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Effect of Different Substances Using Altered Flow Rates in Horizontal Subsurface Wetlands

Elghalban, A. M.[1]; S. N. Moalla[2]; R. El-Shahawy[3]; M. E. Ahmed[1] and A. Y. El-Khateeb[4]
[1]Water and Wastewater Company, Dakahlia, Egypt.
[2]Analytical Chemistry Department, Faculty of Science, Port Said University, Egypt.
[3] Faculty of Engineering Mansura University, Egypt.
[4]Agricultural Chemistry Department, Faculty of Agriculture, Mansoura University, Egypt.

ABSTRACT

A greenhouse experiment was conducted to examine the effect of utilizing diverse substances of assembled wetland on wastewater treating efficiency. Wetland beds were set up with locally accessible plants, particularly (Phragmites Australis). Treatment efficiency was assessed for parameters for example, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS) and Total Phosphorus (TP). The outcomes demonstrated that the supplement decrease compares to a lower stream rate in wetland beds. Under the lower stream rate of 2.34m3/day, the framework with plastic media delineated the most astounding expulsion efficiencies of BOD, COD, TKN, TSS and TP in rates of 74.42, 74.9%, 63.28, 87.49 and 71.29%, individually.

Keywords: Nutrient removal, subsurface constructed wetlands.

INTRODUCTION

Constructed wetlands (CWs) has long established to be an efficient, low-cost and low-maintenance management system for various overflows, community, industrial and agricultural wastewater in eliminating organic matter, nutrients and suspended solids. CWs are engineered systems that have been planned and developed to use the regular procedures including wetland vegetation, soils, and their related microbial arrays to help with treating wastewater. They are intended to exploit a large number of the procedures that happen in common wetlands within a more environment controlled (Natarajan *et al.,* 2018). The innovation of wastewater treatment by methods for CWs with horizontal subsurface flow (HFCWs) (HFCWs) was begun in Germany in view of research by Kathe Seidel initiating in the 1960s and by Reinhold Kickuth in the 1970s (Han *et al.,* 2018).

In these structures the wastewater is bolstered in the bay and streams gradually through the permeable medium under the surface of the bed in a pretty much flat way until the point that it achieves the outlet zone where it is gathered before leaving by means of level control arrangement plan at the outlet. Among this entry the wastewater will come into contact with a system of aerobic, anoxic and anaerobic zones. The aerobic zones occur around roots and rhizomes that break oxygen into the substrate happen around roots and rhizomes that oxygen into the substrate (Fenxia and Ying, 2009) and (Sundaravadivel and Vigeneswaran, 2003). Because of long maintenance time the HFCWs found to be provide a dependable secondary level of treatment with regard to organic matter (OM) and total suspended solids (TSS) (Jäntti *et al.,* 2018), (Hua *et al.,* 2018) and (Seo *et al.,* 2005).

It is well Documented that the benefit of OM and TSS in HFCWs varied from 72.0% to 95.0% for suspended solids, 71.2–94.1% for BOD and from 59.7% to 89.0% for COD (Sudarsan *et al.,* 2015). Substrate can not only afford carriers for the plants and microbes growth, but it is also eliminates contaminants directly by sedimentation, filtration, and adsorption and so on. A great number of investigators from home and abroad discovered the purification of the constructed wetland by choosing of substances and plant species and the planting conditions such as the size of the wetland bed, the extensiveness proportion water operational conditions and temperature and so on (Ong *et al.,* 2009) and (Vymazal and Kröpfelová, 2008).

This investigation deliberated the removal effect of the HSFW to pollutants with different substances to discover a scientific and effective substance. An suitable constructed wetland substance plays a dynamic role in optimizing the sewage treatment technology of the constructed wetland. The experiments were carried out in a pilot scale constructed wetland with (Phragmites Australis) under the flow rates of 4.99, 3.39, and2.34m^3/day.

