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Performance Removal Nitrate and Phosphate from Treated Municipal Wastewater Using Phragmites Australis and Typha Latifolia Aquatic Plants

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ORIGINAL ARTICLE

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ABSTRACT: Effluent generally includes nutrient elements like nitrogen and phosphorus. Its discharge to water resources leads to an increase in the growth of different types of algae، hence it is necessary to decrease the amount of phosphorus and nitrogen as much as possible before discharging of effluent to water resources. The use of aquatic plants is one of the effective methods for refining nitrogen and phosphorus in polluted water. In this research, performance of Phragmites australis and Typha latifolia planted in sewage channels with subsurface flow to filter nitrate & phosphate of municipal wastewater is investigated. To carry out, outdoor channels with 3 meters length and 0.15 meter width were build. The pilot system consisted of channels which were filled with ripples (diameter of 10-20 mm, 50% porosity) up to 0.07 of height of channel. The plants was planted in channels and the sewage sample, which was taken from Urmia University wastewater with a constant flow 30 ml/min routed through the system in form of subsurface flow. The effluent inters a tank outlet. Samples were taken every week for a period of 6 weeks and DO, PH, Nitrate (NO-3 – N) and phosphate (PO4-3 – P) were measured in output and input of the system. Average increase of DO and PH for Phragmites australis and Typha latifolia channels were 204, 205 & 9, 9.1 percent respectively and average reduction of Nitrate and phosphate were 81.43, 92.66 and 83.66, 74.26 percent respectively.

Keywords: Nitrate, Phosphate, Phragmites australis, Typha latifolia, channel, Wastewater.

INTRODUCTION

Soon after great growth of population, industrial development and water consume now all societies are being challenged with increase of sewage waters. The release of sewage to natural environment may lead to heavy destruction of biological and ecological elements of the environment, pollution of surface and under surface waters and creation of acute and chronic diseases (Hosseini and Ghodsian, 2011).

It is known that ingredients such as nitrogen and phosphorus are the main nutrition elements for all living beings and plants; however the release of such ingredients into the water, which is the result of agricultural and industrial activity and can be found in urban sewage, is among the most menacing factor concerning the quality of water (Chang et al., 2009).

Studies have proven that even the existence of low amount of nitrogen and phosphorous, respectively 0.4 mg and 0.1 mg per Lit in placid waters such as streams and lakes can lead to faster growth of various kinds of algae which will decrease the density of dissolved oxygen and penetration of sunlight into the beneath of water. So that all these alterations will end with the destruction of fishes and microorganisms, which result in an increase of oxygen demand for their carcass being decomposed. In such conditions an aerobic alters to anaerobic and all of the mentioned process will lead to creation of phenomena called enriched waters. Beside the outbreak of issues which are related to the phenomenon for the environment, the price and cost of purification of such waters is considered to be splurge and undesirable (Camargo and Alonso, 2006). The consumption of water that are polluted with nitrate can lead to the spread of Methemoglobinemia diseases among the children and gastrointestinal cancer among the adults (Lin et al., 2002). So, the reduction in nitrogen and phosphorus before discharging wastewater into water sources should be conducted.

Nowadays there are many choices of sewage purification systems and all of them have some drawback like their price, high energy consumption, maintenance and complex utilization, but they have high performance and efficiency (Sperling, 1996).

One of the natural ways of filtration of urban and industrial sewage is the use of lagoon. This is one of the most economical and affordable methods, because of its low price of construction, utilization and simple maintenance procedures and its high performance in elimination of environmental pollution (Reed et al, 1996). The lagoon is defined as "a ground which its water lever is as much as needed for providing condition within which the soil is saturated with water and condition for growth of plants is being provided (Crites et al., 2010). In the developed countries for indoor filtration, agricultural runoff, industrial sewage, landfill Leachate, floods and urban runoffs, sewage filtration, autotrophic lake restoration and purification of water that are polluted by

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nutrients such as nitrate and phosphorus the use of artificial lagoons is so prevalent (Moor et al., 2000, Vymazal, 2007).

