study was to check the quality of the treated and untreated water and to investigate whether the treated water is fit for agricultural purposes. Following parameters were studied which include: Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Turbidity, pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Fecal Coliform (FC) and Total Coliform(TC) were analyzed using standard laboratory procedures. Analysis of the physicochemical parameters revealed significant reduction in the COD levels throughout the system with levels decreasing by up to 80 % across the phytoremediation plant. Microbial removal varied from 88.5% for the phytoremediation system. There was significant turbidity removal by the system. These treated water parameters were found within the permissible limits to be used for agricultural purposes and can stimulate economic and agricultural growth. In general, constructed wetland systems have proven to constitute a suitable ecotechnology for wastewater treatment and reuse in small communities of warm climate areas.

Key words: Constructed Wetlands, COD, Total Coliform, Fecal Coliform, Turbidity

1. Introduction

Inadequate approach to clean water and hygiene has turn into one of the most persistent issues afflicting public throughout the developing world. Imitation of centralized energy, water and cost effective technologies have proved useless in solving the intricate water linked problems resulting from quick urbanization in the developing countries and problems with water are expected to worsen in coming decades (Fountoulakis *et al*., 2017).

[1] **Corresponding Author**: kandleeb.mses7iese@iese.nust.edu.pk

Institute of Environmental Sciences and Engineering, School of Civil and Environmental Engineering, National University of Sciences and Technology, Islamabad, Pakistan

With deficient water possessions to meet increasing water demand, many sources of water (e.g., groundwater) that are considered simple to be developed technologically have been overexploited in many developing countries. This short-term strategy is likely to have damaging effects on the environment. Among the diverse developments, treatment of wastewater is always considered one of the lowest priorities. The consequence of this is the common practice of discharging large amounts of untreated wastewater directly into streams and lakes in many developing countries (Vymazal *et al.,* 2014) (Mander *et al*., 2014).

Constructed wetlands (CWs) have emerged and become a viable option for wastewater treatment, and are currently being recognized as attractive alternatives to conventional wastewater treatment methods (Ávila *et al.,* 2015) (Zhang *et al*., 2015). According to a recent report by World Health Organization (2012), more than one-tenth of the global population (780 million) still relies on sub-standard drinking water sources in 2010.

Constructed wetlands are engineered wastewater treatment systems that encompass a plurality of treatment modules including biological, chemical, and physical processes similar to processes going on in natural management. They have been successfully used to mitigate environmental pollution by removing a wide variety of pollutants from wastewater such as organic compounds, suspended solids, pathogens, metals, and nutrients (Lavrnić & Mancini, 2016). Because of high removal efficiency, low cost, simple operation, and great potential for water and nutrient reuse, CWs have become an increasingly popular option for wastewater treatment (Berberidou *et al.*, 2016). Source control is the first and foremost way to avoid pollution and re use that for the agricultural purposes especially in the arid regions which are being severely affected by the climate change (Muga & Mihelcic, 2008).

Annual per capita water availability in Pakistan has decreased from 5,000 in 1951 to 1038 cubic meter in 2010. This is slightly above the internationally recognized scarcity level of 1000 cubic meter. The projection for 2015 is 900 cubic meter per annum. In addition, discharge of untreated wastewater into fresh water bodies is polluting this already squeezing resource (Haider *et al*., 2015).

The present study was conducted to analyze the performance efficiency of the constructed wetland system and to check whether the treated water is fit for agricultural purposes. Four macrophytes species that were cultivated in the system were *Pistia stratiotes* (Water lettuce), *Centella asiatica* (Pennywort) and *Typha latifolia* (Typha).

1.1 Study site

The site is located at the main campus of the National University of Sciences and Technology, Islamabad, Pakistan. The project was completed by the funding of UNESCO and is being maintained by NUST Research and development funds.

1.2 Treatment to the Ponded Water by different plants:

Constructed wetland consists of eight ponds which comprises different Phytoremediation species and an inlet and outlet. About 283 cubic meter of water is being treated daily and is used for horticultural purposes. Table 1 comprises the detail of the ponds cultivated with diverse plant community.

