FACTORS AFFECTING THE PERFORMANCE OF HORIZONTAL FLOW CONSTRUCTED WETLAND VEGETATED WITH *CYPRUS PAPYRUS* FOR MUNICIPAL WASTEWATER TREATMENT

[1]

Abou-Elela, Sohair, I.[(1)]; Elekhnawy, M. A.[(2)]; Khalil, M. T.[(3)]; Hellal, M. S.[(1)] and Ibrahim, M. A

1) National Research Center 2) Holding Company for Water and Wastewater
3) Faculty of Science, Ain Shams University

ABSTRACT

The impact of hydraulic loading rate (HLR) and hydraulic retention time (HRT) on the bioremediation of municipal wastewater using a horizontal flow constructed wetland (HFCW) vegetated with *Cyprus papyrus* was investigated. Three different HLRs were applied with values of 0.18, 0.10 and 0.07 m^3/m^2.d with corresponding HRT of 1.8, 3.2 and 4.7 days. The flow rate was 8.3 m^3/d and the average organic loading rate was 0.037kg BOD/m^3/d. Results showed that the performance of HFCW is linearly affected by decreasing HLR and increasing the HRT. The remediation for the heights HRT (4.7) days and lowest HLR (0.07 m^3/m^2.d) produced high quality effluent in terms of reduction of chemical oxygen demand (COD; 86%), biochemical oxygen demand (BOD; 87%) and total suspended solids (TSS; 80%) as well satisfactory nutrient removal. Also, removal of 2-3 logs of bacterial indicators was achieved. The dry biomass of *Cyprus papyrus* was 7.7 kg/m^2. Moreover, *Cyprus papyrus* plant proved to be very efficient in nitrification processes due to high diversity of the roots that increase the treatment surface area.

Keywords: Constructed wetland**,** horizontal flow**,** wastewater, treatment, hydraulic loading rate**,** hydraulic retention time**,** *Cyprus papyrus.*

INTRODUCTION

The shortage of water supplies is emerging as a critical issue for the future development of Egypt. Poor sanitation in Egypt is part of this problem especially in rural areas, villages and small communities where only 15% are served by wastewater treatment plants (Abou-Elela and Hellal, 2012). Conventional wastewater treatment plants involve large capital investments and operating costs. These systems are not suitable solutions for rural communities and villages (Abou-Elela *et al.,* 2013). Given the need to seek alternative solutions to conventional systems, priority has been given to those technologies which have a minimum or null energy cost, simple operational and maintenance procedures and high treatment efficiency. During the last 35-40 years, considerable interest has been expressed in the potential use of a variety of natural biological systems for effective purification of polluted waters (Guimaraes *et al.*, 2010). Constructed wetlands (CW) are described as a simple and low-cost domestic water remediation systems (EPA, 2004) and are reported to be capable of removing contaminants including metals, organic and inorganic matters as well as pathogens from different wastewaters (Choudhary *et al.*, 2011). Recently, Abou-Elela *et al.,* (2013) discussed the application of constructed wetlands for wastewater treatment in small communities and concluded that a high percentage reduction of organic load, ammonium ion, and total phosphorus could be achieved even when the system was operated at short detention time. The use of CWs with horizontal flow is increasing around the world for domestic wastewater treatment (Liu *et al.*, 2005). Horizontal flow constructed wetlands (HFCW) are an alternative option for secondary treatment prior to land application (Tanner *et al.*, 2012). They are well suited to decentralized applications as they are requiring no mechanical components or external energy supply and have relatively long residence times. Furthermore, they are effective in removing biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total and fecal coliform, (Solano *et al.*, 2004). However, nitrogen and phosphate removal is limited (Abou-Elela *et al.*, 2014). The performance of HFCW is affected by many factors such as surface area, hydraulic loading rates (HLR), hydraulic retention time (HRT), type of vegetation, type of substrate, influent pollutant concentrations and the local environment (Trang *et al*., 2010). The plants growing in CWs are the most obvious visual characteristic of the systems. The plants used to stabilize the bed surface, increase porosity throughout the wetland volume, adsorb and store plant nutrients, prevent channelized flow and give the wetland a nice appearance (Abou-Elela and Hellal, 2012). There are many types of plants that are used as microphytes in constructed wetland, such as *Cyprus papyrus, Canna, Phragmits and Typha. Cyprus papyrus spp.* and other species of plants were studied by Abou-Elela *et al.* (2014) in a HFCW pilot plant. They reported that *Cyprus papyrus* was effective in nitrogen and phosphorus uptake and the removal of total coliforms, fecal coliforms and *E. coli.*