It is for a long time that human beings are using lagoon as a means for pollution control (Mitsch and Jrgensen, 1989; Mitsch and Jrgensen, 2004). Generally speaking, the lagoon is divided into two groups named natural lagoons and artificial lagoons. The artificial lagoons themselves are divided into two subgroups, the former called artificial lagoons with subsurface flow within which the flow of liquid existing beneath the gravel or sad sub-level. The latter is called artificial lagoons with free water surface, within which the liquid and sewage are in the connection with air and use soil or other suitable environment for the growth of plants that are resulted from water (Reed et al., 1989). In artificial lagoons the process of filtration is more controlled when it is compared with natural lagoons (Kadlec and Knight, 1996). The lagoon is replete with sand, gravel and soil along an appropriate grading. This kind of bed provides a suitable place for the growth of bacteria and basically possesses a mineral soil (Thurston et al., 2001).

Lagoon system can omit BOD, suspended solids, nitrogen, phosphorous also metals and other rare ingredients and pathogens. This system has a hyperactive biological activity, since there are different ilk if plants and species within the soil compound. This ilk can lead to the filtration of sewage and improvement of sewage quality (Kadlec and Brix, 1994). Phytoremediation is an economic, environmental and business technique. Yet, this technique is not localized in countries such as Iran.

Phytoremediation is based on the potential physiological capacity of green plants, various kinds of weeds, water and crop plants and even trees for elimination of pollutants from water, sewage and soil or it may be used for reducing the dangers of environmental pollutants like heavy metals, rare ingredients, mineral compounds and radioactive materials (Gillan, 2012).

Aquatic shrub like Phragmites australis and typha are used in countries like Egypt, Thailand and Japan under different conditions for purification of sewage (Tang et al., 2009). Studies have proved that the influence of artificial lagoons that are made of Phragmites australis and louse in elimination of nitrogen and phosphorous is between 20-98 and 18-94 percent, respectively (Vymazal, 2007, Tang et al., 2009).

The Phragmites australis can efficiently absorb the nutrients. This plant possesses a great biomass lump that is located in the upper region (leaves) and underneath region (Underground stems and roots) which is considered as substrate surface. Subsurface plant tissues grow in vertical and horizontal form and they form an extensive matrix which connects soil articles to each other and provide an extended surface for absorption of nutrients (nitrogen and phosphorous) and ions. The empty tube within the tissue of the plant makes it able to convey the oxygen from the leaves to the stem and surrounded soils. This mechanism lead to creation of a process which is responsible for decomposition of active aerobic microbial and absorption of pollutants in water system (Robert and Kadlleck, 1996, Vymazal, 2005, Wood, 1995). The scattering of this global plant and optimized PH for this plant is between 6 and 8.5. The desirable temperature for growth of Phragmites australis is between 20 to 30 C and it has no major activity in temperature lower than 0 C.

Typha latifolia is one of the shrubs which is hydrophilic and its stem is located in bed and its upper part appears above the water. This perennial plant can be found in stagnant waters, near rivers and rice fields (Hunter et al., 2001). The tolerance of this plant against the salt is average and its optimized PH is between 4 to 10. The desirable temperature for this plant is between 10 to 30 and for growth of seed is 12 to 24 C. this plant growths via the spill development at high pace (Mofazi et al., 2009). Since the typha plant possesses an especial kind of tissue system, it can have absorb, storage and elimination of nutrient abilities per a year, even if its upper region being cut. The root section of this plant act as biological filtration for removing different kinds of mineral substances (Werker et al., 2002). With regard the pollution of some sewage with nitrogen and phosphorous and the release of this runoffs into agricultural field and other water streams, also their undesirable effect on making the surface water being much more enriched which also menace human life, this study and survey is designed and undertake for investigation of influence of typha Phragmites australiss and aquatic plants on elimination of nitrogen and phosphorous from sewage water of Urmia City.

Research Method:

This study aims at investigation of function of aquatic and typha plants in under surface lagoons in the elimination of nitrate, phosphorous and increasing the amount of dissolved oxygen in Do and PH water. The needed sewage is collected from Urmia University refinery. This refinery is based on lagoon system.

In this experiment, the sewage was passed through a shallow channel which were filled with pebbles, also aquatic Phragmites australis and typha plant is planted. The diameter and discharge coefficient of the used pebbles are equal to 10 to 20 mm and 50 percent, respectively. The sewage is passed in subsurface form, so that the mainstream of sewage is marinated under the pebbles. In pilot plan, seven channels were parallel used, wherein 3 of them there exists 20 days old 30 Phragmites australis plant and in other 3 channels there exist typha. The main justification of why we have used 3 channels for Phragmites australis and typha plants is to obtain more data within the limited range of time to plant and to obtain more redundant data.