Table 1: Characterization of Ponds

PONDS	CHARACTERISTICS
Inlet	Sedimentation tank
Pond 1	*Typha latifolia*
Pond 2	*Pistia stratifolia*
Pond 3	*Centella asiatica*
Pond 4	*Centella asiatica*
Pond 5	Control
Pond 6	Control
Pond 7	*Pistia stratifolia*
Pond 8	Aeration tank
Outlet	Treated water to be used for horticulture

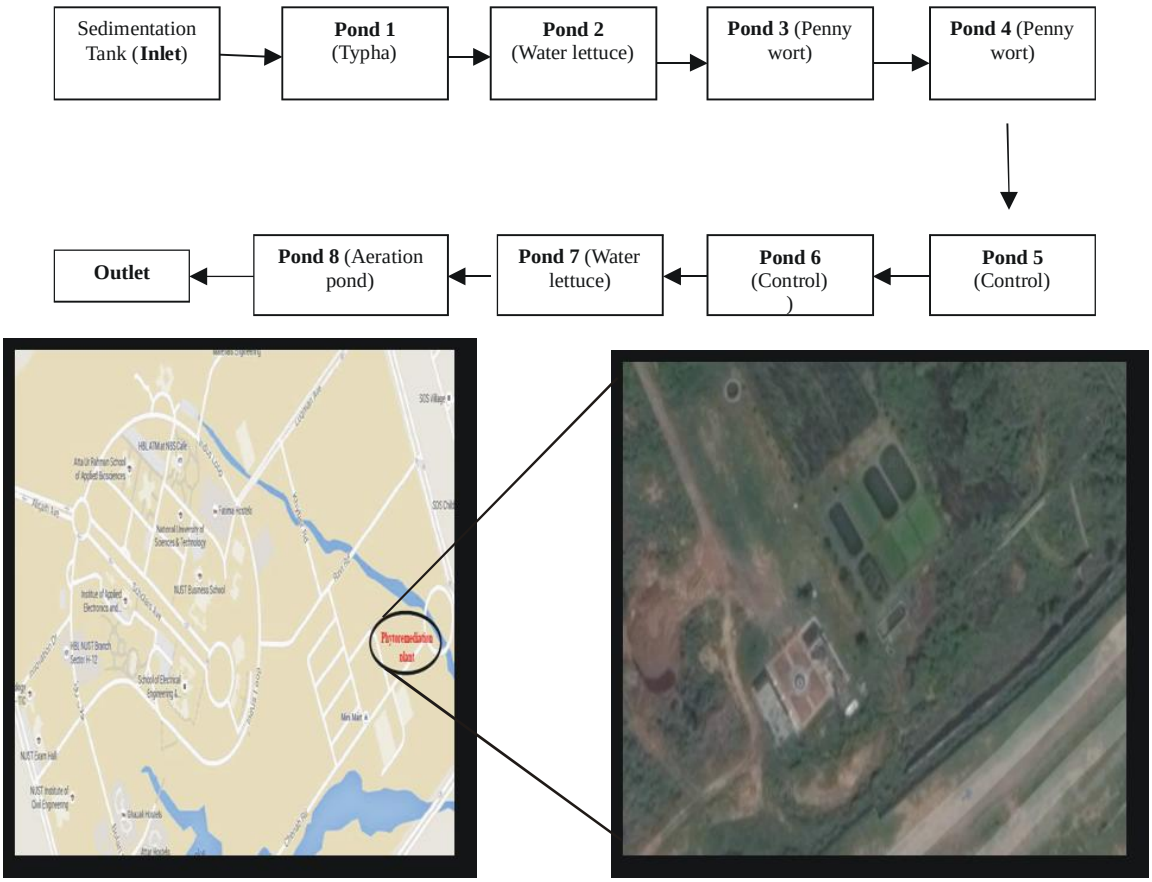


Figure 2: Layout of Phytoremediation Plant of NUST

1.3 Cost benefit Ratio:

NUST PHYTOREMEDIATION PLANT	NUST MBR PLANT
Funding Agency – UNESCO Project Cost – PKR 6.5 Million IMPACTS • Waste Water generated within NUST treated daily using zero Energy (Gravity Flow) • Conservation of stressed fresh ground water aquifer • Collected solias usable as fertilizer • Field operational site available for teaching • 253 cubic metres of recycled water available daily for horticulture	Funding Agency-NUST R&D Fund and Samsung corporation Korea Project cost – PKR 40 Million IMPACTS • NUST MBR Plant is partially meet ion as coping and horticulture water demand as well as serving as MBR Research Laboratory for MS and PhD • It has been proved to be reliable and efficient method • It provides the unrestricted supply of water. • It has the capacity of about 50 cubic metre per day.

1.4. Retention time of water to get the fertilizers:

At the sedimentation tank, water is retained for one day to get the fertilizer which is then recovered to be used for agricultural purposes.

1.5 Surface area of wetlands:

Pilot scale phytoremediation plant has the ability to treat supply of one sewerage line i.e. 0.1 MGD. The total area of pilot scale plant is 120 ft. * 100 ft. The dimension of sedimentation tank is 35 ft. * 12 ft. * 6 ft. and dimension of each wetland is 22 ft. *50 ft.*7 ft. The wetlands were covered with Low-density polyethylene (LDPE) to prevent the infiltration.