Also, there is a correlation between the hydraulic parameters and pollutants removal from HFCWs. For instance lower HLRs or longer HRTs typically result in better pollutant removal. Weerakoon *et al.*, (2013) reported that the most efficient pollutant removal can be accomplished within a 4–15 days HRT. In pilot studies carried out on HFCW, Tawfic (2003) evaluated the remediation efficiency under conditions of less than 1 day and 4 days HRT and concluded that the performance of the studied aquatic species varies in narrow ranges of 29% and 37% under conditions of hydraulic retention below one day, while high rates of remediation (75-85%) where attainable with four days retention time. Although in the great majority of studies on the effect of HLR and HRT on removal efficiency of HFCW systems is statistically proven, however, studying the application of different HLR and HRT at the same time on HFCW was not well investigated (Çakir *et al.,* 2015). In this study, the performance of a pilot plant HFCW vegetated with *Cyprus papyrus* for wastewater treatment was evaluated at different HLR, HRT and organic loading rate (OLR).

MATERIALS AND METHODS

In order to achieve the objectives of this study, a pilot plant horizontal flow constructed wetland (HFCW) planted with *Cyprus papyrus* was designed, constructed and put into operation within the vicinity of a wastewater treatment plant (WWTP). The treatment basin was fed continuously with real settled municipal wastewater.

Pilot plant description

The total surface area of the HFCW was 115.5m^2 with a depth of 0.85 m and 0.7% slope along the basin. It was filled with 20- 25 mm diameter gravel in the entire unit except one meter from the beginning. The end of the basin was filled with 40- 80 mm gravel to prevent clogging. Figure (1) shows a schematic diagram of the HFCW.

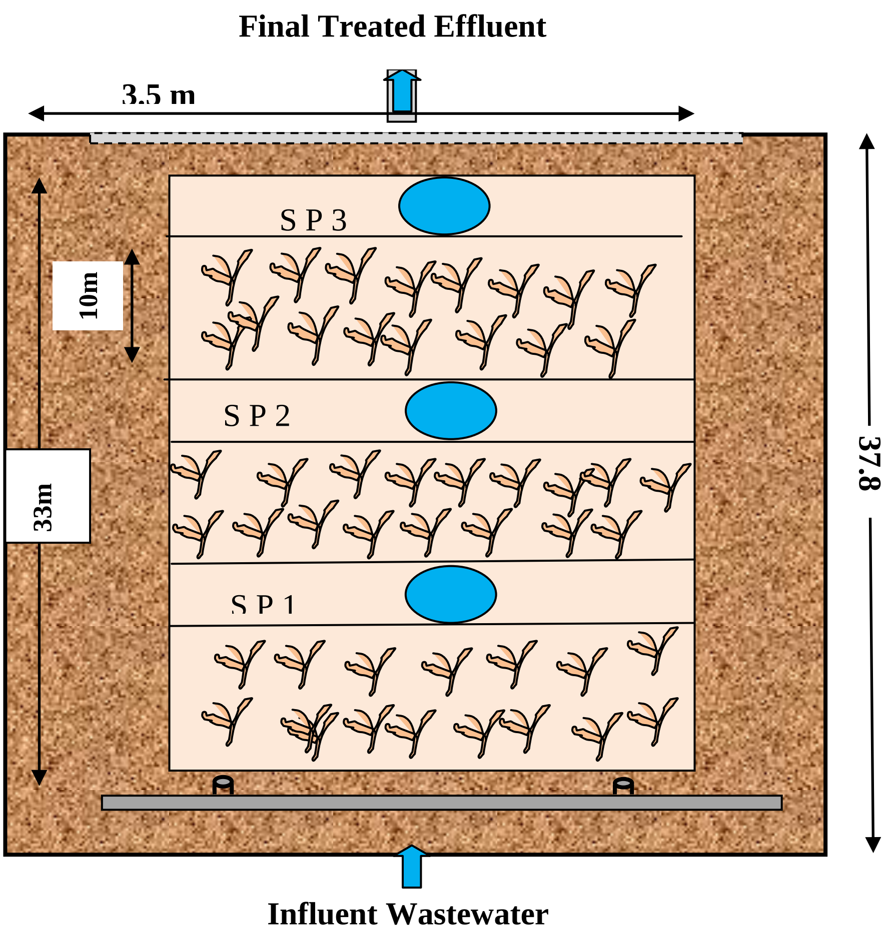


Figure (1): A schematic diagram of the HFCW

Table (1): Operating conditions and design criteria of HFCW

Design Parameters	Basin		
	S P 1	**S P 2**	**S P 3**
Flow rate	8.3 m^3 / day		
Length	13m	23m	33m
Width	3.5m		
Depth	0.85 m		
Porosity	40 %		
Surface area	45.5 m^2	80.5m^2	115.5m^2
Total volume	38.7 m^3	68.4 m^3	98.2 m^3
Effective volume	15.5 m^3	27.3m^3	39.3m^3
HRT	1.8 days	3.2 days	4.7 days
HLR $m^3/m^2.d$	0.18	0.1	0.07
OLR average	0.037kg BOD/m^3/d		

Sampling location and duration:

Wastewater samples were collected on weekly basis from the influent and the different sampling points along the basin. Also, different parts of the plant (stem, leaves and roots) were collected on monthly basis for analysis. The samples were collected and analyzed for a duration of almost one year.

