Treatment of the Wastewater Using a Constructed Wetland System

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Abstract

A –four stages constructed wetland system consisting of 4-stages (vertical flow Beds) connected On series has been investigated in my research, in the four stages I use the same media, it was Three layers for height 50cm, the first layer from the Bottom of the bed was 13 cm height with Gravel it size (10-15) cm, the second Layer of the bed was 27cm height it was gravel with size (1 -2) cm the third layer Was 10 cm height with gravel size (1-2) cm mixed with sand with Percentage (3:1), the general porosity in the system was 45% which is high porosity, which Mean more durable system, I replicated the system five times with different types Of plants (Corn Brooms, Corn, Parley, Alfalfa, and Sunflower) and the testes done For the five plant, I do Many tests for BOD, COD, TSS, TKN, the Removal of BOD was surrounding between (94-96.9) % with HLR = 72.3Kg/ha.d, the removal of COD was (79.4-88.5) % with HLR=99.3Kg/ha.d , the Removal of TSS was (90.8-97.1) % with HLR=41.1Kg/ha.d , the Removal of TKN was (62.5-65.4) % with HLR=41.8 Kg/ha.d, this system can be applied in Slope grounds successfully.

INTRODUCTION :

The Middle East countries are suffering from sharp shortage of water resources and increasing water demand due to the increase of population and exploitation of the available water resources. Since all the countries in the region are located in arid or semi-arid zones, water resources in these countries are very limited. In the last few decades, attention was paid to finding new resources of water in the area. One of these other resources is the treatment of wastewater. Management and treatment of wastewater also protect the environment and water resources from pollution.

In Palestine, wastewater collection and disposal is considered one of the most significant environmental problems. Wastewater collection systems are available in most cities in Gaza and the West Bank, but wastewater treatment plants had not been constructed for all the cities that have wastewater networks, so wastewater still flows in the Wadis from many cities.

Many of the wells have been polluted and the percentage of pollution is high in the water pumped from the wells.

In the West Bank also, there are many villages that do not have wastewater collection systems and depend on septic tanks for the disposal of wastewater and there are many environmental problems that result from using this system.

During the past few years, a new technology for treating municipal and industrial wastewater has emerged. This technology involves the construction of “artificial wetlands,” which use the physical, chemical and biological processes in nature to treat wastewater. These specially built wetlands are also referred to as “Constructed Wetlands” or “Created Wetlands” constructed wetlands can be designed for whole communities, subdivisions, private developments, and even for individual homes.

WHAT IS CONSTRUCTED WETLAND?

Constructed wetlands (CWs) are engineered systems (artificial wastewater treatment systems) that have been designed and constructed to utilize natural processes involving wetland vegetation, soils and the associated microbial assemblages to assist in treating wastewaters. They are designed to take advantage of many of the processes that occur in natural wetlands but do so within a more controlled environment.

TYPES OF CONSTRUCTED WETLAND SYSTEM.

There are various types of constructed wetland systems for treating wastewater based on various parameters. The most important criteria are water flow regime which include:

- Surface flow
- Sub-surface flow

The surface flow is also divided into various types based on types of plants and its situation in the system.

- **Systems with free-floating macrophytes**
- **Systems with floating-leaved macrophytes**
- **Systems with submerged macrophytes**
- **Systems with emergent macrophytes**

The sub-surface is also divided into two main types based on the movement of flow inside the media whether it is a vertical movement from the planted layer or horizontal one parallel to the surface .

WETLAND CONSTRUCTION:

This system was done in **An-Najah National University;** the system that the researcher did consisted of plastic barrels 45cm in diameter, bigger barrels of 60 cm in diameter were used as storage tanks for the wastewater which contained raw wastewater.

Iron stands were built with different heights to put the barrels on them so that the system can be run by gravity (free energy) without any pumping to minimize the cost as possible. The outflow from the first barrels will be inflow in the second barrels and so on for the four barrels (4- stages).

