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Research Article

STUDY OF DOMESTIC WASTEWATER TREATMENT BY MACROPHYTE PLANT IN ARID REGION OF SOUTH-EAST ALGERIA (CASE OF EL OUED REGION)

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ABSTRACT

Removal of wastewater pollution by natural treatment systems such as wetlands is achieved using filter media and macrophytes plants. The functioning of constructed wetlands relies on physical, chemical and biological processes. The aim of the present study is to evaluate the performance of the *Phragmites australis* for domestic wastewater treatment under an arid climate. Experiments were conducted during three months (February, March and April). Results indicate that the variation of pH values of raw and treated wastewater is not significant. The electrical conductivity increases strongly during March and April. It was also found that dissolved oxygen in planted filter exceeds that of the unplanted one. Also, the higher performance in BOD and Ntot removal by the planted filter confirms the important role of this plant in the treatment process.

Keywords: Pollution; wetlands; filter media; performance; *Phragmites australis.*

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1. INTRODUCTION

The strategy of reuse treated wastewater in irrigation seems indispensable to avoid the future problems of water scarcity. Wastewater contains several pollutants such as biodegradable organic components, inorganic and organic chemicals, toxic substances and biological organisms (bacteria, viruses, parasites, etc.) [1, 2, 3]. For this reason, discharge of domestic wastewater without treatment forms a serious environmental problem as contamination of aquatic environments (rivers, dams, oceans…) and become a threat to the human health [4]. In fact, there is no unified regulation regarding the reclamation of treated wastewater for irrigation purpose [5,3]. For example, Algerian legislation establishes a list of limit values for physical, chemical and biological parameters [6].

Until now, various techniques are used for pollutants removal include wich physical, chemical and biological treatment processes [7]. However, these mentioned methods are expensive and require several technological equipments [8, 9]. Recently, the wetland technology as natural filters seems to be practical because it is simple, efficient and inexpensive [10,11,12]. Moreover, municipal wastewater treated with wetland filters (beds) has been found suitable for crop irrigation [3,13,14]. The choice of appropriate plant species improves usually the efficiency of wetland [15], which varies with other environmental conditions [9]. Vascular plants, most commonly *Phragmites australis* (reed), form the main biological component of wetlands [16,11]. This macrophyte species is an aquatic plant that grows widely in tropical and temperate regions. Reed not only contributes to increasing the permeability and porosity of the substrate [17,18], but also creates oxygenated microsites by releasing oxygen from the roots [16,19]. Several studies suggest that the plant plays an important role in depuration process by: (i) assimilation of minerals pollutants into their tissues, (ii) acting as catalyst for purification reactions by increasing the environmental diversity in the rhizosphère, (iii) promoting a variety of chemical and biological reactions [3, 20]. Until now, the use of wetlands system for wastewater treatment in Algeria is limited.

The present work studies the possibility of pollutants removal from wastewater using wetland planted of *Phragmites australis* in the southeast of Algeria. The used wastewater was taken from the main discharge of El Oued city at the entrance to the aerated lagoon plant (STEP1).

Several physicochemical parameters have been tested to evaluate the purification performance of the plant. Also, the obtained results of *Phragmites australis* filter were compared to those of unplanted control.

2. MATERIAL AND METHODS

2.1 Climate Overview

Experiments were carried out in 2016 at El-Oued University which has a hyper-arid of Saharan-type climate, with a hot, dry summer and a very cold winter [21].

Climatic data during the period 1989-2015 show that the maximum of mean monthly temperature is of 32.78°C in July and the minimum is of 11.39°C in January. This region also characterized by variable weak and irregular precipitation (about 70.29 mm/year). The value of interannual monthly average evaporation is of 147.52 mm, the sunshine in this region is very high (average of 351.4 hours per month). The average temperature measured in February, March and April was 14.6, 16.8 and 23.2°C (year 2016), respectively [22].

2.2 Experimental Design

Experiments were carried out by implantation of *Phragmites* in a basin (height=0.3m) filled with washed gravel (vertical flow). The substrate is composed of three layers of different particle size (Fig.1). *Phragmites australis* were planted in January 2016 and watered during this month. Then, they are irrigated with raw wastewater at the begininig of each month (February, March, April).