Physico-chemical, biological and heavy metals analysis:

The pH, total dissolved solids (TDS) and temperature were measured using Thermo Scintific Orion 5 star. Chemical oxygen demand (COD), Nitrite (NO^{-2}) and Nitrate (NO^{-3}) were measured by spectrophotometer, Hach (DR 6000). Analysis of $N\text{-}NH^{+4}$ and TKN were carried out using Gerhardt Digestion and Distillation apparatus, Vapodest 10sn. Biological oxygen demand (BOD_5), total suspended solids (TSS), total coliforms (TC), Fecal coliforms (FC) and *Escherichia coli (E-coli)* were determined according to the standard methods for water and wastewater examinations (APHA, 2012). Analysis of heavy metals namely Lead (Pb), Chromium (Cr), Nickel (Ni), Copper (Cu), Cadmium (Cd) and Zink (Zn) were carried out using inductively coupled plasma-atomic emission spectrometry (ICP).

RESULTS AND DISCUSSION

Characterization of influent wastewater: Physico-chemical and biological analysis of the influent wastewater is depicted in Table (2). The results indicated a great variation in the strength of the influent wastewater. TSS was ranged from 84 to 122 mg/l with an average value of 102.4 mg/l, while TDS ranged from 430 to 550 mg/l. The BOD concentration ranged from 150 to 220 mg/l, with an average value of 175.7 mg/l. The COD ranged from 260 to 360 mg/l, with an average value of 304.5 mg/l. The ammonia and TKN concentrations varied from 19 to 27.1 mg N/ l and from 30.6 to 50.2 mg N/l, respectively.

Table (2): Characterization of influent wastewater to HFCW

Parameters*	Unit	Range	Mean
pH	--	6.9- 7.2	--
TDS	mg/l	430-550	498 ± 25
TSS	mg/l	84 – 122	102.4 ± 9.2
BOD	mg O_2/l	150 – 220	175.7 ± 18
COD	mg O_2/l	260 – 360	304.5 ± 25.3
NH_3	mgN/l	19 – 27.1	22.8 ± 2.5
TKN	mgN/l	30.6 – 50.2	41 ± 5.5
Total Coliform (TC)	MPN-Index/100ml	3.6×10^5 - 1.20×10^8	4.06×10^7
Fecal Coliform (FC)	MPN-Index/100ml	5.60×10^4 - 1.10×10^7	2.95×10^6
E. Coli	MPN-Index/100ml	2.10×10^3 – 7.90×10^4	2.09×10^4

* Mean of 25 samples

Analysis of heavy metals (Pb, Cu, Ni, Cr, Cd and Zn) indicated the presence of very low concentrations. This was expected since the raw wastewater used is mainly municipal wastewater. All physico-chemical analysis and bacteriological examinations of influent wastewater indicated that the wastewater used in this study is considered as a medium strength wastewater.

Effect of HLR, HRT and OLR on the performance of HFCW vegetated with *Cyprus papyrus:*

Performance of the HFCW at different HLRs, organic loading rates OLRs and hydraulic retention time HRT are depicted in Table (3

Table (3): Physico-chemical characteristics of the effluents at different sampling points along the basin.

Parameters	Unit	Raw wastewater	SP 1 Min	SP 1 Max	SP 1 Mean	% R.	SP 2 Min	SP 2 Max	SP 2 Mean	% R.	SP 3 Min	SP 3 Max	SP 3 Mean	% R.
pH	--	7.2	6.9	7.7	7.2	--	7.0	7.7	7.3	--	7	8	7.4	--
TDS	mg/l	498	400	600	527	--	499	650	559	--	512	685	601	--
TSS	mg/l	102.4	39	75	53	48.2	29	62	36	64.8	10	34	20	80.4
BOD	mg/l	175.7	37	108	62	64.7	27	68	40	77.2	14	37.4	23	86.9
COD	mg/l	304.4	61	185	103	66.1	48	121	68	77.6	24	56	38	87.5
Operating conditions			HLR = 0.18 m^3/m^2.d OLR = 0.094 kg BOD/m^3/d HRT = 1.8 days				HLR = 0.1 m^3/m^2.d OLR = 0.053 kg BOD/m^3/d HRT = 3.2 days				HLR= 0.07m^3/m^2.d OLR = 0.037 kg BOD/m^3/d HRT = 4.7 days			
NH_3	mg/l	22.7	13	24	17	25.1	8	18	13	42.7	3.2	12.7	7.1	68.7
TKN	mg/l	41.07	18	39.6	28	31.8	15	35	22	46.4	9.5	22.2	15.5	62.2
NO_2^-	mg/l	0.03	0.04	0.14	0.07	--	0.04	0.16	0.1	--	0.81	1.87	0.15	--
NO_3^-	mg/l	0.7	0.22	1.22	0.9	--	0.7	1.7	1.2	--	0.09	0.99	1.4	--
Operating conditions			HLR = 0.18 m^3/m^2.d OLR = 0.094 kg BOD/m^3/d HRT = 1.8 days				HLR = 0.1 m^3/m^2.d OLR = 0.053 kg BOD/m^3/d HRT = 3.2 days				HLR= 0.07m^3/m^2.d OLR = 0.037 kg BOD/m^3/d HRT = 4.7 days			