The system was replicated five times with different types of plants, and the flow entered to each barrel by means of gravity without any pumping, so the barrels. This was achieved by placing the barrels at different heights.

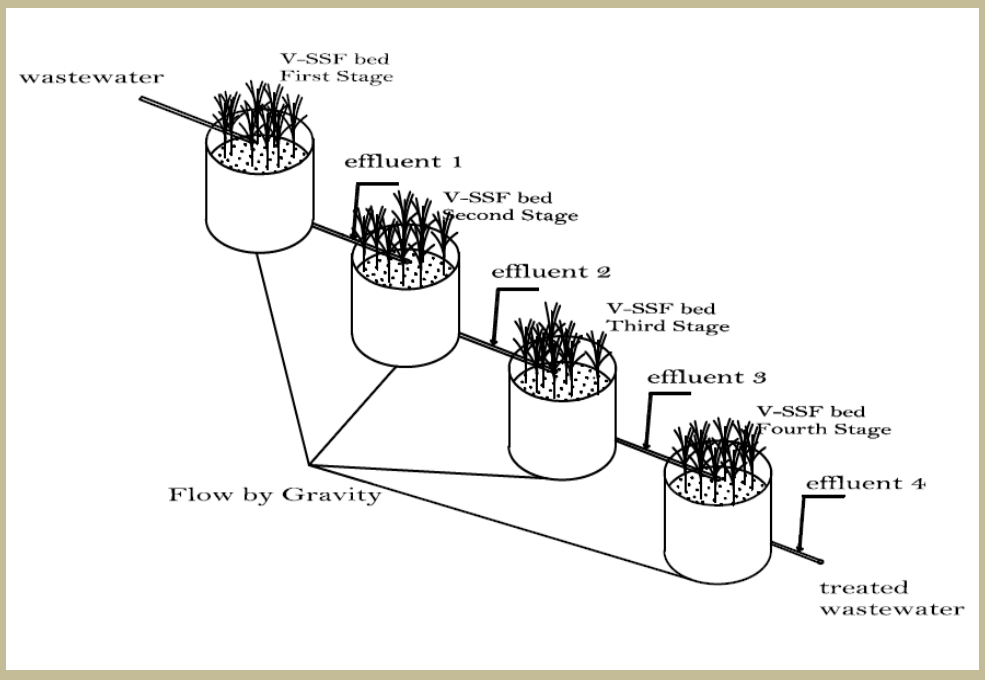

Figure (1) (4-stages) sub-surface constructed wetland system with VF was repeated five times each one with a different plant.

Figure (2) Constructed wetland system with vertical flow (4-stages) for treatment.

Every barrel is filled with coarse aggregates on layers. The first layer consisted of gravel whose size was between (10-15) cm at 13cm high as shown in figure (3).

Figure (3) The first layer in the constructed wetland is gravel for a 13cm-height.

This layer is the first one from the bottom and this size was chosen to be bigger than the opening of the outlet of the valves that control the volume of the flow in the system so it will not be clogged in the future.

The second layer is filled with aggregates with sizes between (1-2) cm for a 27cm-depth. The third layer had the same characteristics as those of the second layer but is mixed with sand with percentage (3:1) (aggregates: sand) and was 10cm high as shown in figure (4)

Figure (4) constructed wetland with total height for media equal to 50 cm

The total thickness (depth) of the media inside each barrel was 50 cm. Figure (5) shows longitudinal section for the treatment cell.

The constant level of wastewater was 40 cm; 10 cm were left to allow aeration of the system and the roots of the plants. The flow in each barrel was 12ml/min (HLR) was (22 l/M-day) and this flow to achieve HRT = 6 days in the system.

There was a perforated 1.5 inch diameter pipe placed inside each barrel with a length of 60 cm. The researcher put it to measure the level of wastewater inside the barrel to provide 40 cm for aeration. It is very important to calculate the volume of water that can be obtained in each barrel in the system, it is also important for calculating some values such as porosity (if it is not calculated before) and hydraulic conductivity. The porosity in the system was (45%); high porosity in constructed wetlands has many benefits.