Effluent tanks are made of plastic and their capacity is about 50 lit. The channels are made of 6 inch PVC pipes with a length of 3 meters and 0.15 diameters which are horizontally bisected. Pebbles are placed at 8.2 feet long, 15.0 mm width and 07.0 meter height of channels.

The whole system is constituted of 7 shallow channels, 7 supply and wastewater collection tank. This system acts as surveillance circle. In order to prevent any increase in the amount of sewage in rainy days, we have used a plastic cover. In this system, about 30 Lit sewage is being used for filtration in every channel. The sewage is allowed to pass from storage tank under a stable stream with constant intensity of 30 ml/min in form of a subsurface stream through the channels, so that the filtration process is being fulfilled by the use of

Phragmites australis and typha plants. The crossed sewage through the channels is being collected in terminal tanks and again they are being returned to the storage tanks. The sampling is done form channel after passing of10 days after the launch of the system. After the growth of plants, sampling is done once upon a week from the first half of November till second half of December year of 2013, from the outputs of the channel. There were totally 42 samples provide and this number with regard to other similar studies were opted (Yousefi et al., 2001).

After the execution of different experiments, the resulted data were analyzed via SAS Software. A multivariate test of Duncan was used for comparison of deviation average of parameters among the channels linked to the Phragmites australis and typha channels with the control channel (no plant).

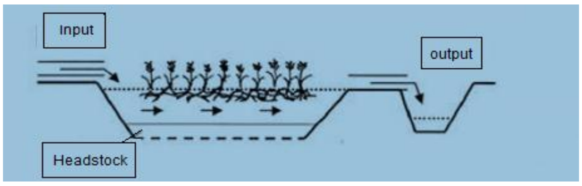

Figure 1. Schematic Plan of Under investigation Channels

RESULTS AND DISCUSSION

Throughout the study the dose of Nitrate (N-No_3), phosphate (P-$PO^3{}_4$) and dissolved oxygen (DO) and PH of Input and output section of channels which are being planted with Phragmites australis and typha plants were measured and you can find the average and standard deviation of input, output parameters of channels in Tables 1 and 2.

Table 1. The average and standard deviation of input and output parameters of channels including Phragmites australis plant

Parameters	Input Sewage	1st Channel output Phragmites australis plant	2nd Channel output, Phragmites australis plant	3rd Channel output, Phragmites australis plant	Control Channel (no plant)
NO3_N (mg/L)	± 0/0083.7	9.2 ±29.26	9.15 ± 24.96	8.63 ± 26.65	8.1 ± 49.95
PO4-3_P(mg/L)	± 0/0014.4	0.85 ± 3.52	0.71 ± 3.44	0.83 ±3.39	1.53 ± 8.43
DO (mg/L)	± 0/001.47	1.88 ±4.39	1.82 ± 4.42	1.95 ±4.62	2.15 ± 5.13
PH	± 0/007.74	0.2 ± 8.61	0.24 ± 8.56	0.23 ± 8.62	0.23 ± 8.54

Table 2. The average and standard deviation of input and output parameters of channels including typha plant

Parameters	Input Sewage	1st Channel output typha plant	2nd Channel output, typha plant	3rd Channel output, typha plant	Control Channel (no plant)
NO3_N (mg/L)	± 0/0083.7	10.45 ±21.65	10.09 ± 19.58	11.21 ±17.06	8.1 ± 49.95
PO4-3_P(mg/L)	± 0/0014.4	0.96 ± 5.11	1.09± 5.01	1.02 ±4.74	1.53 ± 8.43
DO (mg/L)	± 0/001.47	1.87 ±4.41	1.97 ± 4.56	1.97 ±4.51	2.15 ± 5.13
PH	± 0/007.74	0.18 ± 8.37	0.23 ± 8.42	0.25 ± 8.52	0.23 ± 8.54

The Efficiency of Channel System including Phragmites australis Plant with subsurface stream in Elimination of Nitrate:

The variations of nitrate dose within the channels that are under experiments are presented in diagram 2. Throughout the experiment period the amount of nitrate linked to the 1st , 2nd and 3rd channels including Phragmites australis plant is being filtered from to 83.7 mg/lit to 17.5 mg/lit, 13.4 and 15.6 mg/lit, respectively . The amount of same parameter in the other channels that include typha plant is decreased from to 83.7 mg/lit to 9 mg/lit, 6.2 mg/lit and 3.1 mg/lit. Within the control channel we also have faced with reduction of nitrate from 83.7 mg/lit to 40.8 mg/lit. It can be deduced that the ability of control channel to reduce the nitrate during the experiment period when it is compared with other channels including read and typha plant is about 30 and 41.46 percent lower that mentioned channels, respectively.

