

Gardens planted with macrophytes filters, purification performance in an arid climate. Pilot station of Témacine, Ouargla (Algeria).

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ABSTRACT

In this study, we are interested in evaluating the performance of a system for purifying wastewater by plants in an arid climate. The treated water is wastewater from domestic sources in the region of the old Ksar Temacine (Wilaya of Ouargla, South-East of Algeria). The results show good yields for organic and particulate pollution. Drawdown rate of approximately 97.49 % of Suspended Solids (SS), 90.85 % of Chemical Oxygen Demand (COD), have been achieved. The system effectively removes nitrate pollution 100 % of ammonium and phosphorus pollution moderately 62.28 % of orthophosphates. The system shows a very high removal of total coliforms (90 %).

Keywords: Wastewater, treatment, phytopurification, arid climat, bed planted, macrophytes.

1. INTRODUCTION

For decades, the wastewater managers in Algeria have favored the creation of sewage activated sludge (100 % of sewage wastewater in 2005). This technique is very effective but raises a number of constraints: it is not green (sludge production) and requires heavy investment.

Recent years alternative techniques are introduced, natural ecological techniques do not nécessitants large investments in their easy implemented and can be adapted to the climatic conditions of each region, it is the case of treatment by plants or phytopurification.

The first pilot plant using the purifying power plants in Algeria was made at the edges of the old Ksar Temacine in the province of Ouargla. The objective of this study was to evaluate the treatment performance of this type of treatment of urban wastewater in arid climate like the area Temacine.

2. PRESENTATION OF THE STATION

The sewage wastewater plants of the old Ksar of Temacine is the first of its kind in Algeria. It is sized to treat 15 m³ of wastewater from residential, corresponding to the production of 100 people or 20 houses in the old Ksar Temacine at a rate of 150 L / per / day. The wastewater treatment is made by two successive stages, a primary treatment followed by a secondary treatment.

Primary treatment (physical) is provided with a septic system, consisting of three rooms with a volume of 45 m³, which corresponds to a residence time of water in the pit for three days. On leaving the water is filtered through a filter of palm fiber (lif).

Secondary treatment (biological) is carried out in a 400 m³ tank filled with gravel. The basin is filled with water so that the level of the water is 10 to 15 cm below the gravel, subsurface flow can at no time the wastewater is in contact with the air, this has the advantage of avoiding any human contact, odors, or the proliferation of mosquitoes. Inside the basin walls slowdown allow water to stay for 4 days, which means a residence time of 7 days.

In the basin are planted 941 plants distributed among 23 species plants recognized by their ability to live in an environment saturated with water (Vetiver - Figuier - Jasmin - Lantana - Touggourt Rose - Hibiscus - Oleander - Cana - Papyrus - mace (Typha) Euonimus - Banana - Guava - Jone, Washingtonia, etc.). The discharged water is directed to the basin drainage ditches that supplies a green zone.