The flow in the system was a vertical one from top to the bottom in all four stages.

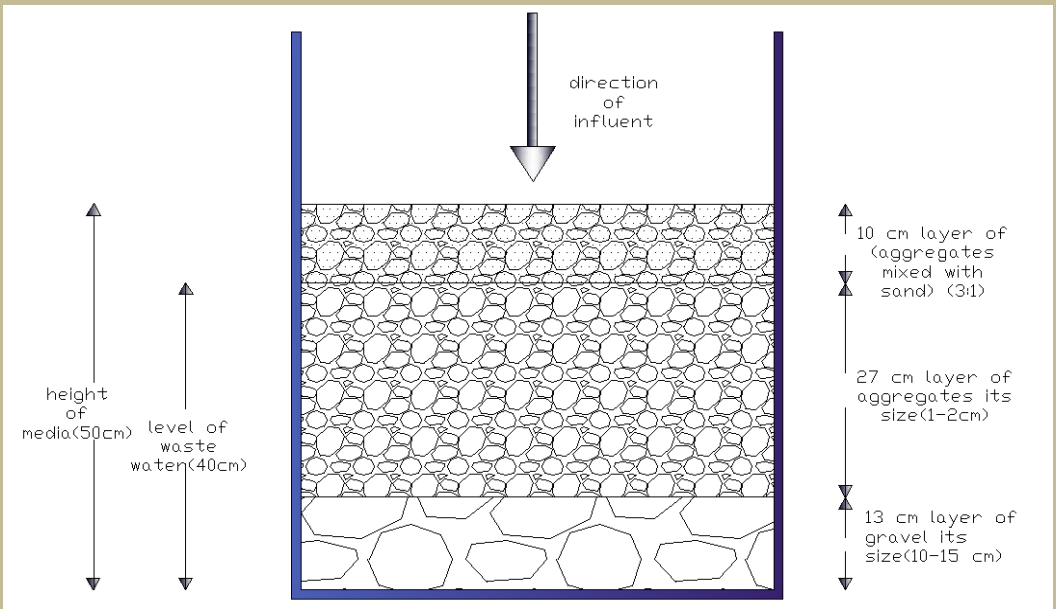

Figure (5) Profile of the treatment cell.

EXPERIEMENT PROCESS:

Flow and Loading rates in the system were as shown below in the table .

Table (1) Loading rates for the different parameters in the experiment:

Parameter	Loading rate (for 4-stages)	Loading rate(for 4-stages)
BOD	72.3Kg/ha.d.	7.3g.d/m2
COD	99.3 Kg/ha.d.	9.93g.d/m2
TSS	41.1Kg/ha.d	4.11g.d/m2
TKN	41.8Kg/ha.d	4.18g.d/m2

PLANTS THAT WERE PLANTED IN THE SYSTEM:

There are five plants that were planted in the system because the researcher replicated the system five times with five different types of plants. These plants were chosen to be seasonal crops because the experiment extended for a 6-month period.

The five crops were Corn Brooms, Alfalfa, Corn, Barley and sunflower it were planted in the 4-stages , all the stages were grown .

WETLAND OPERATION:

After the system was built, and the seeds of the plants planted, we ran the system and wastewater flew through the Barrels continuously by means of gravity. The outflow in the first barrels was inflow in the second ones and so on, until the final stage barrels (4- stages) in which the treated wastewater is obtained. The flow was a vertical one in all four stages.

The flow was 12ml/min and each barrel contained 25.6 l of wastewater whose level was 40 cm, and 10 cm beneath the surface of constructed wetland. The HRT in each barrel was 1.5 a day, which means 6 days for all four stages. We control the flow by using a valves and the flow is measured several times weekly by using graduated cylinder and timer to be sure that the flow is maintained 12ml/min .