The result of diagram 2 implies that in all corresponding curves to the channels there two different inclination for reduction of nitrate; steep

and slow. The steep slope is related to the first week of experiment during which the reduction of nitrate for 1st, 2nd and 3rd channels including Phragmites australis plant is equal to 47.6 percent, 51.8 percent and 51.8 percent, while for channels including typha is equal to 55.5 percent, 55.5 percent and 59.2 percent. For control channel the reduction of nitrate is equal to 25.9 percent. The slow slope is related to the 2nd, 3rd , 4th, 5th and 6th week of experiment and the percent of reduction in amount of nitrate during this period for 1st, 2nd and 3rd channels including Phragmites australis plant is equal to 31.4 percent, 32.2 percent and 29.5 percent, while the amount of same parameter for 1st, 2nd and 3rd channel including typha plant is equal to 33.7 percent, 37 percent and 34.1 percent. The reduction of nitrate for control channel is also equal to 25.3 percent. Minor changes that occur in reduction of nitrate within 1st, 2nd and 3rd channel including Phragmites australis and typha plants is so obvious which in fact it originate from the changes that occur in the root and density of plants. In diagram 2 we notice the high efficiency of typha plant in reducing the nitrate because of its physiological feature when it is compared with Phragmites australis plant.

Diagram 3 shows the efficiency of channels including Phragmites australis and typha plant in eliminating the nitrate. As it is obvious, the maximum efficiency is related to 3rd channel including typha plant which is equal to 96.3 percent, the minimum efficient is related to 1st channel including Phragmites australis plant which is equal to 79 percent and the efficiency of control channel in eliminating the nitrate is equal to 51.2 percent.

The results proved that the impact of Phragmites australis and typha plants in reducing the rate of nitrate existing in sewage is so obvious when compared with lagoons without any plants. It should be pointed out that lagoons without plant also have efficiency in reducing the rate of nitrate, since in other survey it was deduced that denitrification and nitrification processes efficiency in removal of nitrate rate is higher than plant absorption method (Zimmo et al., 2004).

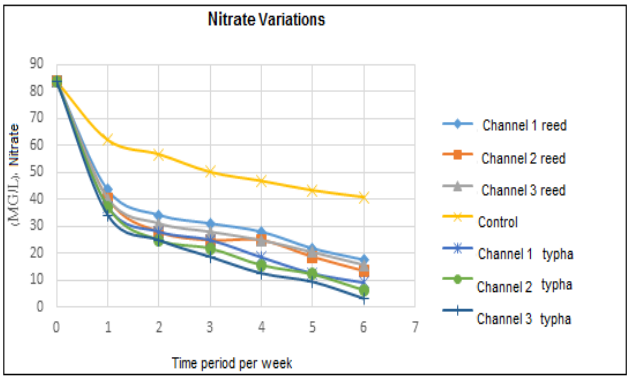

Figure 2. The variations of Nitrate during the 6 week of experiment for 1st, 2nd and 3rd channels (Including Phragmites australis plant), 1st,2nd and 3rd channel (including typha plant) and control channel (no plant)

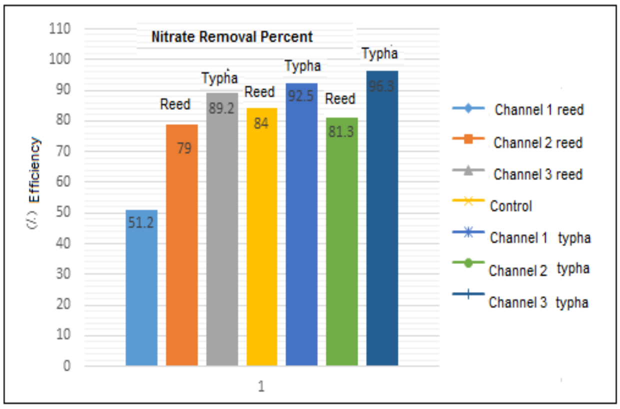

Figure3. Nitrate removal rate for channels 1, 2 and 3 (include Phragmites australis), channels 1, 2 and 3 (containing typha plant) and control channel (no plant)