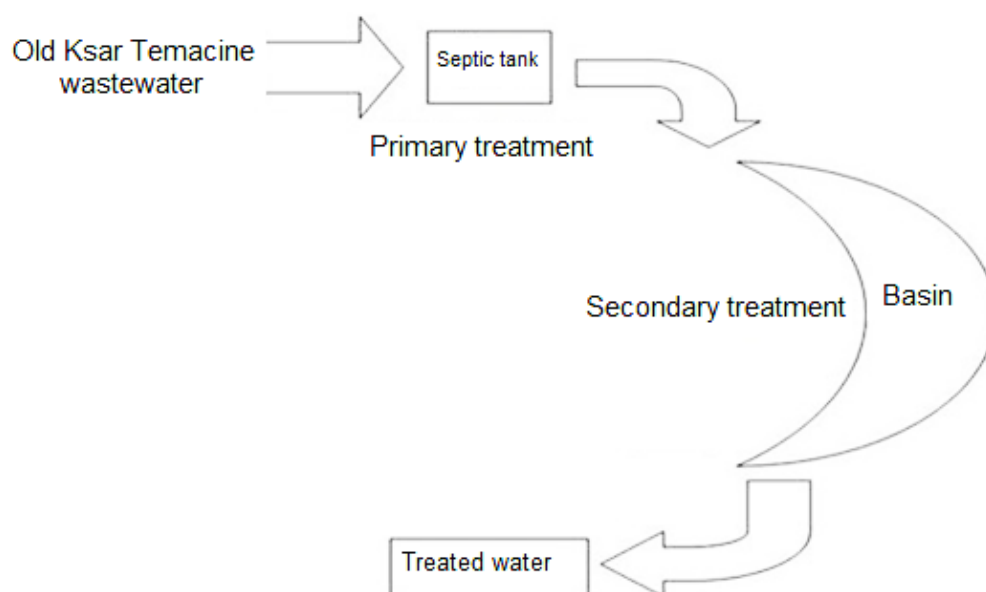


Fig. 1. Schematic of sewage wastewater plants of the old Ksar of Temacine.

3. MATERIALS AND METHODS

Analyzes were performed in the laboratory of Use and Promotion Resources Saharan University of Ouargla. Our measurements were carried on eight parameters: pH, electrical conductivity, SS, COD, dissolved oxygen, ammonium, orthophosphate and total coliforms. Water samples are collected at the entrance to D-Day and out of the pool after 7 days. For the

determination of pH, we used a pH meter HANNA pH 213. The conductivity was determined using a multi-parameter HACH HQ40d. SS were determined by the method of filtration on glass fiber according to NF EN 872. COD was determined by oxidation with potassium dichromate according to the standard NF T 90-101. Dissolved oxygen is determined by the oximeter WTW pH / Oxi 340 i. The ammonium and orthophosphate were determined to using a colorimeter HACH DR/890. Total coliforms were determined by the method of inoculation in liquid medium with an estimate of the most probable number (MPN).

4. RESULTS AND DISCUSSION

The yield is calculated as the difference between the value of the parameter (input) and leaving (output):

$$\text{purification rate} = \frac{C_{\text{input}} - C_{\text{output}}}{C_{\text{input}}} \times 100$$

4. 1. Evolution of physico-chemical parameters

4. 1. 1. Changes in pH

For pH, we take the average values during the month. The evolution of the average pH for each month exit and entry of the basin are shown in Figure 2.

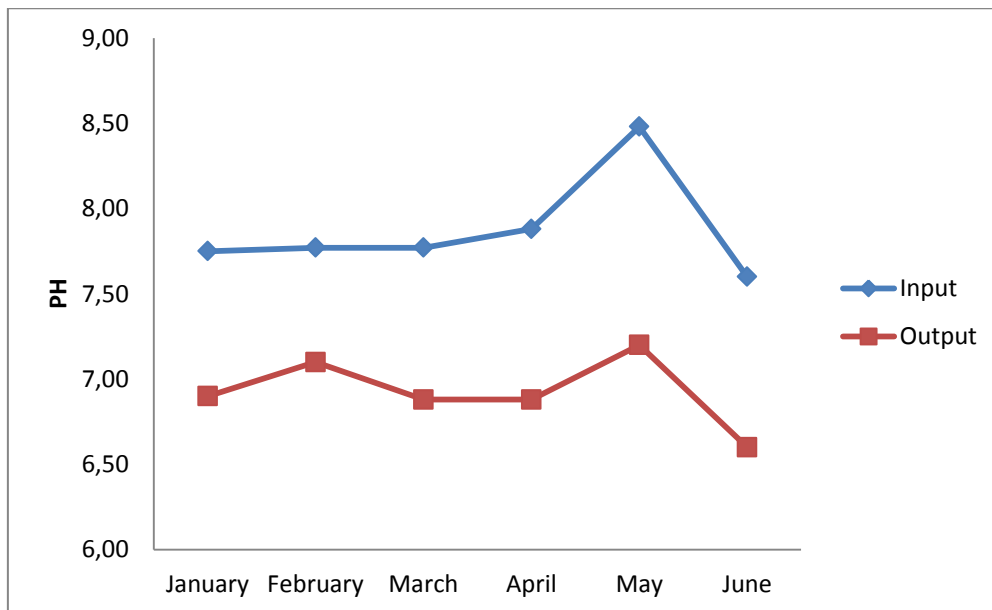


Fig. 2. Time evolution of the pH at the input and at the output of the basin.

