Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2018, 5(3):311-317

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Application of Sedge in an Artificial Wetland to Remove Nutrients from Wastewater

Saeid Eslamian[1], Hajar Fazollahi[1], Kaveh Ostad-Ali-Askari[2]*, Vijay P. Singh[3], Nicolas R. Dalezios[4], Ahmad Sahebi[5]

[1]Department of Water Engineering, Isfahan University of Technology, Isfahan, Iran.
[2]*Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.
[3]Department of Biological and Agricultural Engineering & Zachry Department of Civil Engineering, Texas A and M University, 321 Scoates Hall, 2117 TAMU, College Station, Texas 77843-2117, U.S.A.
[4]Laboratory of Hydrology, Department of Civil Engineering, University of Thessaly, Volos, Greece & Department of Natural Resources Development and Agricultural Engineering, Agricultural University of Athens, Athens, Greece.
[5]Department of Urban Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.

Abstract Today, due to the growing population on the one hand and the shortage of drinking water resources on the other the use of water recycling has grown dramatically. The use of artificial wetlands is one of the wastewater treatment methods its output can be used without problems in the environment or in agriculture. An important issue in these systems the exact knowledge and correct recognition of the type of plant species used in the system.

In this study the removal efficiency of nutrients by sedge plant has been investigated in order to determine the possibility of using this plant in artificial wetland system. For this purpose, four cells were considered. The conditions were completely identical in all cells one cell was also considered to have a course of growth with normal water (control cell). After 6 months the plant was sampled and the individual organs and underground samples were tested and the removal efficiency of nutrients was determined. The percentage of nutrient removal by the plant and by the total cell system for sedge was %58.6 N, %35.71 P, %73.64 N, %56.25P, respectively.

Keywords Artificial wetland, Nutrient removal, Sedge, phosphorus, Nitrogen

1. Introduction

In general, the wetland refers to soils that are wet or humid most of the time or throughout the year. Abundant water is very important in the formation and expansion of plants and microorganisms in the soil. Therefore, wetlands in comparison to other ecosystems have more biological activities and are able to eliminate water contaminating parameters by various mechanisms. Urban wastewater treatment plants and non-centrifugal current water use the use of networks as low-cost systems Low investment that uses technology and natural energy is appropriate. In synthetic wetlands, humans provide conditions for plant growth and plant roots in the soil and have better control of conditions such as time of stay, plant type and type of bed. This system is divided into two types of surface and subsurface that are in the surface type of the surface of the fluid flow on the soil bed and in the subsurface type of the surface of the fluid under the soil bed. The contents of artificial insemination are mentioned in four main sections: Substrates with different water holding capacity adapted plants with non-humus substrates columns of water entering the bed, aerobic and anaerobic microbes. Plants used in a natural wastewater treatment system are generally divided into two types of grass and wood [1-2]. Herbaceous plants are those that have a smooth non-woody stem and are often one-year-old. Based on a variety of forms of life, plants the grasses are divided into aquatic plants attached to the soil or sediment layers and those that are suspended free. Connected species include surface species floating leafy plants and sub-surface plants. Surface plants are species in which at least part of their foliage lies above their surface. Typical names of these plants include Louie 1 and sedge 2. Surface species are usually found in shallow or saturated soils. Floating leafy plants, floating leaves on the surface they have water but they are connected to the floor by long stems. This species is usually found in shallow water (about 12 to 40 inches). Typical of this type is Egyptian lotus 3. Sub-surface plants are those whose all branches are submerged in the 4th sample of the herb. Floating aquatic plants are similar Lemna minor 5 which float on the surface of the water and have no connection to the lower layers. Wood species are generally divided into trees (taller than 20 feet) and shrubs (3 to 20 feet). Trees and shrubs are generally found in saturated soils, with few exceptions that can be found in permanent water. The wood species used in this system are generally characterized by physiological features such as knees, roots, retaining roots, open and expanded openings (which enable oxygen exchange in saturated and anaerobic conditions). Some wood species of the common tree and plant include apple 6 and beard 7 and eucalyptus 8, although they are considered as an important component in natural wetlands of wood species, but are not commonly used in artificial systems [3].