Many tests were executed to test the water before and after treatment. TSS, TDS, BOD, COD, N, CL tests were done throughout the period of the experiment. These tests were applied to all types of plants planted in the system. Samples taken from the inlet and outlet of the system. The average temperature of the wastewater in the treatment plant was (24±2) ^{o}C.

RESULTS AND ANALYSIS:

(TSS) REMOVAL PERFOMANCE:

Table (3) Performance of TSS removal for the VF constructed wetland which was replicated 5 times using different types of plants.

Parameter	Type of plant	Outflow (Mg/l)	Removal (%)
TSS Inflow = 150 mg/l	Corn Brooms	13.8	90.8
	Barley	6.1	95.9
	Alfalfa	12.5	91.7
	Corn	4.4	97.1
	Sunflower	11.5	92.3

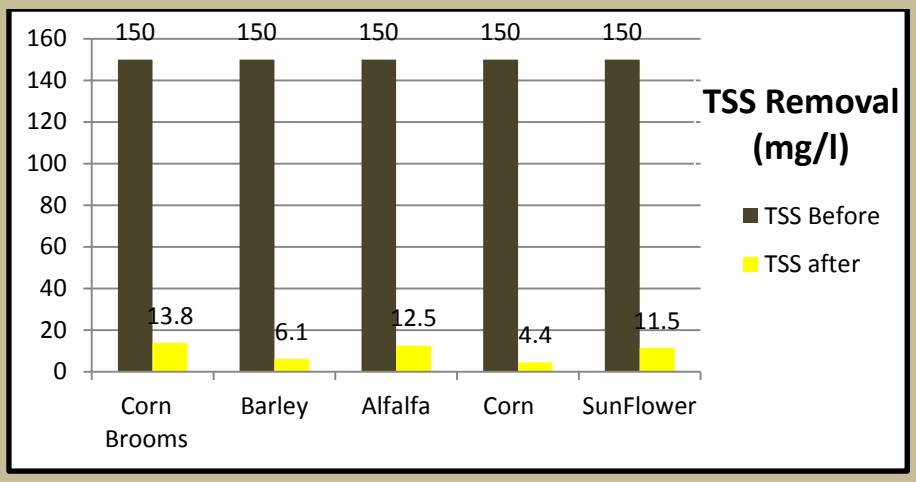

Figure (6) Removal efficiency of TSS

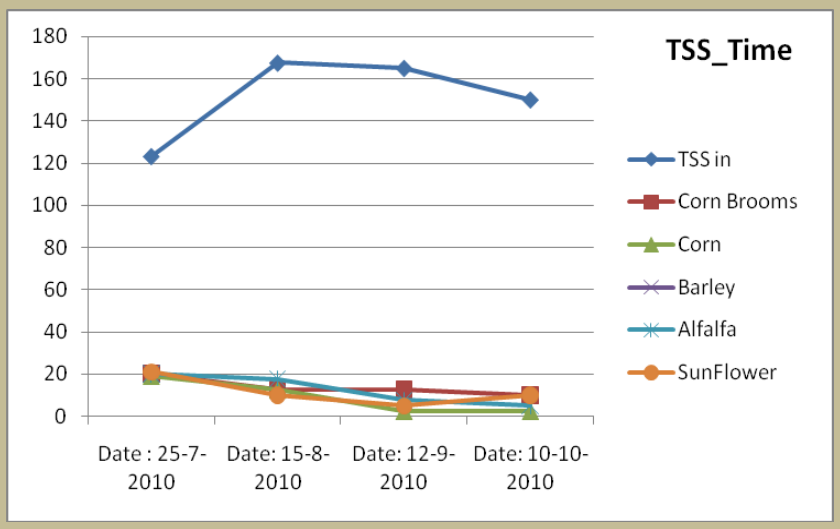

Figure-7 Removal efficiency of TSS during the operation's period

(BOD) REMOVAL PERFORMANCE:

Table (4) Performance of BOD removal for the VF constructed wetland which was replicated 5 times using different types of plants.