MATERIALS AND METHODS

All experiments were carried out on a field scale subsurface flow constructed wetland system exists in Samaha Wastewater Treatment Plant (WWTP), Samaha village, Aga, Dakahlia Governorate, Egypt. Some modifications have been conducted on Samaha WWTP to serve different purposes in the present research investigation. A comparative study among the used media; rubber, gravel, and plastic to select the suitable one which gives the best efficiency in Horizontal Subsurface Flow (HSSF) wetlands treatment system.

Experiments were carried out in three similar parallel field-scale horizontal subsurface flow constructed wetlands. All the units have a rectangular shape with identical dimensions of 10 m × 2.0 m × 0.65 m (length × width × depth). Three selected media were chosen for this study (shredded tires as rubber media, graded gravel and small pieces of hollow electricity corrugated pipes as plastic media). The flow rates were maintained at 2.34, 3.39 and 4.99 m^3/day fig (1). The samples were collected twice a week and were immediately analyzed. The experimental determinations of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS) and Total Phosphorus (TP) were carried out according to standard methods for examination of water and wastewater (Eugene *et al.,* 2012).

RESULTS AND DISCUSSION

1. Biological Oxygen Demand (BOD)

BOD is removed by procedures of biological corruption and sedimentation. Biological corruption of organic carbon in the organic matter issue happens in the wetland in oxygen consuming conditions to produce CO_2 and in anaerobic environments to produce methane. As Shown in Fig (2) plastic media gives the highest removal efficiency 74.43%, at the lowest flow rate (2.34m^3/day) and the removal of gravel was68.16% and rubber was61.2% at the same flow rate.

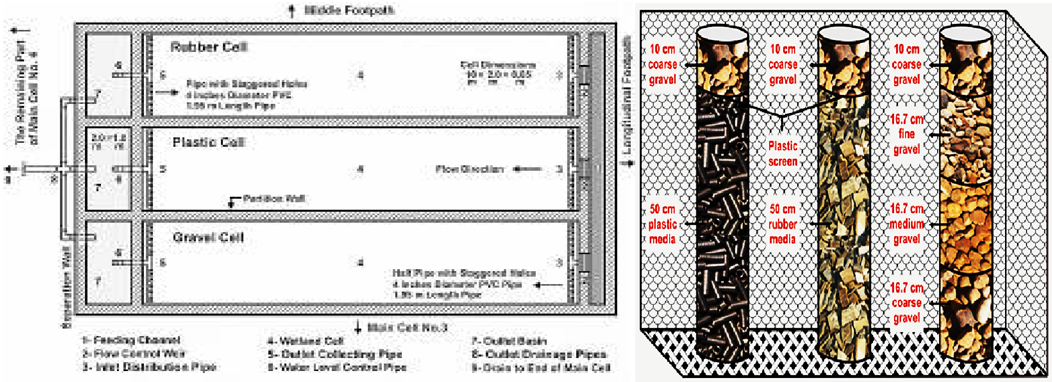

Fig. 1. Design of wetland treatment cells.

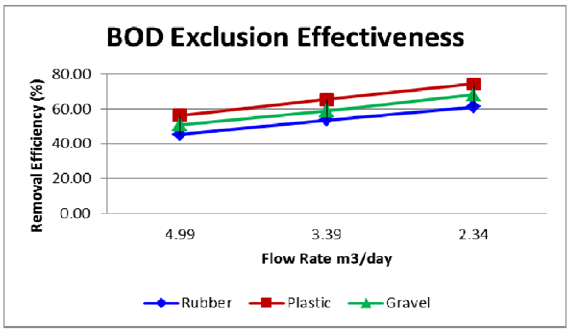

Fig. 2. BOD removal using different types of media.