1.1. The role of macrophytes in synthetic wetlands

The presence of macrophytes is one of the most prominent features of wetlands and their presence in artificial wetlands is recognized as uncovered soils or lagoons. The growth of macrophytes in artificial lagoons has several characteristics related to the purification process, which designates them as an important component of the process [4].

The presence of vegetation in synthetic wetlands, spreads water intensity and reduces this condition creates a better way to suspend suspended solids and reduces the risk of re-suspending. The presence of external macro Porites actually decreases the wind speed near the surface of water and soil in comparison with its speed above the vegetation [5-6]. This creates favorable conditions for the establishment of suspended solids and prevents them from suspending, so the removal of suspended solids in artificial wetlands with free water levels improves. In other words, the lower speed of aeration in water columns decreases. Macrophytes reduce the penetration of light into the water and thus limit the growth of algae. It is expected that the shadows of macrophytes are important on phytoplanktons especially in shallow habitats, which cover large macrophytes. In the case of free floating macrophytes, such as blueberries or Lemna minor, which can completely cover the surface of the wetlands, the growth of algae is minimized due to lack of light. This is desirable in synthetic wetlands and the growth of phytoplankton is not due to the increase of suspended solids in the outflow stream.

Another important effect of insect plants is that it covers the winter, especially in temperate and cold regions [6-7]. When the litter layer is covered with snow, it creates a complete insulation [8], this layer also helps in protecting the soil from freezing during the winter, but on the other hand keeps the soil cooler throughout the spring. This Insulation is especially important in artificial wetlands with underlying surface flow. In the vertical direction of artificial wetlands, where water reaches the surface of the bed, the presence of macrophytes helps prevent blockage [9]. The movement of plants as a result of wind, etc, causes the water to be treated by the annular cavities formed at the surrounding area of the stem.

2. Materials and Methods

2.1. Preparation of cells

Four cells were considered for selective plant species. The conditions were completely identical in all cells. One cell was also considered for the plant to grow its course with normal water (control cell), compared to the average sample used for wastewater treatment. Determine the plant's effect on the amount of purification. In order to investigate the effect of the cell itself and its internal materials on the treatment, an unplanted cell was considered, which was sampled at the outlet of the cell several times to obtain a mean concentration of nutrients in it. To prepare the cells, the soil was first drained from plants and wastes. Then, with the plaster the cells were marked in rectangles of 2 by 0.7 meters, all drilled at a depth of 0.5 meters.

After digging, a soft bed layer of the cells was poured and concentrated so that a 1% slope was obtained, then insulating the bottom and walls of the cells using thick and grained plastics. Afterwards, the inside of all cells was filled with pepper grit (2-6 mm), at which point tubes were inserted into the cells to enter the water and control of the amount of water drop in the cells in the elementary cell. An outlet was also provided for a cell that was not considered a plant.

2.2. Plant planting

In order to plant the cells in the cells, early March, the areas that were previously identified, plants were taken along with rhizome and transferred to the site. The cells were then cultured at a distance of 20 cm from each other and at a depth of 20 cm. After planting for one month, all of the cells were irrigated with normal water and then except for the first three cells, the wastewater was introduced to the rest of the cells.

2.3. Sampling and doing experiments

Considering that the purpose of this study was to investigate the efficiency of removal of nutrients in the plant, after 6 months, the plant was sampled, and the routine organs and underground organs were examined separately, so that the nutrient accumulation in the plant to be determined.

By obtaining nutrient accumulation in plants that were irrigated with ordinary water and the average accumulation of nutrients in plants used for treatment of wastewater, the net extraction of nutrients from wastewater was determined by plants. Also, removal of nutrients by the cell itself was done by analyzing the effluent from the unplanted cell. Therefore, according to the formula below the concentrations of these pollutants were estimated at the cell output:

1) $S_{out} = S_{in} - S_{net} - S_p$

2) $R_{net} = R_t - R_c$

Thus, the efficiency of removal of nutrients by the plant was calculated as follows:

3) $R = ((S_{in} - S_{out})/ S_{in}) * 100$

In these relationships, Sin is the concentration of diuretics, the South concentration at the outset, Rent, the removal rate by the plant, Rp, the removal rate by cell, Rt, the removal rate by the plants, and the Rc is the removal rate by the control plants.