The pH values of the wastewater entering the basin vary between 7.60 and 8.48 values that fall within the pH range usually observed for urban wastewater (Rejsek, 2002). At the exit of the basin they fluctuate between 6.60 and 7.20.

Contrary to what observed by FINLAYSON and CHICK (1983), ABISSY et al (1999) and TIGLYENE et al (2005), the pH of the water becomes more acidic at the exit of the basin, this is the result of the oxidation of organic matter and nitrification of NH_4^+ (DOMMERGUES and MANGENOT, 1970 MÜNCH, 2004), effect of COD oxidation product of carbon dioxide (CO_2), which acidifies the medium, and the nitrification (oxidation of NH_4^+) causes acidification of the filtrate as the plants release root exudates which are mostly acidic, which can lead to acidification of the medium (VINCENT et al, 1994).

4. 1. 2. Evolution of electrical conductivity

For conductivity, we take the average values during the month. The evolution of conductivity during six months at the entrance and exit of the station are shown in Figure 3.

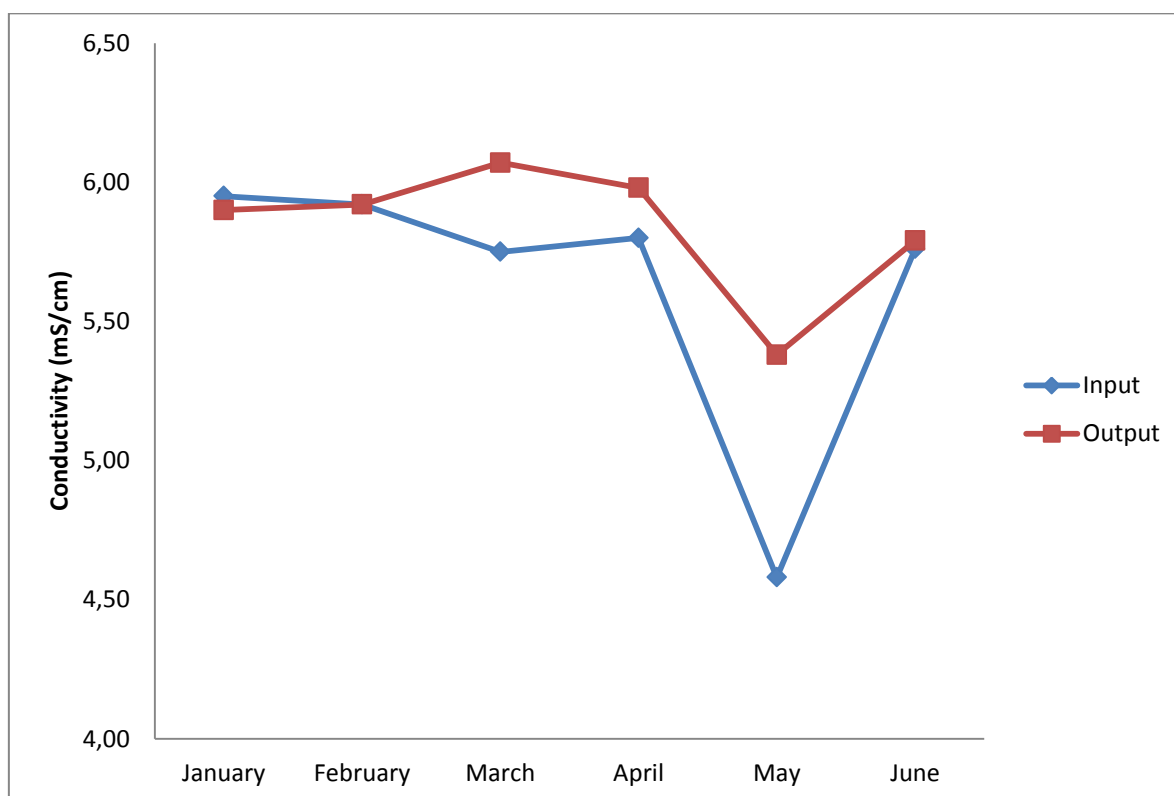


Fig. 3. Time evolution of the conductivity at the input and at the output of the basin.

The conductivity values of wastewater entering the basin vary between 4.58 and 5.95 mS / cm, and the output of the latter between 5.38 and 6.07 mS / cm, this increase could be related to the mineralization of the organic material.

Our results are similar to those found by FINLAYSON and CHICK (1983) for a plantation of *Typha latifolia* who interpret this phenomenon by evapotranspiration from vegetation which tends to focus more effluent. According RANJANI et al. (1996), the increase in conductivity is more related to leaching of soil minerals and organic matter mineralization.

Other studies show that by cons there is no trend in the change of electrical conductivity (RIVERA et al., 1996).

4. 2. Evolution of particulate pollution

The results are summarized in Figure 4.

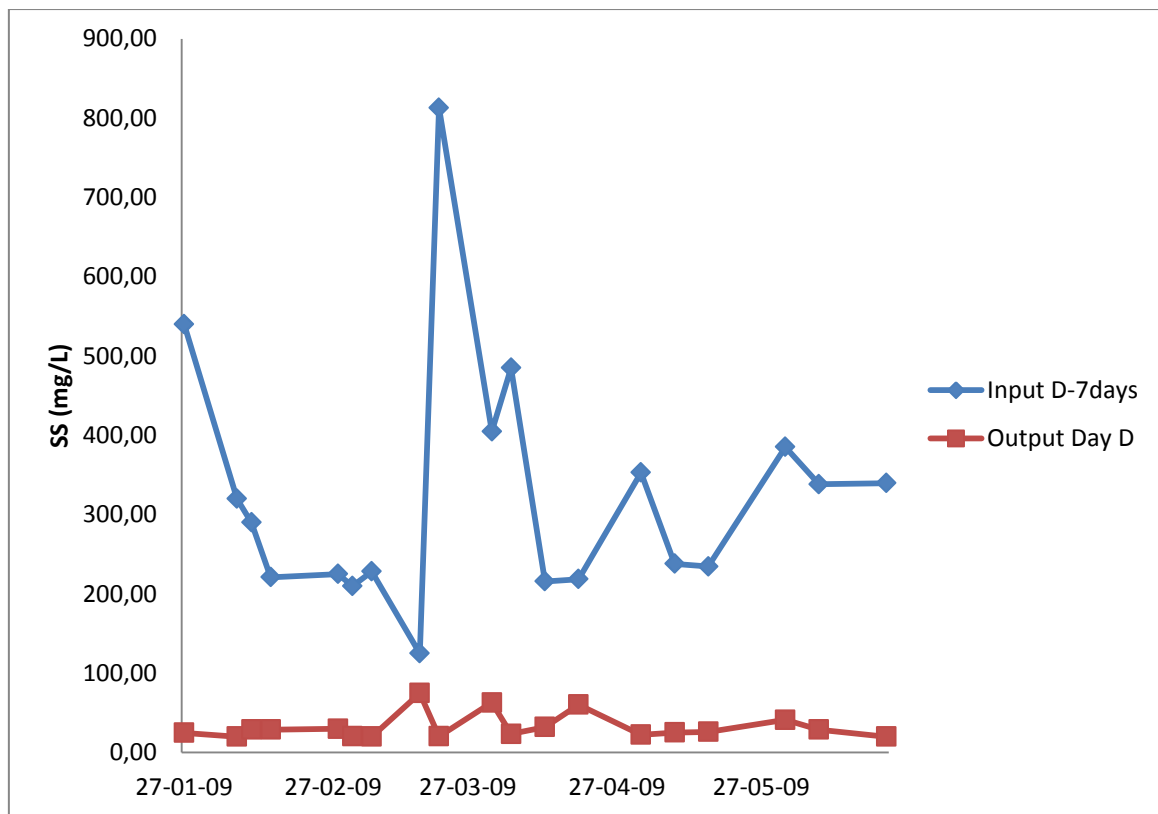


Fig. 4. Temporal evolution of MES at the entrance and exit of the basin.