* Mean of 25 samples

Reduction of TSS, BOD and COD: Increasing the HRT from 1.8 to 3.2 days, while decreasing the HLR from 0.18 to 0.10 m^3/ m^2.d improved greatly the quality of the treated effluent. The average removal of TSS increased from 48.2 % at HLR 0.18 m^3/m^2.d to 64.8 % at HLR 0.10 m^3/m^2.d and then reached 80.4 % at HLR 0.07 m^3/m^2.d. The results obtained are in agreement with Shubiau *et al*, (2011). The reduction in TSS in wetlands is supported by physical processes such as filtration, sedimentation and microbial assimilation within the wetland substrate media. Further, Manios *et al.* (2003) listed substrate hydraulics and microbiological characteristics as the other main TSS reduction processes in a wetland system. At increased HLRs solid particles have more tendencies to escape the substrate media with increasing flow velocities. Similar results were also observed in other studies. Manios *et al.* (2003) illustrated that TSS removal depends on the type and size of the substrate media and hydraulic retention time (HRT) or HLR.

The same behavior was observed for BOD and COD removals. BOD removal value was 64.7 % at HLR 0.18 m^3/m^2.d and improved to 77.2 % at HLR 0.10 m^3/m^2.d and reached 86.9 % at HLR 0.07 m^3/m^2.d. The average of COD reduction was 66.1 % at HLR 0.18 m^3/m^2.d and increased to 77.6 % at HLR 0.10 m^3/m^2.d and 87.5 % at HLR 0.07 m^3/m^2.d.

The drop in BOD_5 and COD removal efficiencies at high HLRs can be attributed to the insufficient contact time within the system. According to Reed and Brown (1995) the BOD_5 removal in a wetland system is critical below 1 day HRT and improves until HRT of about 7.5 days. The results obtained during our study gave a very high quality effluent at a HRT of 3.2 days. In addition, the COD removal efficiencies achieved in this study under different HLRs are comparable with the average results reported by Konnerup *et al.* (2009) using HFCW. They achieved 41 % and 80 % COD reduction at 0.44 m^3/m^2.d and 0.55 m^3/m^2.d HLR. Figure (2) illustrates the average removal rates of TSS, BOD and COD at different HLRs and HRTs.

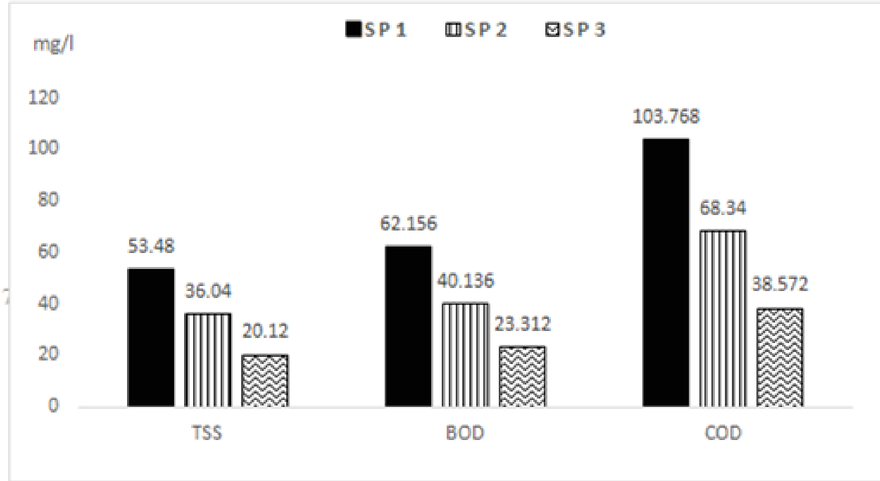
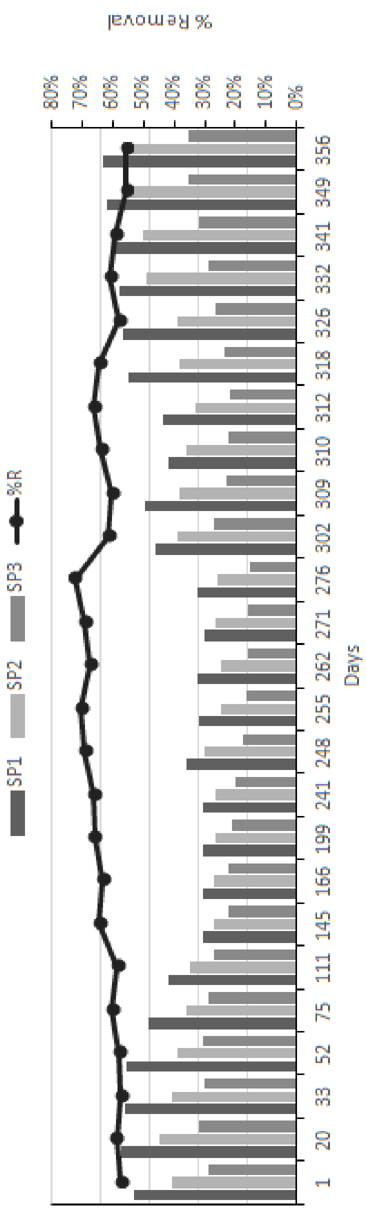