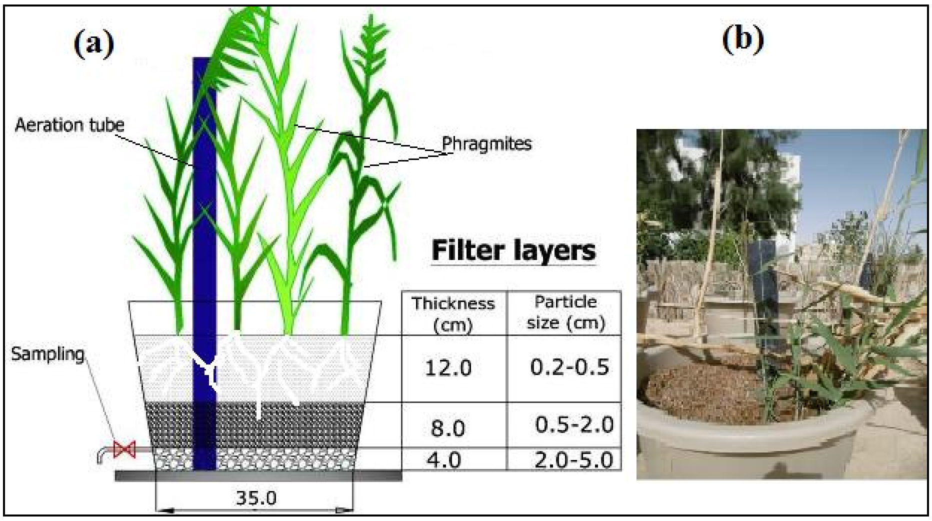

Fig.1. Schematic appearance of planted filter with vertical flow **(a),** photo of the used filter **(b)**

2.3 Sampling and Dosage

Samples of treated water were taken from sampling valve every 10 days. Analyses of the studied parameters (pH, EC, O_2, TSS, BOD and N_{tot}) were carried out for raw and treated wastewater at the laboratory of treatment plant (STEP1- El Oued). These parameters have been determined by standard analytical methods cited by Rodier et al. [23] or by following the catalogs of the equipment used. Pollutant removal efficiency is given as follows [16, 24]:

$$Efficiency(\%) = 100.(c_i - c_f)/c_i$$

C_i : initial concentration of component expressed in (mg/l).

C_f : final concentration (mg/l) of component expressed in (mg/l).

3. RESULTS AND DISCUSSION

3.1. PH

The experimental results (Fig.2) indicate that the variation of pH values of raw and treated wastewater is not significant (varies between 7.32 and 8.35).

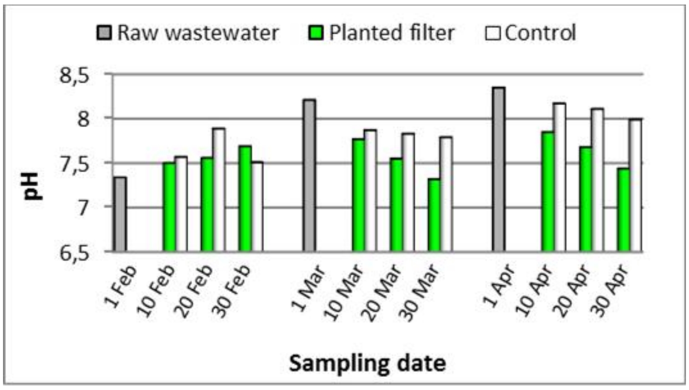

Fig.2. Variation of pH values of raw and treated wastewater

As shown in Fig.2, pH values of treated wastewater increase in February, which can be explained by the plant respiration and photosynthetic activity consuming of H^+ protons [25]. During March and April months, the decrease in pH values in the case of planted filters can result from, (i) the accumulation of H^+ protons from the activity of nitrifying bacteria, (ii) the release of CO_2 from the degradation of organic matter by heterotrophic bacteria and the respiration of plant [26].The same result is also found by Tenner et al. [27].

3.2. Electrical Conductivity

Results of Fig.3 clearly show that the electrical conductivity (EC) values of treated water slightly exceed those of raw wastewater in February, this s can be interpreted by the beginning of reed adaptation [28]. Whereas, the conductivity increases strongly during March and April (ranging from 6.17 to 16.21ms/cm, in April).