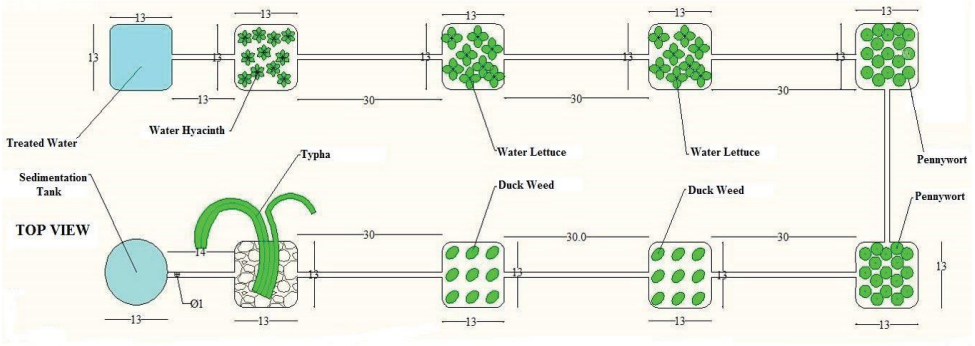


Figure 3 Surface areas of different ponds of wetlands

2. Methodology

To analyze the efficiency of the wetlands that how these wetlands will help to improve the agricultural system that is severely being affected by the water scarcity resulted from the climate change. Different Physicochemical and Biological parameters were checked to evaluate the performance efficiency of the system during the three months period from November 2016 to January 2017. Sampling was carried out on weekly basis and all the physicochemical parameters were performed under the standard method for examination of water and wastewater (APHA, 2012).

Sampling was done weekly from November 2016 to January 2017from inlet and outlets of each selected plants. All methods for the collection, transport and storage of samples were carried out under the standard method for the examination of water and wastewater (APHA, 2012). Table 2 characterizes the equipments and methods used for various physicochemical parameters.

Coliform test was performed using Membrane filtration technique and Eosin Methylene Blue Agar media was used for the test. The measuring unit was CFU/100 mL.

Parametres	**Instruments Used**	**Method of Analysis**
pH	pH meter	Potentiometric method
Temp(˚C)	HACH session 1	Laboratory method
DO(mg/L)	DO meter	Potentiometric method
Turbidity	Turbidity meter	Laboratory method
Chemical oxygen demand (mg/L)	Through titration	Closed reflux method
Biological oxygen demand	DO meter	Dilution method

Table 2: Methods and Equipments for Physicochemical Parameters

3. Results and Discussion

Inlet and outlet concentrations of desired Physicochemical and Biological parameters were measured and sampling was done almost weekly for the period of three months.