In order to enter the effluent into the cells, tubes embedded at the beginning of the cells were used, first the amount of wastewater required to fill the cells was calculated with respect to the intake flow (0.5 liters per second) and time (4 minutes), which was equal to 120 liters was.

The amount of water drop in the cells was then determined in a few times, which was an average of 8 centimeters per week, and only 55 liters of wastewater were needed to compensate for this drop every hour. Therefore, for the 6-month period, the total wastewater used in each cell was 1275 liters (it was not introduced into the cells during the first three weeks of the waste). In order to extract the unplanted cell, an intermittent flow of wastewater was introduced to the input for 2 weeks, during which time, three times the samples were taken out of the outlet and their mean as the quality of the effluent was recorded.

3. Summing up and conclusions

3.1. The quality of the wastewater used

In order to determine the quality of wastewater during the experiment period, intake of wastewater was sampled several times and the total nitrogen and total phosphorus concentrations were measured, which was 13.3 and 0.14 mg / l respectively. Considering these concentrations and the total volume of wastewater entering into each cell, which was previously calculated, the amount of nitrogen and total phosphorus entered into each cell during the experiment was calculated to be 16.957 and 0.561 grams, respectively.

3.2. Plant Growth and Nitrogen and Phosphorus Emission Efficiency

In order to study the growth of the plant in the cell, during each experiment, the length of the plant stem was measured each week, during the first three weeks of plant growth, the plants were very slow so that the buds did not leave the soil during this period, and from the beginning of the fourth week after cultivation. The first signs of growth were observed. The reason for this is that this species of plants after the transfer to the bed and the establishment in its first begin to grow and develop the roots and stems of the underground, and then the buds out of the strands of the stem underground and start Grow up. The growth diagram of plants based on stem length in 24 weeks of the growth period is shown in Fig 1. As can be seen, during this period the length of the stem increased and reached the maximum at the end of the period. The growth rate in the purification cell was higher than that of the control cell which indicates that the plant is suitable for use in the artificial wetland since it not only resists the load of pollution of the effluent but even shows a better growth.

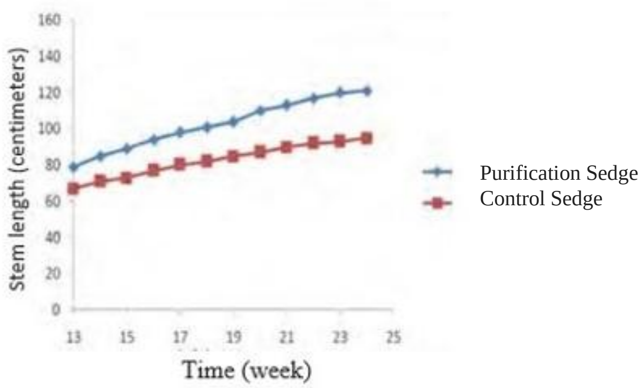

Figure 1: Growth of Plant stem length for 24 weeks

In Table 1, the biomass of whole plants including underground biomass and aerial biomass is presented after 24 weeks of growth.

Table 1: Wet and dry biomass of plants in purification and control cells

Parameter	Purification Sadg	Control Sagd
Moist air biomass (Kg)	0.85	0.23
Underground wet biomass (Kg)	1.3	0.8
Moist air biomass / Underground wet biomass	0.65	0.29
Moisture percentage from air biomass	58	58
Percentage of moisture in the underground biomass	61.9	61.9
Dry air biomass (Kg)	0.52	0.14
Underground dry biomass (Kg)	0.8	0.49

Generally, the biomass of plants in the treatment cell is greater than that of the control cell which is due to the better growth of plants and the greater absorption of nutrients by them in the cells of the treatment than the control cells. Also, the underground biomass is more than the biomass in the air Is.