Parameter	Type of plant	Outflow (Mg/l)	Removal (%)
BOD Inflow = 268 mg/l	Corn Brooms	10	96.4
	Alfalfa	16	94
	Corn	10	96.2
	Barley	12	95.4
	Sunflower	8	96.9

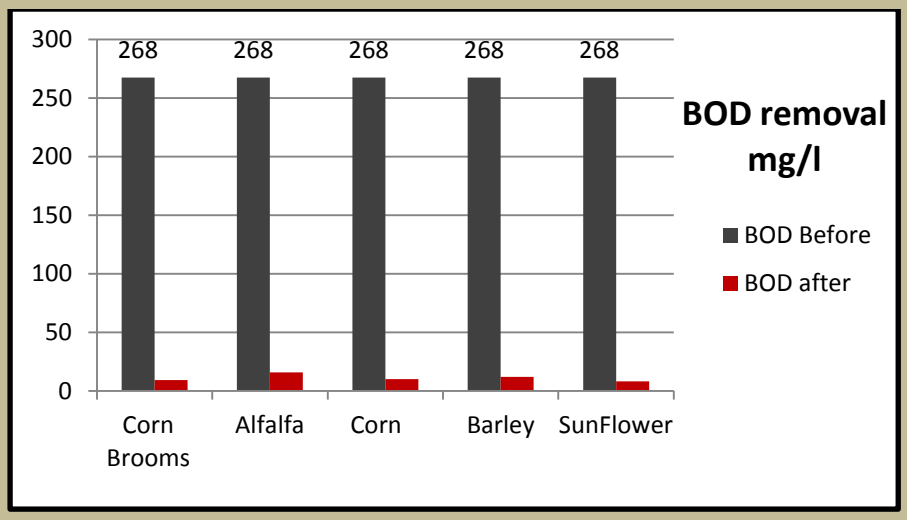

Figure- 8 Removal efficiency of BOD

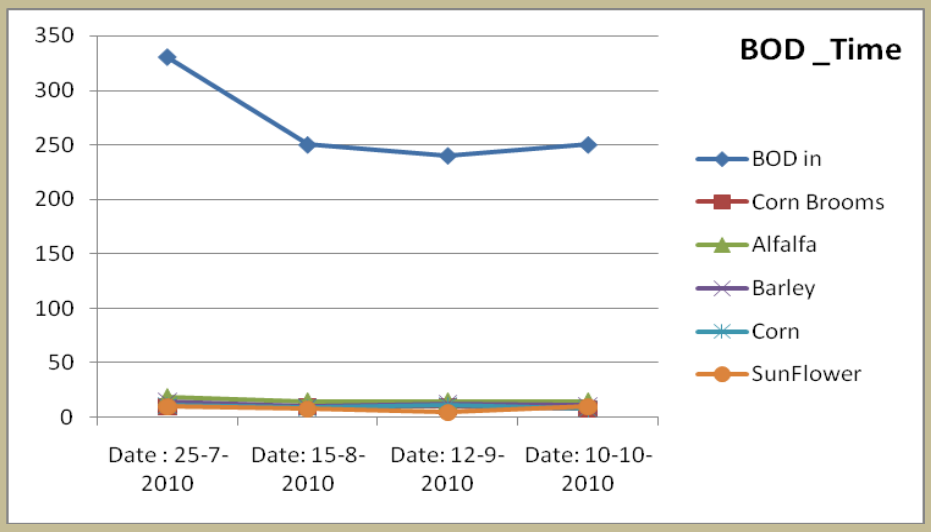

Figure -9 Removal efficiency of BOD during the operation's period

(COD)REMOVAL PERFORMANCE:

Table (5) Performance of COD removal for the VF constructed wetland which was replicated 5 times using different types of plants

Parameter	Type of plant	Outflow (Mg/l)	Removal (%)
COD Inflow = 375 mg/l	Corn Brooms	43.3	88.5
	Barley	51.3	86.3
	Alfalfa	51.3	86.3
	Corn	76.3	79.7
	Sunflower	77.3	79.4