There was not much significant difference observed in the pH. Temperature has a very slight effect on pH. With the increase in temperature there is more breakdown of water molecules leading to the shift of pH to slightly acidic. More temperature leads to the more breakdown of water molecules, hence shifting of pH to slightly acidic (Clark, 2002). Also no significant correlation exists between DO and Temperature (Figure 2).

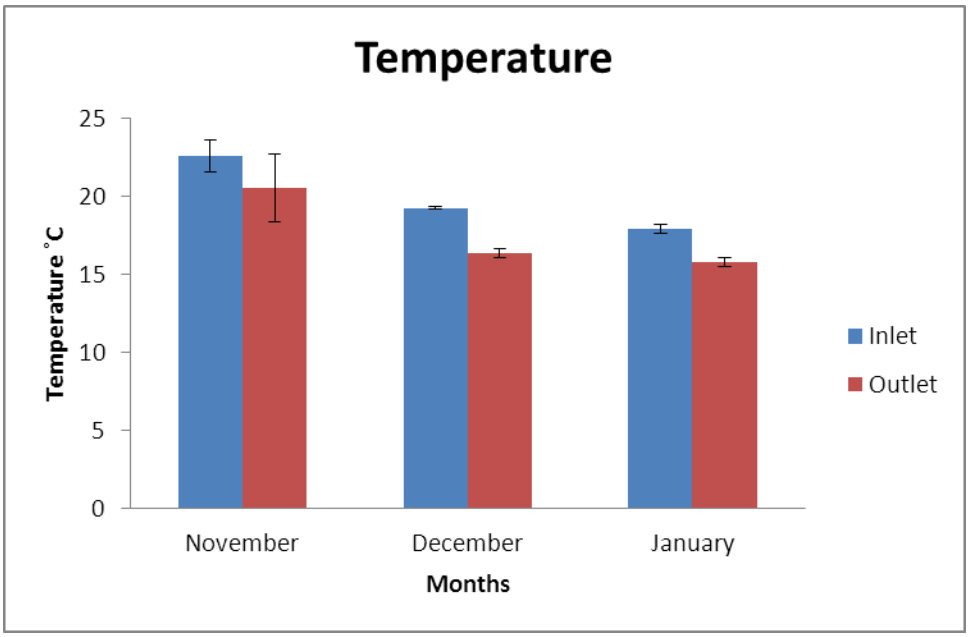


Figure 4: Temperature variations

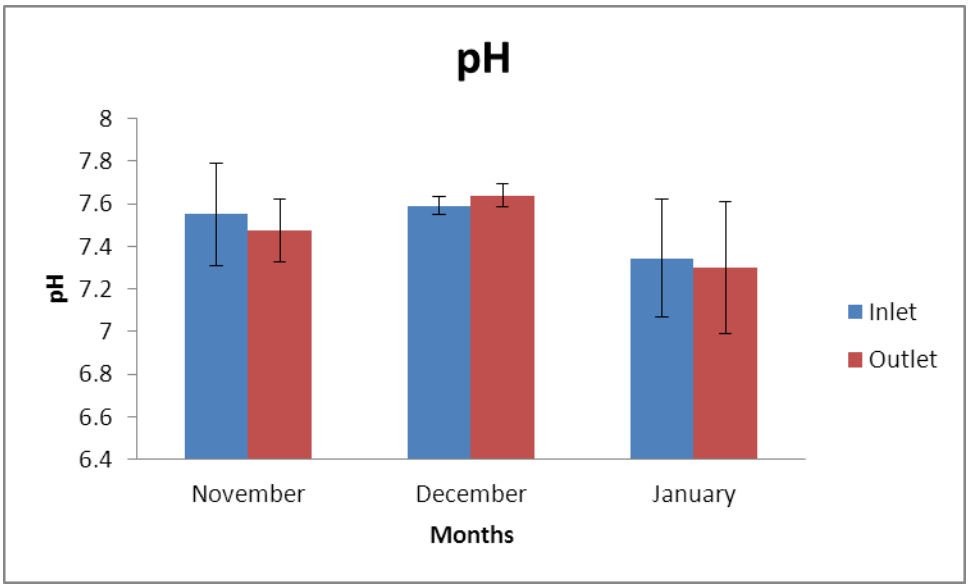


Figure 5: pH variations

The amount of dissolved oxygen that a given volume of water can hold is a function of atmospheric pressure, water temperature, and the amount of other substances dissolved in the water.