The SS concentration wastewater entering the basin varies between a minimum of 125 mg / L and a maximum of 813 mg / L. That at the output oscillates between 20 and 75 mg / L. The reduction of particulate pollution in terms of MES could reach a value of 97.49 %, a very satisfactory performance. SS reduction is similar to that found by GESBERG et al. (1986) and URBANC-BERCIC (1994). Much of suspended solids is retained by physical filtration (ABISSY, 1999) through the gravel and plant roots.

4. 3. Evolution of organic pollution

4. 3. 1 Evolution of COD

The results are shown in Figure 5. The COD values of the waste water to the input of the basin fluctuate between 530 and 179.50 mg / L, that of the output 35 to 98.30 mg / L.

The system allows a reduction of almost all of the COD, the reduction of the latter was able to achieve a yield of 90.86 %. The COD reduction obtained is similar to that found by GESBERG et al, (1986) and higher than that obtained by URBANC-BERCIC (1994). The COD reduction involves physical phenomena filtration and biological degradation and decomposition of the organic material due to its oxidation by bacteria. Sedimentation of solids and their filtration gravel and plant roots have certainly contributed to the elimination of carbon pollution.

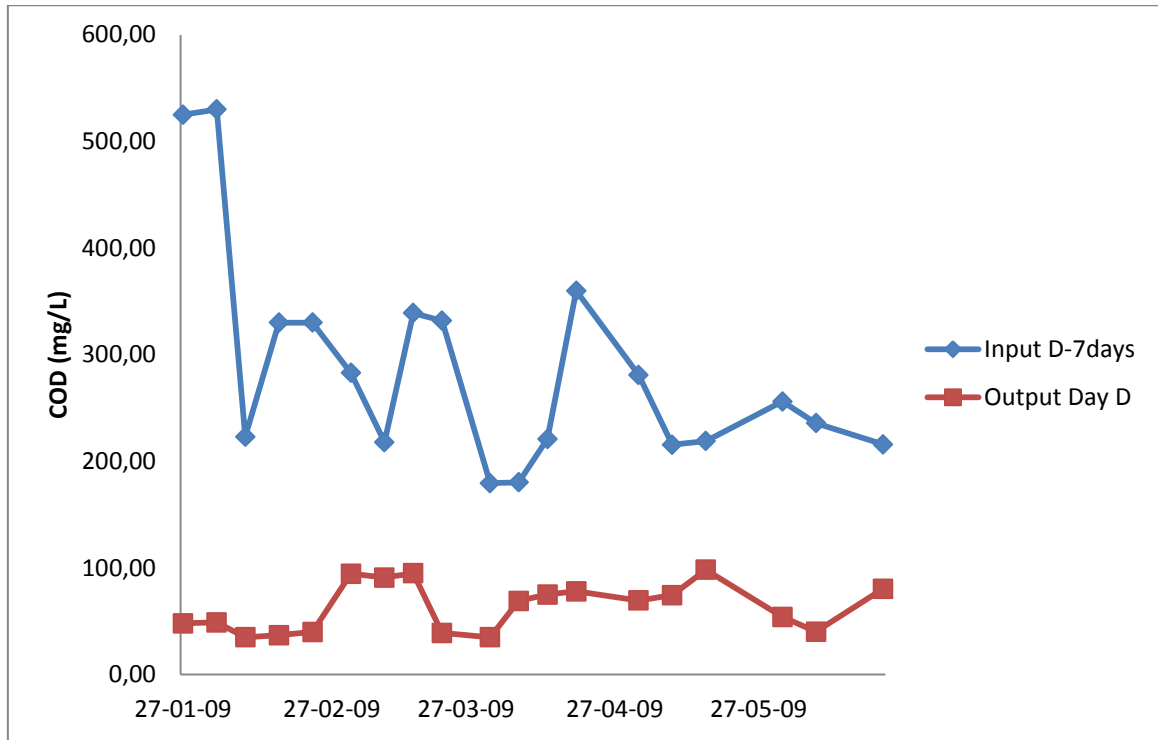


Fig. 5. Time evolution of COD input and the output of the basin

4. 3. 2. Evolution of dissolved oxygen

The results are summarized in Figure 6.

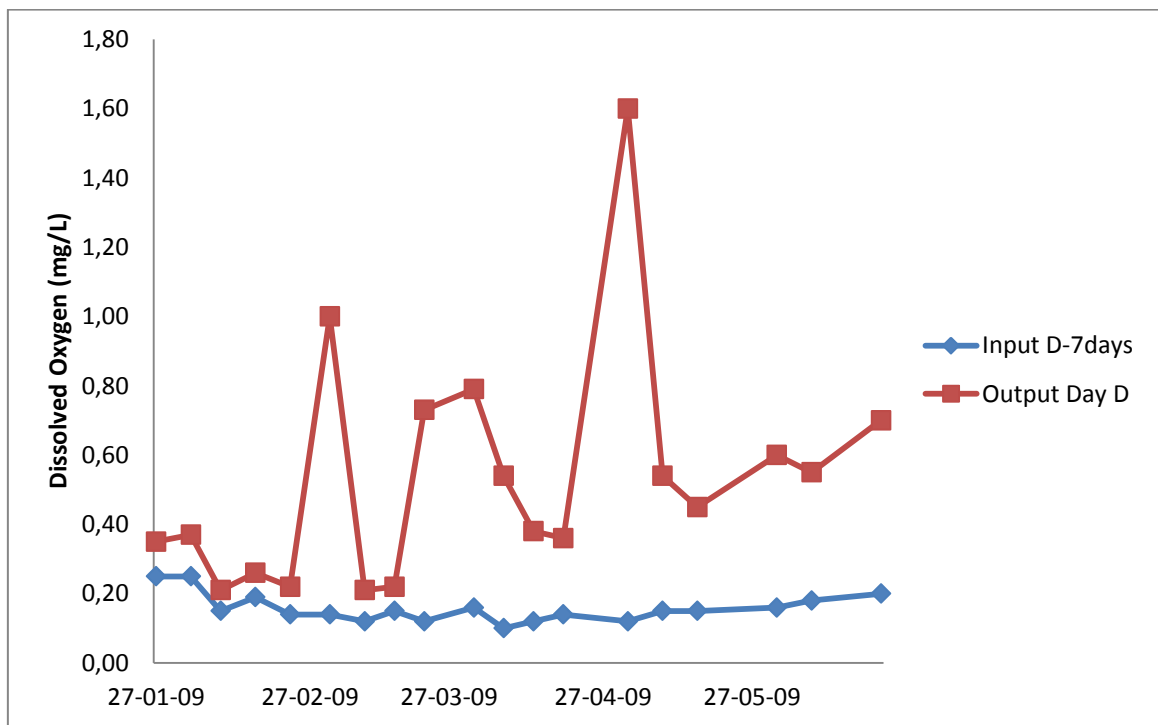


Fig. 6. Time evolution of dissolved oxygen at the input and at the output of the basin.

The dissolved oxygen concentrations in the wastewater basin entrance fluctuate between 0.10 and 0.25 mg / L and from 0.21 to 1.60 mg / L to the output thereof.

There is an improvement in the concentration of dissolved oxygen out of the pool this is due to the fact that the waters become less charged after purification.