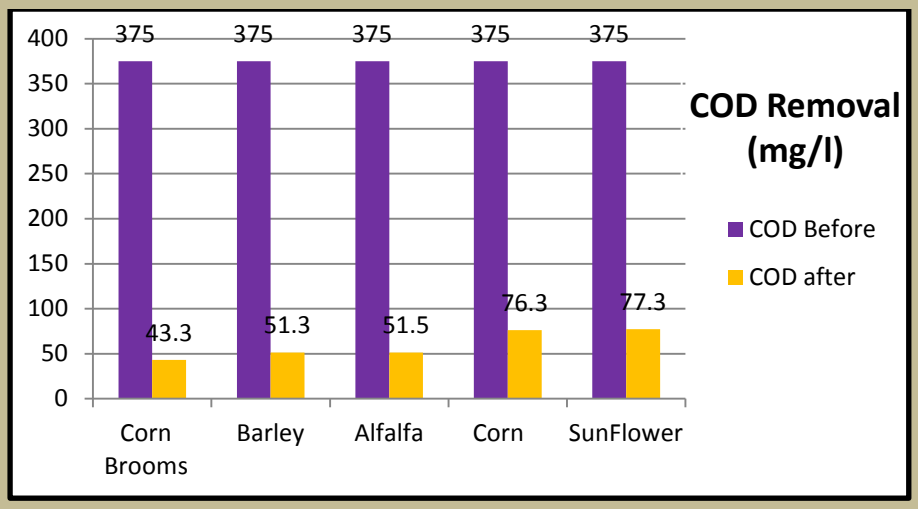

Figure (10) Removal efficiency of COD

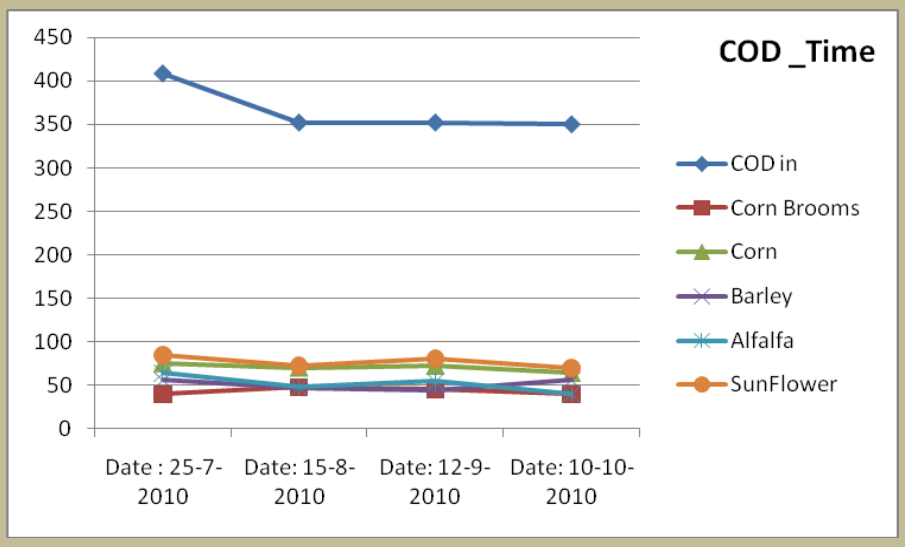

Figure (11) Removal efficiency of COD during the operation's period

(TKN) REMOVAL PERFORMANCE:

Table (6) Performance of TKN removal for the VF constructed wetland which was replicated 5 times using different types of plants.