With the decrease in temperature, the amount of dissolved oxygen increased in the system as cool water can hold more oxygen than warm water. Water with high

concentrations of dissolved minerals such as salt will have a lower DO concentration than fresh water at the same temperature (Doney, 2010).

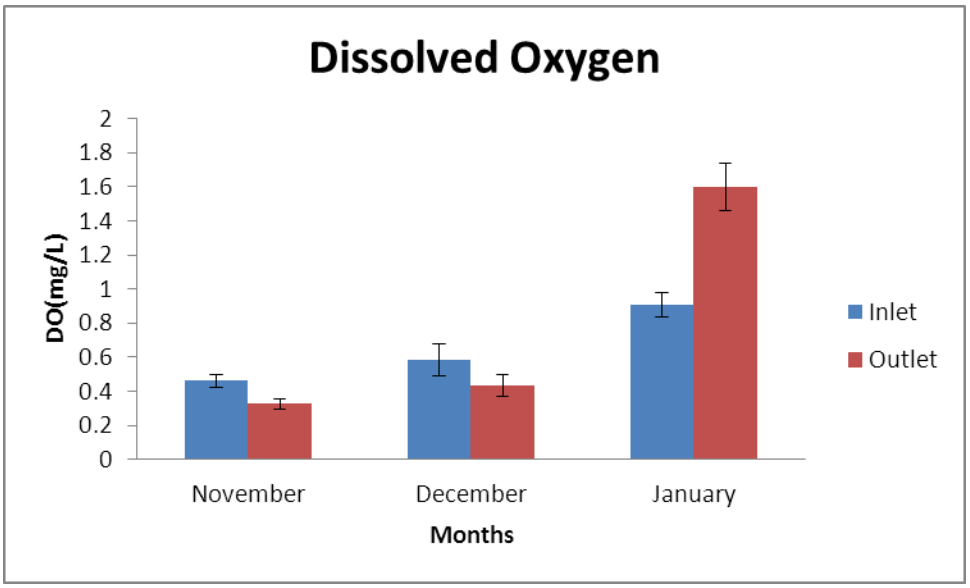


Figure 6: Dissolved Oxygen Comparison of Inlet and Outlet

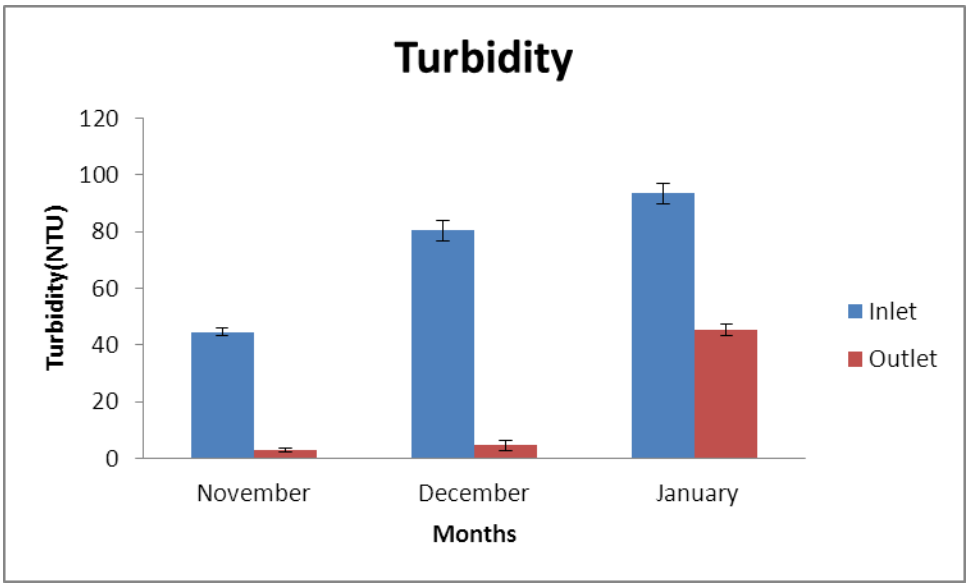


Figure 7: Turbidity removal efficiency

COD was measured for the inlet, outlet and the selected plant species and the results have clearly demonstrated the strong removal efficiency of the system. With decrease in temperature there is a continuous increase in the COD levels. COD is because of the presence of organic matter so its major contributors are the dead plants. High COD value is due to the decaying organic matter (Konnerup, 2009).