In the explanation of this, as mentioned earlier these plants begin to grow underground tissues before the onset of air growth and then gradually the buds are brought out of the soil and air growth begins and continues, so the biomass The underground is more than the biomass in the air.

Table 2 shows the mean nitrogen and phosphorus recovered by the plant after 24 weeks. With Comparison of aerial and underground biomass, absorption rate in underground biomass is more than air biomass.

Table 2: Nitrogen and phosphorus removal by plant

Parameter	Purification Sadg	Control Sagd
Total nitrogen harvested by (g /kg) Air Biomass	4	1.7
Total phosphorus harvested by biomass(g /kg) of air	0.12	0.02
Total nitrogen harvested by (g /kg) underground biomass	14.05	6.4
Total phosphorus taken by biomass (g / kg) underground	0.1	0.24

Table 3: Harvest of plant nutrients in cells

Parameter	N	P
Harvesting pure nutrients in each cell(g)	9.94	0.2
The nutrients entered into each cell(g)	16.96	0.56
Percentage of nutrient removal by the plant in each cell	58.6	25.71
The rate of nutrient intake per cell (gm-2 day-1)	0.042	0.00085

In this 24-week period, the percentage of removal of nitrogen was higher than that of phosphorus removal. This result is in accordance with previous studies in this field. In the explanation it should be mentioned that phosphorous removal in artificial wetlands is mainly due to surface absorption by bedding materials and plants have a lower share in removal of phosphorus, but more nitrogen is absorbed by plants it is removed from the wastewater. Absorption of nitrogen and phosphorus by ions occurs by plants. Therefore, in the case of nitrogen the amount of nitrogen in the sewage should be converted from nitrogen oxidation to nitrogen fertilizer to ammonia nitrogen.

$$NO_2^- + 6H^+ + 6e^- \rightarrow NH_3 + H_2O + OH^-$$

Nitrification (nitration) is also catalyzed by two groups of bacteria (nitrosmonase and nitro bacteria):
Nitrosmonase:

$$NH_3 + \frac{3}{2}O_2 \rightarrow H^+ + NO_2 + H_2$$

Nitro Bacteria:

$$NO_2^- + \frac{1}{2}O_2 \rightarrow NO_3^-$$

These two aerobic bacteria are compulsory, so oxygenation is required for these reactions and nitrogen uptake by the plant. As noted earlier, Sadg has a dense root system and as a result of further development of the oxygenated roots they distribute airborne organs more in cellular space and as a result more oxygen is available to react and nitrogen is absorbed. In the case of phosphorus absorption, it is also worth noting that phosphate is a non-moving ion and unlike movable ions such as nitrate and potassium that can be used throughout the root development zone only a layer adjacent to the root can be therefore root propagation is an important factor in the absorption of ions especially those that do not have high mobility. Meanwhile, the increase of the absorbent levels of the root causes an increase in the phosphorus absorption efficiency. Therefore, with higher development of roots Sadg can cause better phosphorus absorption. In order to calculate the efficiency of removal of nitrogen and phosphorus by cells, nitrogen and phosphorus concentrations should be initially estimated at the outlet of the cells. For this purpose, the concentration of nitrogen and phosphorus at the outlet of the control cell (without plants) was first obtained and, given that in the first period of the experiment, 615 liters of wastewater was introduced into each cell the removal of nitrogen and phosphorus by the cell itself would be 1.23 and 0.055 grams respectively.

Table 4: Efficiency of removal of nutrients by cells

Parameter	N	P
The nutrients entered into each cell(g)	16.96	0.56
Removal of nitrogen and phosphorus by cells (g)	2.55	0.115
Removal of nitrogen and phosphorus by plant (g)	4.94	0.2
Nitrogen and phosphorus extracted from each cell(g)	4.47	0.245
Cell removal efficiency (%)	73.64	56.25

According to the above, it can be said that the use of artificial wetland system is a suitable solution for wastewater treatment which is especially noticeable in our country. Regarding the results of this study and comparing it with the results of other studies in this area (Table 5), Sadg shows high removal efficiency for nutrients and is suitable for use in artificial wetland system. Of course, for each region, more studies are needed to select the most appropriate plant according to the region and type of wastewater.