Nonetheless, this study has proved that artificial lagoons that are based on plant are more efficient in removing the nutrients than the same kind of lagoons which are not based on plant, this conclusion is identical to other research results (Hunter et al., 2001). The reason lies in the fact that since these lagoons are based on plant and these plant root are best domicile for growth of bacteria that lead to more elimination of nutrients. But in lagoons that are no based on plants the population of bacteria is very low, however the fact that bacterial processes also play an important role in reducing the amount of nutrients is undeniable fact (Zimmo et al., 2004).

Aquatic plants release oxygen via the photosynthesis process in aquatic environment provide needed oxygen for oxidation of aluminum into nitrate through the bacteria, Moreover Plant respiration process can reduce the oxygen lever and activate the denitrification which will lead to conversion of nitrate into nitrogen gas (Chang et al., 2009).

In this paper, the average removal rates of nitrate via the channels including Phragmites australis and typha plant is equal to 81.4 and 92.6 percent, respectively for input concentration of 83.7 mg/lit which report higher amount of efficiency when compared with results of other similar researches.

Boorgheie and Nurbakhsh have reported the efficiency of subsurface horizontal artificial lagoons based on Phragmites australis plant (Phragmites Australis) in elimination of nitrate to be about 79.62 percent (Boorgheie and Noorbakhsh, 2002). Pandashte and et al have proved that the nitrogen pollution via canebrake is equal to 60 percent (Pendashteh et al., 2006). Vymazal have reported that the average efficiency of subsurface artificial lagoons for filtration of sewage and elimination of nutrients within plant substrate for total nitrogen is equal to 41.6 percent (Vymazal, 2007).

Thus, according to the layering and the use of mineral shells of the layer below the soil surface and plant roots and place and sewage flow, the increase of the absorption and elimination of nitrate from system may be due to the use of such materials in layering of system. Indeed, the nitrogen removal rate of fine-grained soil via surface absorption was always better than coarse-grained soil. The main reason of such phenomena is due to the higher capacity of cations exchange of fined-grained soil (Vymazal, 2005).

We should notice that this system is based on a layer of sand for raising water to the stem along with the pebbles of 1 to 2 cm. the other factor for high rate of nitrate removal of this system may be due to the retention time since the supposed retention time for system within the growth time range of plant was somehow longer.

The Efficiency of Channels including Phragmites australis plant with subsurface stream in removing phosphate:

The variation of phosphate within the experiment channels are presented in diagram 4. During the experiment period the amount of phosphate in 1st, 2nd and 3rd channels including Phragmites australis plant were filtered from 14.4 mg/lit to 2.35 mg/lit, 2.49 mg/lit and 2.2 mg/lit, respectively. The same parameter for the 1st, 2nd and 3rd channels that are based on typha plant is reduce from 14.4 mg/lit to 3.89 mg/lit, 3.67 mg/lit and 3.53 mg/lit, respectively. The reduction of phosphate for control channel was from 14.4 mg/lit to 6.67 mg/lit. It can be deduced that the ability of control channel to reduce the phosphate during the experiment period when it is compared with other channels including read and typha plant is about 30.6 and 21.26 percent lower that mentioned channels, respectively.

The result of diagram 4 implies that in all corresponding curves to the channels there two different inclination for reduction of phosphate; steep and slow. The steep slope is related to the first week of experiment during which the reduction of phosphate for 1st, 2nd and 3rd channels including Phragmites australis plant is equal to 67 percent, 68.4 percent and 69.3 percent, while for channels including typha is equal to 55.1 percent, 53 percent and 59.1 percent. For control channel the reduction of phosphate is equal to 27.5 percent. The slow slope is related to the 2nd, 3rd , 4th, 5th and 6th week of experiment and the percent of reduction in amount of phosphate during this period for 1st, 2nd and 3rd channels including Phragmites australis plant is equal to 16.6 percent,14.3 percent and 15.4 percent, while the amount of same parameter for 1st, 2nd and 3rd channel including typha plant is equal to 17.76 percent, 21.5 percent and 19.3 percent. The reduction of phosphate for control channel is also equal to 25.5 percent. Minor changes that

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occur in reduction of phosphate within 1st, 2nd and 3rd channel including Phragmites australis and typha plants is so obvious which in fact it originate from the changes that occur in the root and density of plants within the channels. In diagram 4 we notice the high efficiency of Phragmites australis plant in reducing the phosphate because of its physiological feature when it is compared with typha plant.