2. Chemical Oxygen Demand (COD)

The COD removal of CWs is mainly relying on microbiological deprivation of the matrix involved to the plant roots (Watabe and Saitoh, 2015). This mechanism responsible for COD reduction were probably bacterial degradation in which oxygen photo synthetically produced by the plants leaves were transported to the root zones for the bacteria growing in the HSSF beds to biodegrade the organic compounds (Kadlec, 2009). As Shown in Fig (3) plastic media gives the highest removal efficiency (74.9%) for removing COD of constructed wetlands at the lowest flow rate of (2.34m^3/day) and the removal efficiency of gravel media was 68.87% and rubber media has the lowest value for removing COD which was 63.72% at the same flow rate.

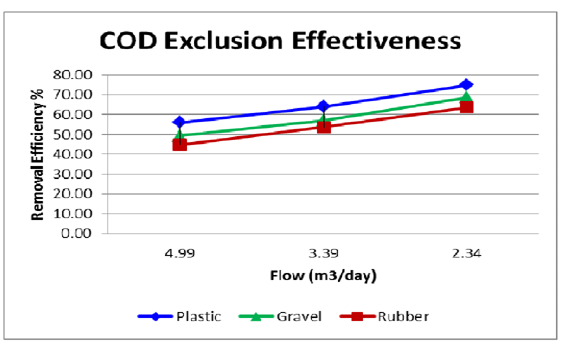

Fig. 3. COD removal using different types of media.

3. Total Kjeldahl Nitrogen (TKN)

The confiscation of nitrogen in the form of ammonia and organic nitrogen requires a resource of oxygen for nitrification. This oxygen more often originates from the plant roots. As the absorbency of media increases the oxygen transfer crosswise the media increases, hence TKN decreases. Plastic and Gravel medias distribute better aeration sites for microbial layer than rubber which providing better mineralization of organic nitrogen and ammonium ions oxidation. As shown in Fig (4) the removal efficiency ranged between 53.33 % for rubber to 57.7 for gravel and 63.28% for plastic media.

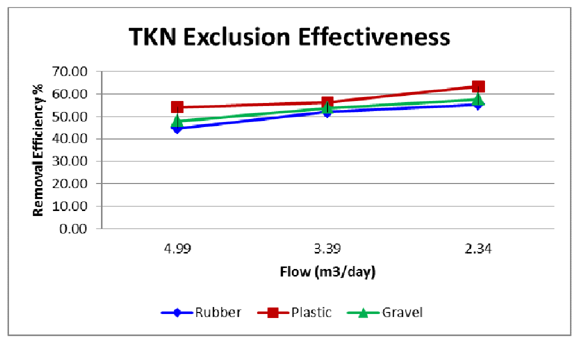

Fig. 4. TKN removal using different types of media.

4. Total Suspended Solids (TSS)

Total suspended solids (TSS) are solids in water that can be expelled from the water by filtration. For adequate filtration to occur. The hydraulic conductivity of the bed must be large enough to allow the wastewater to exchange the media. Suspended solids are removed by sedimentation, filtration and adsorption on the substrate. As presented in Fig (5) TSS removal efficiency percentages of 87.49 % for plastic media, 73.66 % for gravel media and 68.82% for rubber media at the lowest flow rate (2.34m^3/day).

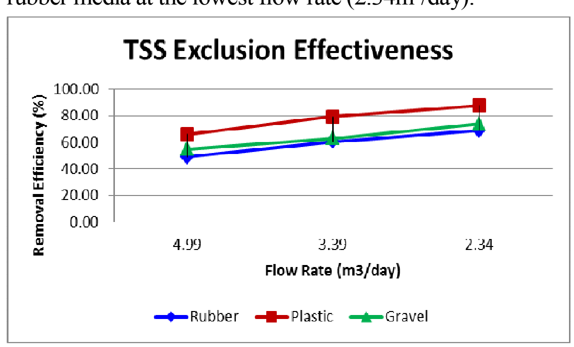

Fig. 5. TSS removal using different types of media.