Figure (2): Variations of TSS, BOD and COD concentrations at different samples points.

TKN and ammonia removal: The results illustrated in Figure (3) indicate that by decreasing the HLR and consequently increasing HRT improves the removal rate of TKN. The average reduction of TKN reached 31.8% at HRT 1.8 days with a residual value of 28 mg/l, then reached 46.4% at HRT 3.2 days with a residual value of 22 mg/l and finally it was 62.2% at HRT 4.7 days with a residual value of 15.5 mg/l.

The same behavior was observed for NH_3. Figure (4) indicates that by decreasing the HLR and consequently increasing HRT, the removal rate of NH_3 has been improved. The average reduction of NH_3 reached 25.1% at HLR 0.18 m^3/m^2.d with a residual value of 17 mg/l, then reached 42.7% at HLR 0.10 m^3/m^2.d with a residual value of 13 mg/l and finally it was 68.7% at HLR 0.07 m^3/m^2.d with a residual value of 7.1 mg/l.



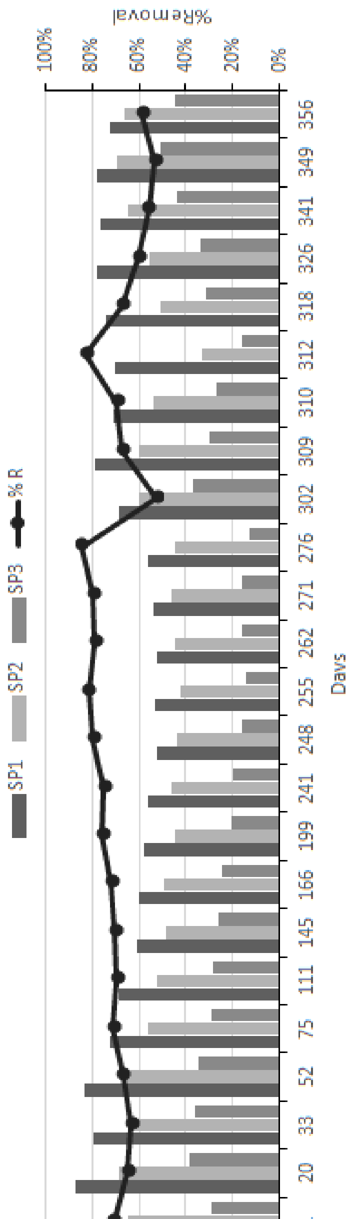


Figure (3): Variations of TKN concentrations at different HLRs

When the HLR increased, soil clogging occurred due to overfeeding and soil permeability decreased quickly to a small value (Haibo Li *et al.*, 2012). Deterioration of nitrification was obvious caused by soil clogging, resulting in the great elevation of NH_3 concentration in effluent at this condition. Correspondingly, 3 averag3e TKN 2 removal efficiency decreased. The transformation and removal of nitrogen in CWs could be accomplished by ammonification (Amino acids → NH_4-N), classical route of nitrification (NH_4-N → NO_2-N → NO_3-N), and classical denitrification (NO^{-} ^{3}-N → NO^{-2}-N → NO → N_2O → N_2) (Vymazal, 2007). Nitrification is the second step of nitrogen trans-formation if the wastewater is primarily composed of organic nitrogen. However, if NH_4^{+}-N predominates, the nitrification process becomes the first step to convert the existing form (Saeed and Sun, 2012). The results depicted in Figure (5) showed that the ammonia removal increased with the increase of nitrification process and the decrease of HLR. Also, *Cyprus papyrus* plant proved to be very efficient in nitrification processes due to the high diversity of the roots that increase the treatment surface area. These results coincide with those found by Kyambadde *et al.* (2004). *Cyprus papyrus* root structures provided more microbial attachment sites, sufficient wastewater residence time, trapping and settlement of suspended particles, surface area for pollutant adsorption, uptake, assimilation in plant tissues and oxygen for organic and inorganic matter oxidation in the rhizosphere, accounting for its high treatment efficiency. In addition, *Cyprus papyrus* exhibited a significantly large number of adventitious roots. Nitrifying bacteria attached to *Cyprus papyrus* and the corresponding nitrification activities were consistent with this finding.