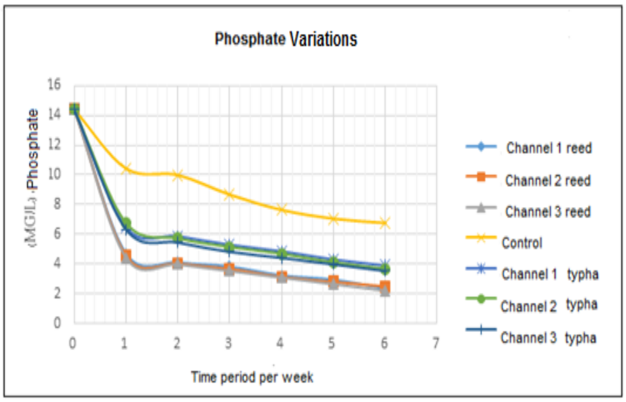

Figure4. The Variation of Phosphate during the 6 week of experiment for channels 1, 2 and 3 (Including Phragmites australis plant), Channels 1, 2 and 3 (Including typha plant) and Control channel (no plant)

The diagram 5 presents the efficiency of channels including Phragmites australis plant and typha plant in elimination of phosphate. As it is presented, the maximum efficiency of channel 3 which includes Phragmites australis plant in removing this substance is equal to 84.7 percent and the minimum value of the same parameter is related to the channel 1 (including typha plant) is equal to 72.9 percent. The same parameter for control channel is equal to 53 percent.

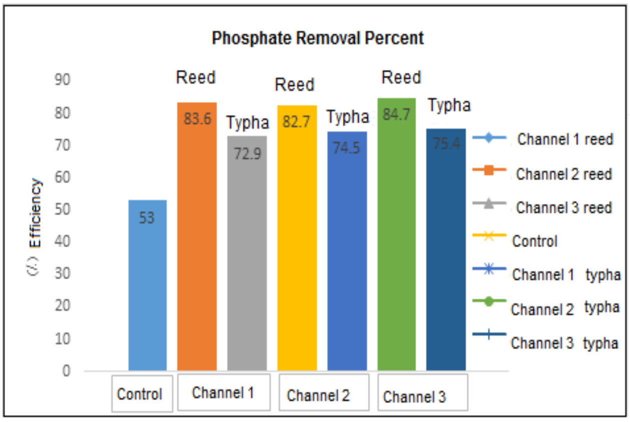

Figure5. Phosphate removal rate for channels 1, 2 and 3 (containing Phragmites australis), channels 1, 2 and 3 (containing typha plant) and control channel (no plant)

According to the obtained result, we should the filtration ability of aquatic Phragmites australis and typha plants in reducing the amount of phosphorous is higher than free plant filtration system. Latter studies also prove this results and they have showed that the impact of Phragmites australis and typha plant in reducing the amount of phosphorous in sewage is between 8 to 30 percent (Tang et al, 2009, Robert and Kadleck, 1996).Thus the important role of these plants in reducing the density of phosphorous in undeniable. These plants also advocate the existence and growth of bacteria which leads to microbial uptake in rhizosphere region of plant (Werker et al., 2002).

But in some studies there were no meaningful difference between free plant filtration system and plant based filtration system, the reduction of phosphorous density in free plant filtration system may be due to the absorption of phosphorous by algae, bacteria and chemical deposition of calcium phosphate by iron and aluminum (Iamchaturapatr et al., 2007, Reddy, 1983).

In this survey, the average removal rates of phosphate via the channels including Phragmites australis and typha plant is equal to 83.6 and 74.3 percent, respectively for input concentration of 14.4 mg/lit which report higher amount of efficiency when compared with results of other similar researches.

Vymazal have reported that the phosphorous removal rate of subsurface artificial lagoons for sewage filtration for total existing phosphorous is between 26.7 to 65 percent. This dissension may be due to the used materials in creation of soil based filtration (Vymazal, 2007).