Parameter	Type of plant	Outflow (ppm)	Removal (%)
N Inflow = 165.8 ppm	Corn	62.2	62.5
	Corn Brooms	57	65.6
	Barley	59.6	64.1
	Alfalfa	62.2	62.5
	Sunflower	62.2	62.5

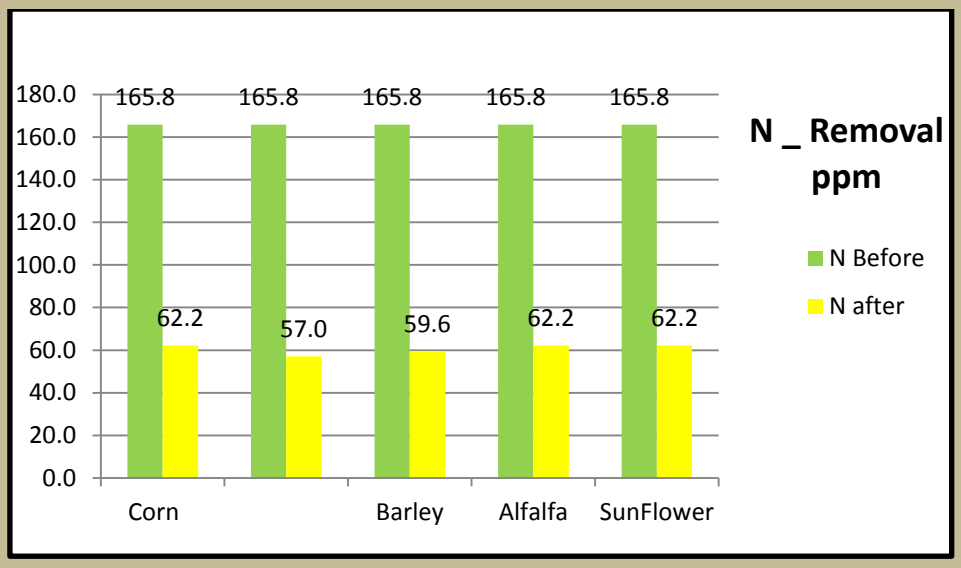

Figure -12 Removal efficiency of TKN.

Figure -13 photo showing the wastewater before (right) and after (left) treatment process.

THE MAIN CONCLUSIONS OF THE STUDY :

1- High removal efficiency for all pollutants that were tested , BOD (94-96.9)%, COD (79.4-88.5) %, TSS (90.8-97.1) %, N (62.5-65.4)%.

2- We can apply this system for treatment of the wastewater in Palestinian Territories successfully This is a simple and cheep technology for the treatment of wastewater.

3- High removal with high porosity to prevent clogging in the future which means a more durable system .

4- High removal of TN (62.5-65.5 %) with high HLR that reaches (4.18 g/m2.d, 1521.5g/m2.yr).

5- There is no high or significant difference between the results from the five systems replicated with different types of plants, but rather a very slight difference.

6- In the BOD values of treated wastewater there was a value higher than the other values which was the value of the system planted with alfalfa, and we enucleated this by the lower concentration of DO for the wastewater in this system which was the lowest among the five systems. Whenever DO is more in the system the removal process of BOD will be more. This lower value for DO occurred because the Alfalfa plant was planted and spread in a vertical and horizontal direction which laminated the aeration for the system from the atmosphere, so the BOD removal process was lower. The other plants were planted vertically so that the aeration for the system from the atmosphere would be more.

7- COD removal is less in the systems that are planted with Sun Flower and Corn and we enucleated this by the difference of intensity of the plant per area. When the density of the plant is more per area the removal of COD will be more and in these two types the number of plants per area is less than the rest of plants in the other systems.

8- In the TSS tests the two systems planted with Corn and Barley had the highest removal of TSS and we enucleated this by the intensity of the roots for the plants, that is when it is spread more it would serve as a filter for the SS. The SS accumulates with time on it and then precipitate and falls down, thus, the removal process will be more. See figures (13-1) and (13-2).

Figure 13-1 Roots are strong but are not dense and their spread in the media is less

Figure 13-2 Roots are more dense and their spread in the media is more

9- We can use the treated wastewater irrigation purposes.

10- The advantage of using systems that contain several stages is that we can do maintenance works without the need to shut down the whole system. If we want to do maintenance in each stage we can operate the other three stages and the system still work until we finish our maintenance, this leads to a more practical and durable system.

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