Table 5: Nitrogen and phosphorus removal efficiency in research on plant species in artificial wetland [6]

Remove nitrogen and phosphorus by the plant	Plant species are used	Type of wastewater	Nitrogen and phosphorus removal efficiency (Kilograms per hectare per day)	
			P	N
% 28/92% N; 42/12 P	Phragmiteskarka	Soluble nutrients	0.24	3.44
% 26/08% N; 17/43 P	Lepironiaarticulata	Soluble nutrients	0.23	1.56
% N; 54-41 % P63-36 In the air biomass % N; 30-24 % P39-36 In underground biomass	Phragmitesaustralis	Greenhouse runoff		
% N; 42-37 % P40-22	Phragmitesaustralis	Sewage outlet	0.082	0.53
% N7-9	Cyperusflabelliformis	Livestock effluent		11.2
% N50	Cattail Typha sp.	Septic tank output		4.5
	Soft-stem bulrush Schoenoplectus tabernaemontani	Dairy wastewater	1	3
g / mg 21 / 91-14 / 95 gTP / mg5 / 95-5 / 61N; In air biomass	Cyperus papyrus	Septic tank output	0.24	7.1
g / mg22/16–19/96 TN; mg / g TP10 / 05-7 / 9 In underground biomass	Phragmitesaustralis	Septic tank output	0.26	10.4
% TN43	Cattail Typhaangustifolia	Septic tank output		3
	Typhalatifolia	Sewage outlet	0.229	1.08
% N64 / 8			1.997	3.68
% N64 / 8	Soft-stem bulrush Schoenoplectus tabernaemontani	Dairy wastewater	1.3 – 3.2	1.5 - 14

References

[1]. Akratos, C. S., Tsihrintzis, V. A. (2007).” Effect of temperature, HRT, vegetation and porous media on removal efficiency of pilot-scale horizontal subsurface flow constructed wetlands. “J. Ecol. Eng., 29, 173–191.

[2]. Mander, Ü. And Jenssen P. (Eds.). (2003). Constructed Wetlands for Wastewater Treatment in Cold Climates, WIT Press, Southampton.

[3]. Smith, I.D., Bis, G.N., Lemonand L, E.R., Rozema, R. (1996). ”A thermal analysis of a subsurface, vertical flow constructed wetland. “Proc. 5th International Conference Wetland Systems for Water Pollution Control, Vienna, Austria, Chapter I/1.

[4]. Brix, H. (1996).” Role of macrophytes in constructed treatments wetlands. “Proc., 5th International Conference Wetland Systems for Water Pollution Control, Vienna, Austria, keynote address 2-1.

[5]. Brix, H. (1994).” Functions of macrophytes in constructed wetlands. “J. Wat. Sci. Tech. 29, 71-78.

[6]. HuaSim, C., M.K. Yusoff, B. Shutes, S. Chye Ho and M. Mansor. 2008. Nutrient removal in a pilot and full scale constructed wetland, Putrajayacity, Malaysia. Environ. Manage.88: 307–317.
[7]. Neralla, S., Weaver, R. W., Lesikar, B. J., Persyn R. A. (2000).” Improvement of domestic wastewater quality by subsurface flow constructed wetlands. “J. Biores. Tech. 75, 19-25.
[8]. Brix, H. (1998).” Denmark. “PP. 123-156. In: J.Vymazal, H. Brix, P.F. Cooper, M.B. Green, R. Haberl (Eds.), Constructed Wetlands for Wastewater Treatment in Europe, Backhuys Publishers, Leiden.
[9]. Bahlo, K.E. and Wachs, F.G. (1990). ”Purification of domestic sewage with and without faeces by vertical intermittent filtration in reed and rush beds. “PP.215-221. In: P.F. Cooper,B.C. Find later (Eds.), Constructed Wetlands in Water Pollution Control, Pergamon Press, Oxford.
[10]. The Interstate Technology & Regulatory Council Wetlands Team. (2003). Technical and Regulatory Guidance Document for Constructed Treatment Wetlands.