5. Total Phosphorus (TP)

Phosphorus as orthophosphate has a tendency to aggregate in the framework due to no critical gaseous loss mechanism. Phosphorus maintenance by wetlands is physically controlled by sedimentation and entrainment. Additionally, biological mechanisms by uptake and release by vegetation, periphyton and Microorganisms (Vymazal, 2007). As offered in Fig (6) the removal efficiency values were 71.29, 63.00 and 57.48% for plastic, gravel and rubber media, respectively, at the lowest flow rate (2.34m^3/day).

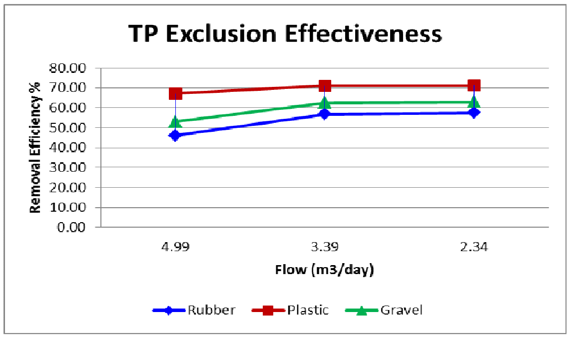

Fig. 6. TP removal using different types of media.

CONCLUSION

In the present study, the plastic media showed the best results of removal percentages for all pollutants for BOD, COD, TKN, TSS and TP in percentages of 74.42, 74.9%, 63.28, 87.49 and 71.29%, respectively. This may be due to the highest surface area and biggest bacterial biofilm layer than both other media. Gravel media took the second order followed by rubber media in the third degree. The characteristics of the wastewater improved expressively as the wastewater flowed through the wetland cell and the quality of the effluent water enhanced along the treatment path of flow.

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دراسة تأثير وسائط صلبة متنوعة ومعدلات تدفق مختلفة فى الأراضي الرطبة الأفقية

أحمد محمد الغلبان[١]، سيد نورالدين معله[٢] ، رجب الشهاوى[٢] ، محمد إبراهيم أحمد[١] و أيمن يحيى الخطيب[٤]

[١] شركة معالجة المياه والصرف الصحى ، الدقهلية ، مصر

[٢] قسم الكيمياء التحليلية ، كلية العلوم ، جامعة بورسعيد ، مصر

[٣] كلية الهندسة ، جامعة المنصورة ، مصر

[٤] قسم الكيمياء الزراعية ، كلية الزراعة ، جامعة المنصورة ، مصر

في هذا البحث تم اجراء تجربة لدراسة تأثير استخدام وسائط مختلفة في أحد محطات الأراضي الرطبة المشيدة على كفاءة الإزالة للعناصر المختلفة في مياه الصرف الصحي تم تجهيز خلايا الأراضي الرطبة وزرعها بأحد النباتات المحلية (البوص) ، حيث تم تقييم كفاءة إزالة العناصر مثل الأكسجين البيولوجي الممتص (BOD) والأكسجين الكيميائي الممتص (COD) والنيتروجين الكلى (TKN) المواد الصلبة الكلية العالقة (TSS) والفوسفات الكلى (TP) وقد اوضحت النتائج انخفاض في نسبة العناصر السابقة في المياه الخارجة وذلك عند اقل معدل تدفق للمياه الداخلة الى خلايا الأراضي الرطبة حيث انه عند معدل تدفق ٢.٣٤ م^٣/يوم . أظهرت النتائج أن الخلية المستخدم بها البلاستيك كوسط ذات أعلى كفاءة في إزالة عناصر الأكسجين البيولوجي الممتص (BOD) والأكسجين الكيميائي الممتص (COD) والنيتروجين الكلى (TKN) المواد الصلبة الكلية العالقة (TSS) والفوسفات الكلى (TP) بالنسب التالية ٧٤.٤٢ و ٧٤.٩٠ و ٦٣.٢٨ و ٨٧.٤٩ و ٧١.٢٩% على الترتيب.