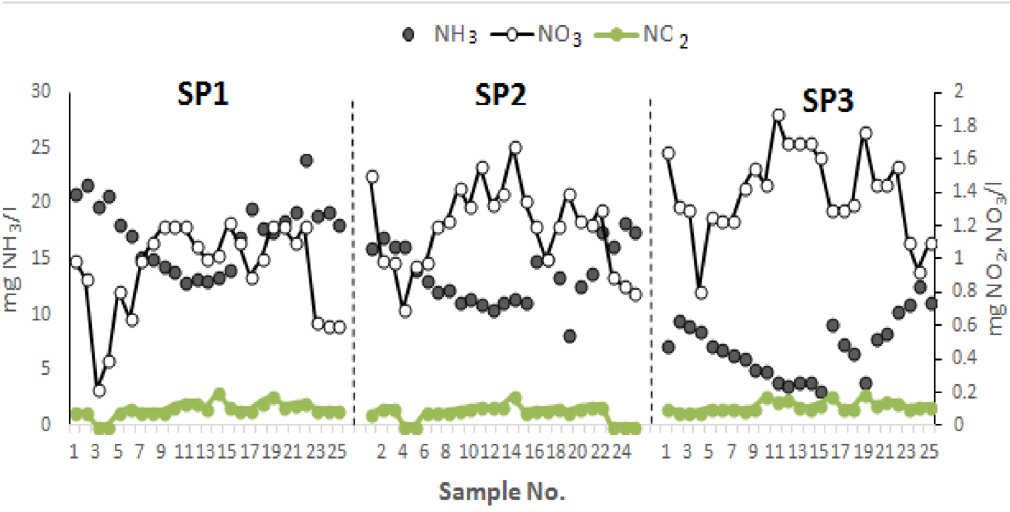


Figure (5): The relation between ammonia removal and nitrate formation at different HLR.

Microbial removal: The results depicted in Table (4) show that the removal rate of bacterial indicators has been increased as the HLR decreased and HRT increased along the basin. By increasing the HRT from 1.8 days at point (SP 1) to 3.8 days at point (SP 2), the removal of TC, FC and *E.coli* increased by 1.5 logs, 1.4 logs and 0.86 log, respectively, while the removal of TC, FC and E.Coli at HRT 4.7 days and HLR 0.07 m^3/m^2.d point (SP3) increased by 2.5 logs, 2.4 logs and 1.0 log, respectively.

The results obtained can be explained on the biases that coliform removal mechanism in a constructed wetland includes physical processes; filtration, sedimentation, ultra-violet radiation, etc., chemical processes; adsorption, oxidation, die-off due to toxins and biological activities; ingestion by protozoans, release of antibiotics by plant roots and natural die-off. Further, it is believed that the plant coverage, hydraulic retention time and settling of microorganisms also play key roles in coliform reduction efficiency **(Trang *et al*., 2010)**.

Table (4): Average bacterial counts in effluent of HFCW at (SP 1, SP 2 and SP 3) points

Parameter	influent wastewater	(SP 1)point MPN-Index/100ml			(SP 2) point MPN-Index/100ml			(SP 3) point MPN-Index/100ml		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Total Coliform (TC)	4.06×10^7	$2x10^5$	$2.5x10^7$	$4.5x10^6$	$3.7x10^3$	$1.7x10^6$	$4.0x10^5$	$1.8\ x10^2$	$1.7\ x10^5$	$3.1\ x10^4$
Fecal Coliform (FC)	2.95×10^6	$3.6x10^4$	$3.1x10^6$	$7.5x10^5$	$3.6x10^2$	$2.1x10^5$	$5.2x10^4$	$1.8x10^2$	$6.1x10^3$	$1.6x10^3$
E. coli	2.09×10^4	$1.5x10^3$	$4.0x10^3$	$2.4x10^3$	$1.7x10^2$	$3.1x10^3$	$1.5x10^3$	$6.3x10^1$	$5.6x10^3$	$1.0x10^3$

Plants uptake and biomass production: Plant harvesting must be practiced in order to remove organic matters and nutrients from the system. Since the aim of this study is to achieve the highest removal of pollutants, biomass was harvested after 12 months operation for *Cyprus papyrus*. The dry biomass of *Cyprus papyrus* was 7.7 kg/m^2. This biomass yield was greater than that reported for the same plant by Abou-Elela *et al.* (2013). They reported maximum dry biomass of 5.6 kg/m^2 at HLR 0.03 m^3/m^2.d and HRT 11 days. The plant nitrogen and phosphorus uptake was 116.4 g/m^2 and 70.2 g/m^2, respectively. These results are in agreement with Abou-Elela *et al.* (2013), who reported that nitrogen and phosphorus uptake by *Cyprus papyrus* was better than other plants used.