Plant purification changes of Phragmites australis and typha plant about DO:

The amount of measured DO within the experimental channels is illustrated in diagram 6. The results showed that in spite of typha and Phragmites australis plant activity during the experiment period within the whole of channels, the amount of DO was less than the one existing in control channel. Furthermore, after the 3rd to 5th week there was a sharp decline in temperature (10.2 C to -2.1 C) the amount of DO in all of the channels was highly reduced and it was almost the same in all of them. From 5th to 6th by the increase of temperature to 5.2 C, DO was increased in all channels containing ¬Phragmites australis, typha and control channels. The minor differences in DO dose curve related to the channels 1, 2 and 3 (containing Phragmites australis and typha plant) is due to the difference in the number of leaves of plants. Indeed, the number of leaves of plants in channel 3 (containing Phragmites australis and typha plants) is less than the channel 1 and 2.

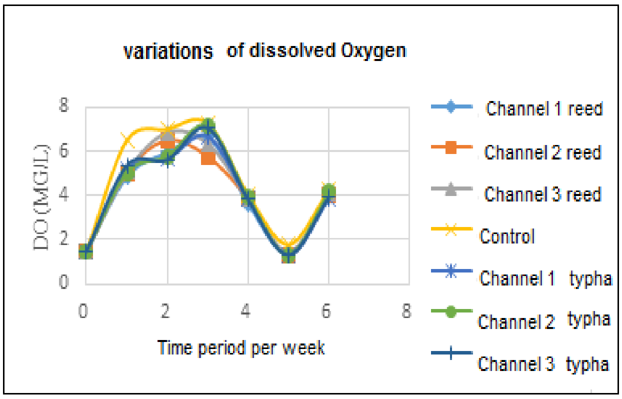

Figure 6. The Variations of DO during the 6 week of experiment for channels 1, 2 and 3 (Including Phragmites australis plant), Channels 1, 2 and 3 (Including typha plant) and Control channel (no plant)

Evaluation of the Statistical Results:

For evaluation of results we have utilized SAS software. To make the evaluation more meaningful, the data are placed within completely random blocks. A multivariate test of Duncan were used for comparison of deviation average of parameters among the 1st , 2nd and 3rd channels (containing Phragmites australis plant), 1st , 2nd and 3rd channels (containing typha plants) and control channel (no plant).

As you see in table 3 and 4, there is meaningful different between 1st, 2nd and 3rd channels (containing Phragmites australis plant), 1st, 2nd and 3rd channels (containing typha plants) and control channel (no plant) about the average data related to the Do, nitrate and phosphate parameters, but this case is not true about the PH amount; there is no meaningful difference.

Table 3. The comparison of mean parameters via Duncan's multiple range tests (Phragmites australis plant)

Parameters	N-NO_3	P-PO_4^{-3}	DO	PH
Control	54.77[a]	9.27[a]	4.61[a]	8.42[a]
Channel 1	37.04[b]	5.07[b]	3.97[b]	8.48[a]
Channel 2	33.35[b]	5[b]	3.99[b]	8.44[a]
Channel 3	34.8[b]	4.89[b]	4.16[b]	8.49[a]

Table 4. The comparison of mean parameters via Duncan's multiple range tests (typha plant)

Parameters	N-NO_3	P-PO_4^{-3}	DO	PH
Control	54.77[a]	9.27[a]	4.61[a]	8.42[a]
Channel 1	30.48[b]	6.43[b]	3.99[b]	8.28[a]
Channel 2	28.74[b]	6.35[b]	4.12[b]	8.32[a]
Channel 3	26.58[b]	6.12[b]	4.08[b]	8.41[a]

The statistical evaluation of meaningful data can be described as " the repetition of parameters of Do, phosphate and output PH from channels containing Phragmites australis and typha plant on surface, have only one percent of meaningful impact, moreover, the meaningful filtration impact on Do, nitrate and phosphate parameters on surface were about 1 percent but on PH it has no meaningful impact.

CONCLUSION

Untreated sewage may lead to severe environmental problems. The use of low-tech wastewater treatment systems and low consumption systems can result in reduction of economic cost and modification of the environment.

The results of experiments proved that the nutrients removal rate of channels containing read and typha plants is more than control channel. It was also demonstrated that the channels that including typha and read plants are more efficient in the elimination of nitrate and phosphate, respectively. Therefore, for increasing the performance of nutrient removal rate from the urban sewage, we can combine and implement a system which is constituted of panted Phragmites australis and typha plants.

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