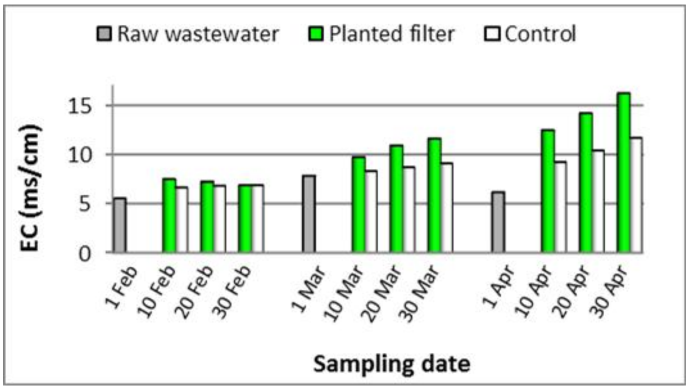

Fig.3. Variation of EC values of raw and treated wastewater

This increase results from the leaching of soil minerals [29], the evapotranspiration phenomenon [15] and decomposition of the organic matter by improvement of the bacterial activity [30].

3.3. Dissolved Oxygen

As shown in Fig. 4, dissolved oxygen concentration with *Phragmites australis* is lower than that obtained by the unplanted control during February. This indicates that, in the planted filter, the photosynthetic activity was not significant and the amount of O_2 consumed by the bacterial biomass was high.

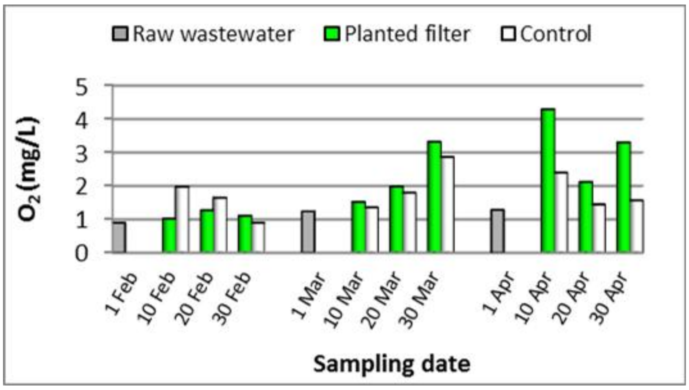

Fig.4. Variation of dissolved oxygen values of raw and treated wastewater

On the other hand, in March and April, the concentration of dissolved oxygen after treatment by using the macrophyte plant widely exceeds that of the raw wastewater and unplanted filter. This results to the improvement of vegetation photosynthetic activity, which leads to the leak of oxygen into other anaerobic zones through the plant roots and rhizomes in the rhizosphere, which leads to the transfer of oxygen from the rhizome to the roots and promotes the creation of an aerobic zone [17, 31, 32, 33]. Dissolved oxygen can also come from the exchange of molecular diffusion, between the gaseous phase of the porous medium and the atmospheric air [34, 35].

3.4. Total Suspended Solids

Results indicate that the TSS values were high and variable in raw wastewater (Fig.5). Treated wastewaters by both planted and unplanted system were extremely efficient. Nonetheless, there was no significant difference between the performances of these two systems. The percentage removal achieved 95.5 % (April) and 96.3 % (February) in planted filter and unplanted, respectively.

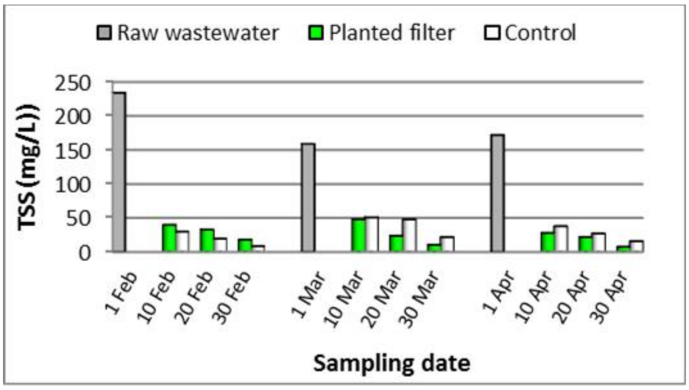

Fig.5. Variation of TSS values of raw and treated wastewater

The important decrease in TSS can be explained mainly by physical processes of sedimentation [28, 35]. The vertical percolation of wastewater through the substrate allows a physical retention of the suspended solids [27]. Results show that this process is hardly affected by *Phragmites australis* growth.