CONCOLUSION

This study investigated the effects of HLR, HRT and OLR on the performance of HFCW vegetated with *Cyprus papyrus* for municipal wastewater treatment. Pollutant removal efficiencies decreased with increasing the HLR and decreasing HRT. Accordingly, HLR and HRT are a significant design parameters determining the treatment efficiency in HFCW. Results revealed that HFCW with *Cyprus papyrus* is capable of substantial reduction of COD, BOD_5, TSS, TKN, NH_3, FC and TC concentrations with a good buffering capacity under HLR, 0.10 and $0.07 m^3/m^2.d$. The application of HLR $0.07 m^3/m^2.d$ and HRT of 4.7 days result in 87.5%, 87% and 80.4% removal of COD, BOD and TSS respectively. This makes the HFCW systems as a useful treatment alternative at places with high flow fluctuations, Furthermore the use of *Cyprus papyrus* proved to be very efficient in nitrification process as well as it can be used as commercial product for many industries. In addition one of the benefits of HFCW is the generation of beautiful landscape generated as a result of the presence of *Cyprus papyrus* plants located in the basin of treatment.

REFRENCES

Abou- Elela, S. I., and Hellal, M. S. (2012): Municipal wastewater treatment using vertical flow constructed wetlands planted with *Canna*, *Phragmites* and *Cyprus*. Ecological engineering, 47, 209- 213.

Abou-Elela, S. I.; Golinelli, G.; El-Tabl, A. S. and Hellal, M. S. (2014): Treatment of municipal wastewater using horizontal flow constructed wetlands in Egypt. Water Science and Technology, 69(1), 38- 47.

Abou-Elela, S. I.; Golinielli, G.; Abou-Taleba, E. M. and Hellal, M. S. (2013): Municipal wastewater treatment in horizontal and vertical flows constructed wetlands. Ecological Engineering, 61, 460-468.

APHA, American Public Health Association, (2012): Standard methods for the examination of water and wastewater, 22nd ed. United Book Press, USA.

Çakir, R., Gidirislioglu, A. and Çebi, U. (2015): A study on the effects of different hydraulic loading rates (HLR) on pollutant removal efficiency of subsurface horizontal-flow constructed wetlands used for treatment of domestic wastewaters. Journal of Environmental Management, 164, 121-128.

Choudhary, A.K., Kumar, S. and Sharma, S. (2011): Constructed wetlands: an approach for wastewater treatment. Elix. Pollut. 37, 3666-3672.

EPA, (2004): Constructed Treatment Wetlands. Office of Water, 843-F-03-013, 2004.

Guimaraes, B.; Simoes, P. and Marques, R. (2010): Does performance evaluation help public managers? A balanced scorecard approach in urban waste services. J. Environ. Manag. 91 (12) 2632- 2638.

Haibo, L.; Yinghua L.; Tieheng S. and Xin W. (2012): The use of a subsurface infiltration system in treating campus sewage under variable loading rates. Ecological Engineering, 38 (6) 105- 109.

Kaplan, R. and Norton, D., (1992): The balanced scorecard measures that drive performance. Harv. Bus. Rev. 70 (1), 70- 79.

Konnerup, D., Koottatep, T. and Brix, H. (2009): Treatment of domestic wastewater in tropical, subsurface flow constructed wetlands planted with *Canna* and Heliconia. Ecological engineering, *35*(2), 248-257.

Kyambadde, J., Kansiime, F., Gumaelius, L. and Dalhammar, G. (2004): A comparative study of *Cyprus papyrus* and *Miscanthidium violaceum*-based constructed wetlands for wastewater treatment in a tropical climate. Water Research, 38(2). 475- 485.

Liu, W.; Dahab, M. F. and Surampalli, R. Y. (2005): Nitrogen transformations modeling in subsurface-flow constructed wetlands. Water environment research, 77(3) 246-258.

Manios, T.; Stentiford, E. I., and Millner, P. (2003): Removal of total suspended solids from wastewater in constructed horizontal flow subsurface wetlands. Journal Environmental Science and Health, Part A, 38(6) 1073- 1085.