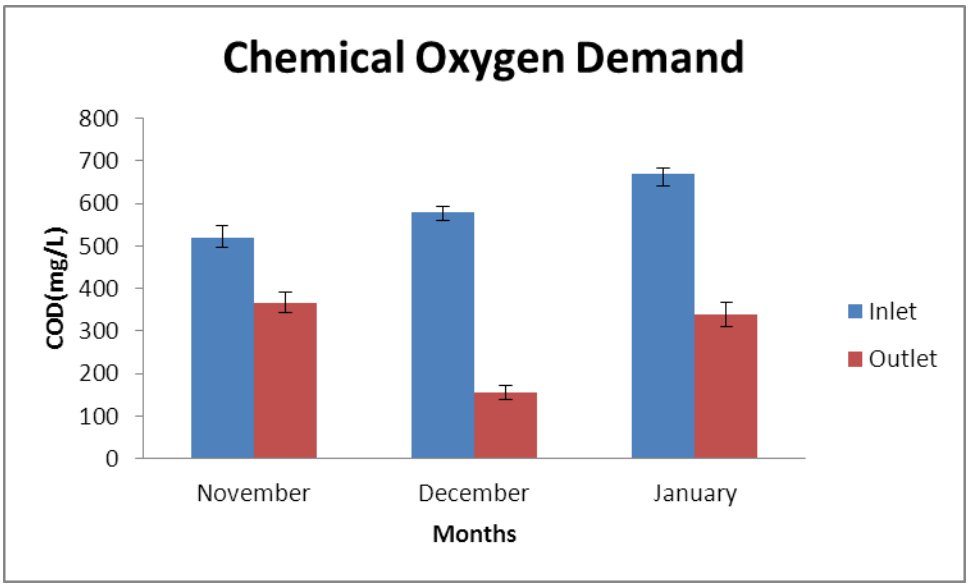


Figure 8: COD Removal Efficiency

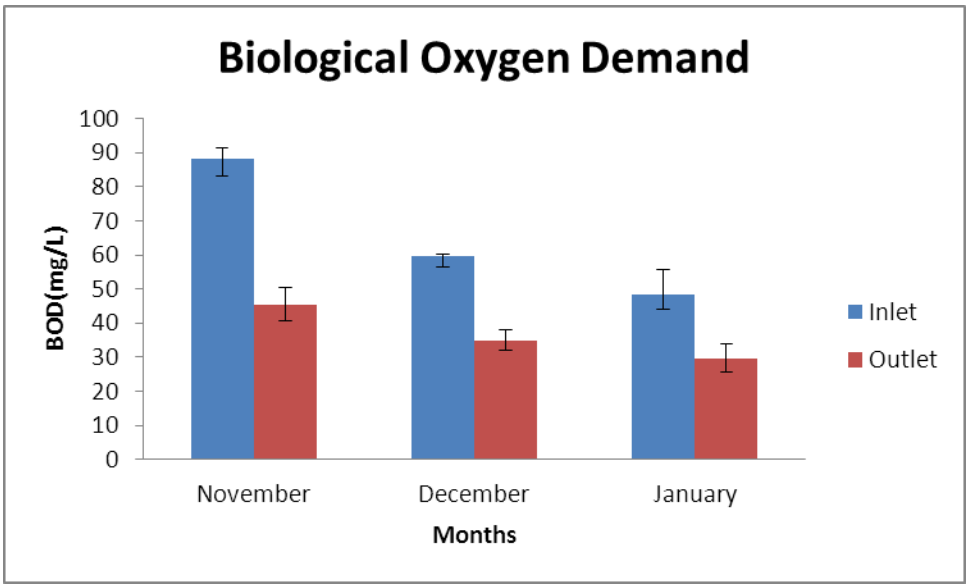


Figure 9: BOD Removal Efficiency

Reduction in the Total suspended solid concentration was observed with the decrease in temperature because with the decrease in temperature there would be the death and decay of plants that lead to the increase in TSS concentrations.

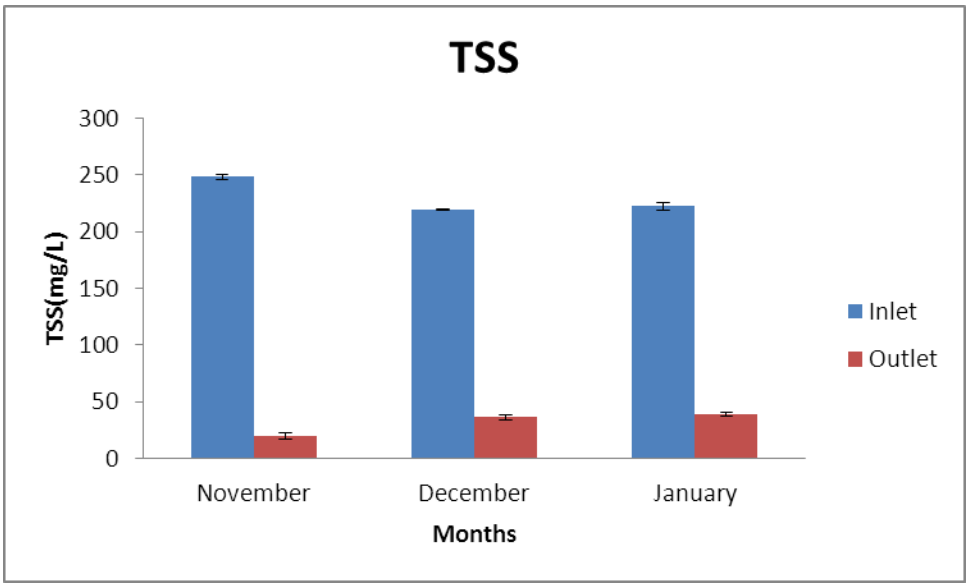


Figure 10: TSS Removal Efficiency

Fecal coliform removal was observed in the wetland system. Efficiency up to 88.5% was achieved overall (Table 2). Growth rate of bacteria is high at higher temperature this is because more bacteria survive at lesser temperature (Sakyi, 2012).

Table 3 % Efficiency of Coliform removal

Months	November	December	January
Inlet (CFU/100 mL)	45×10^5	39×10^5	35×10^5
Outlet(CFU/100 mL)	9.0×10^5	5.7×10^5	4×10^5
%Efficiency	80	85.3	88.5

4. Conclusion and Recommendations

Constructed wetlands are less costly and efficient wastewater treatment technique. Agricultural production can be greatly improved in the arid regions by implementing such techniques and will substantially increase the water use efficiency across all the sectors of the society. Fertilizer production from sludge of the sedimentation pond can reduce the use of costly harmful synthetic fertilizers. There is the dire need of implementing such techniques in the arid region by improving policies, financial management and institutional dialogues, which would ultimately improve the agricultural production and can, boost up the economy of the nation.

This research will be helpful to create awareness among the masses in the form of research papers, newspaper clippings, seminars, and short training programs, poster presentations at local and international levels. This technique if implemented will reduce water borne diseases as mixing of wastewater with the drinking water supplies will be highly reduced which is the major aspect highlighted in Sustainable development goals.

Acknowledgement

This research was supported form the postgraduate Environmental sciences (MS-ES) research grant provided by Research and Development, NUST.

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