3.5. Biochemical Oxygen Demand

It is discovered by this experiment that the rate of the 5th biochemical oxygen demand (BOD_5) removal using the planted filter are relatively higher than those found with the unplanted (Fig. 6). The maximum efficiency of the planted filter reaches 97% (March) compared to 91.6 % (April) for the unplanted control. It was also observed that the efficiency of both filters increases with increasing time for each month. Similar results confirm this finding [36, 37, 38].

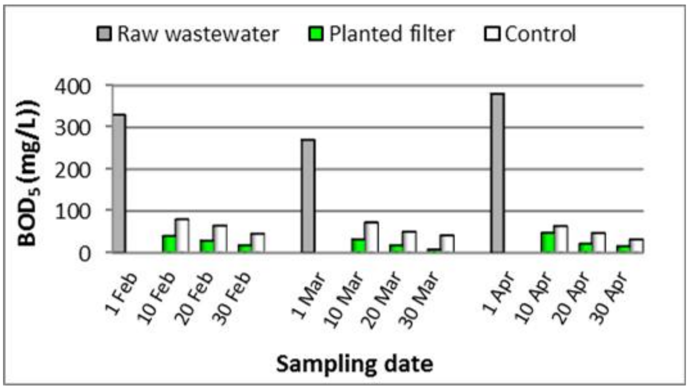

Fig.6. Variation of BOD_5 values of raw and treated wastewater

The higher performance in removing BOD indicates that the *Phragmites australis* was able to oxygenate considerably the treatment system. This has favored the aerobic degradation of the biodegradable organic matters by microbial activity [39, 40].

3.6. Total Nitrogen

Variation of total nitrogen (Ntot) values of raw wastewater did not change significantly during the experiment period (Fig.7). Our results demonstrate that the reed filter leads to a clean improvement of total nitrogen reduction compared to the non-vegetation system (removal percentage achieves 89 % in February).

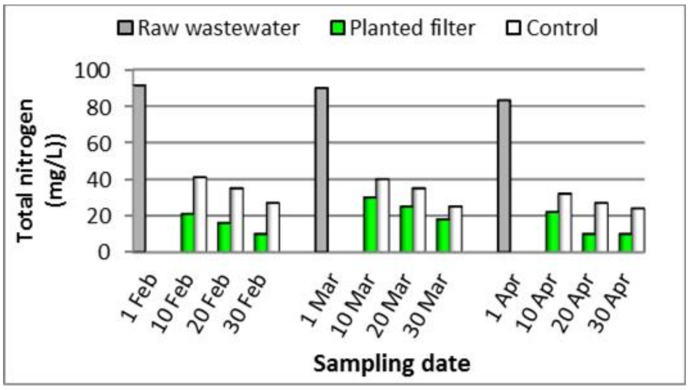

Fig.7. Variation of total nitrogen values of raw and treated wastewater

Organic nitrogen and ammonia nitrogen (NH_3-N) represent the main type of nitrogen in wastewater [35]. The decreasing of Nt values result from: hydrophytes uptake, volatilization and nitrification-denitrification [41, 36]. Lavrova and Koumanova [37] found that the fully removal of the ammonium-nitrogen was achieved for twelve days using lab-scale subsurface vertical-flow wetland.

4. CONCLUSION

The treatment of domestic wastewater by vertical flow filter in arid region was studied during three months. Experiments were carried out by using planted filter of *Phragmites australis* and unplanted control. The study comes to the following conclusions:

- The electrical conductivity measured at the outlet of the *Phragmites* filter exceeds that of the filter without plant.
- Dissolved oxygen concentration after treatment exceeds strongly that of the raw wastewater.
- Both filters have an important capacity for the total nitrogen removal.

- The highest removal of BOD_5 was found to be 97% and 91.6% for planted filter and unplanted, respectively.
- Total nitrogen reduction is improved by the plant presence, and reached a maximum rate of 89%.

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