Reed, S. C. and Brown, D. (1995): Subsurface flow wetlands—a performance evaluation. Water environment research, 67(2), 244-248.

Saeed, T. and Sun, G. (2012): A review on nitrogen and organics removal mechanisms in subsurface flow constructed wetlands: dependency on environmental parameters, operating conditions and supporting media. Journal Environmental Management, 112, 429- 448.

Solano, M. L.; Soriano, P. and Ciria, M. P. (2004): Constructed wetlands as a sustainable solution for wastewater treatment in small villages. Biosystems Engineering, 87(1) 109-118.

Tanner, C. C.; Sukias, J. P.; Headley, T. R., Yates; C. R., and Stott, R. (2012): Constructed wetlands and denitrifying bioreactors for on-site and decentralised wastewater treatment: comparison of five alternative configurations. Ecological Engineering, *42*, 112-123.

Tawfic, T. A. (2003): Effective natural wastewater treatment systems in rural areas of Egypt. In The 4th International Conference & Exhibition for Environmental Technologies, Management & Funding" The Gateway to Profitable Environmental Compliance" Cairo International Conference Center (Vol. 30, pp. 02-09).

Trang, N. T. D., Konnerup, D.; Schierup, H. H.; Chiem, N. H. and Brix, H. (2010): Kinetics of pollutant removal from domestic wastewater in a tropical horizontal subsurface flow constructed wetland system: effects of hydraulic loading rate. Ecological engineering, 36(4), 527-535.

Vymazal, J. (2007): Removal of nutrients in various types of constructed wetlands. Science of the Total Environment, 380 (1) 48-65.

Weerakoon, M.P.R.; Jinadasa, K.B.S.N.; Herath, G.B.B.; M.I.M. Mowjood and Van Bruggen, J.J.A. (2013): Impact of the hydraulic loading rate on pollutants removal in tropical horizontal subsurface flow constructed wetlands. Ecol. Eng. 61, 154- 160.

Wu, S., Austin, D., Liu, L. and Dong, R. (2011): Performance of integrated household constructed wetland for domestic wastewater treatment in rural areas. Ecological Engineering, 37(6) 948-954.

العوامل المؤثرة على أداء الأراضي الرطبة المشيدة بالتدفق الأفقى المزروعة بنبات البردى لمعالجة مياه الصرف الصحي

[١]

سهير إمام أبو العلا(١)– محمد على الإخناوى(٢)– مجدى توفيق خليل(٣)
محمد سعد هلال(١)– محمد علي إبراهيم
١) المركز القومى للبحوث ٢) الشركة القابضة لمياه الشرب والصرف الصحي ٣) كلية العلوم، جامعة عين شمس

المستخلص

إن الهدف من هذا البحث هو دراسة تأثير الحمل الهيدروليكى والحمل العضوى وزمن المكث على كفاءة طريقة معالجة الصرف الصحى باستخدام الأراضي الرطبة المشيدة ذات التدفق الأفقى (HFCW) والمزروعة بنبات البردي. يستقبل حوض المعالجة مياه خام بمعدل ٨،٣ م^{٣}/ يوم بمتوسط حمل عضوى ٠،٠٣٧ كجم BOD/ م^{٣}/ يوم ومساحة الحوض ١١٥،٥ م^{٢}. وقد تم تشغيل حوض المعالجة عند ثلاثة أحمال هيدروليكية مختلفة (HLR) بقيم ٠،١٨ و ٠،١٠ و ٠،٠٧ م^{٣}/م^{٢}.يوم وزمن مكث قدره ١،٨ و ٣،٢ و ٤،٧ أيام على التوالى. وقد أظهرت النتائج المتحصل عليها أن كفاءة هذه الطريقة للمعالجة تتأثر بصورة عكسية مباشرة مع زيادة الحمل الهيدروليكى HLR وتقليل زمن المكث. وبتطبيق الحمل الهيدروليكى (٠،٠٧ م^{٣}/م^{٢}. يوم) وزمن مكث (٤،٧) يوم كان لذلك تأثير إيجابى على جودة السيب النهائى الناتج من حوض المعالجة حيث بلغت نسبة الإزالة فى الإحتياج الاكسجين الكيميائي (COD) ٨٦% والأكسجين الحيوي الممتص (BOD) ٨٧% والمواد الصلبة العالقة (TSS) ٨٠٪ وكذلك فإن استخدام نبات البردى أثبت كفاءة عالية فى عملية النيترة. و تم تحقيق إزالة ٢–٣ لوج من البكتريا القولونية البرازية. والكتلة الحيوية الجافة المنتجة من البردى ٧،٧ كجم/م^{٢}.

الكلمات الدالة: الأراضى الرطبة المشيدة– التدفق الأفقى– البردى– معالجة مياه الصرف الصحى– الحمل الهيروليكى.