4. 4. Evolution of nitrogen pollution

4. 4. 1. Evolution of ammonium

Figure 7 collects all values obtained during the experimental period.

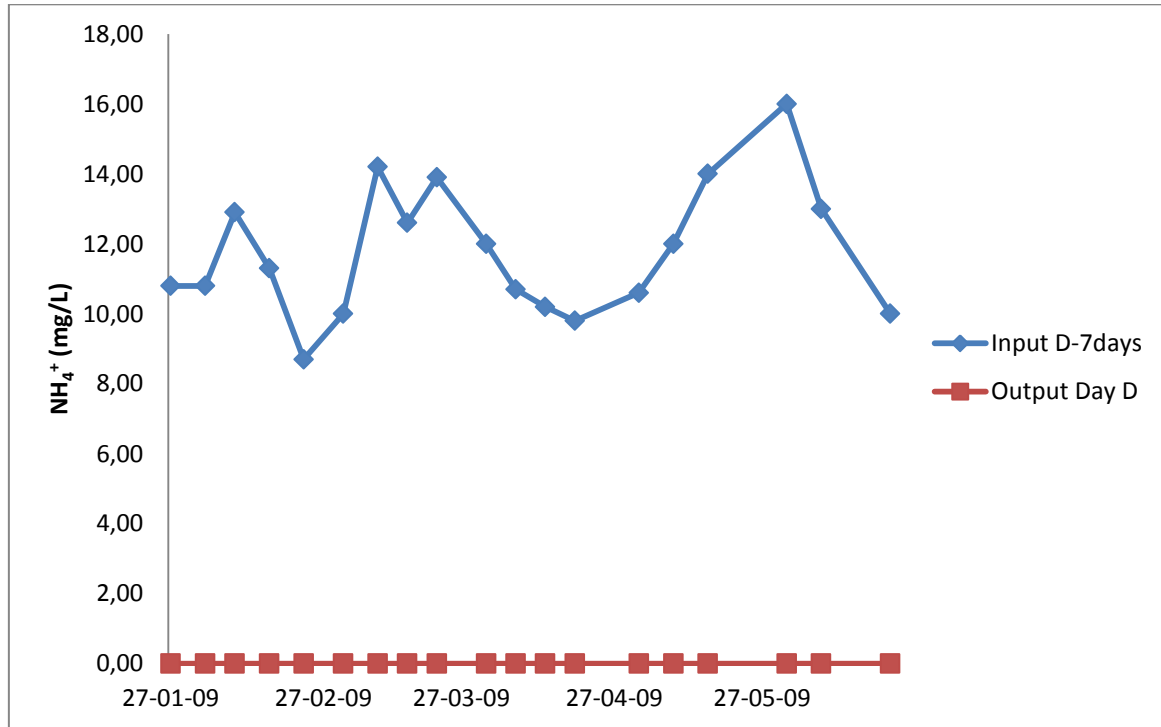


Fig. 7. Time evolution of ammonium at the input and at the output of the basin.

The values obtained for the wastewater entering the basin vary between 8.70 and 16 mg / L. Ammonium from the mineralization of organic nitrogen into ammonia (ammonification). It occurs in both aerobic and anaerobic. At the exit of the basin, there is a total transformation of ammonium.

Our results are significantly higher than the yields of 24 % and 86.5 % found ABISSY (2005) and PETEMANAGNAN OUATTARA (2008) respectively.

This performance can be interpreted by the fact that part of ammonium is assimilated by plants while the other part is converted to nitrite and then to nitrate by biological oxidation by nitrifying bacteria. According BRIX (1994), aquatic macrophytes are equipped with an internal air space well developed (aerenchyma) through plant tissues which ensures the transfer of oxygen to the roots and rhizomes.

The oxygen diffuses through the roots stimulates the growth of nitrifying bacteria in the rhizosphere (GESBERG et al, 1986; ARMSTRONG and ARMSTRONG, 1988, 1990).

4. 4. 2. Evolution of phosphorus pollution

The results are shown in Figure 8.

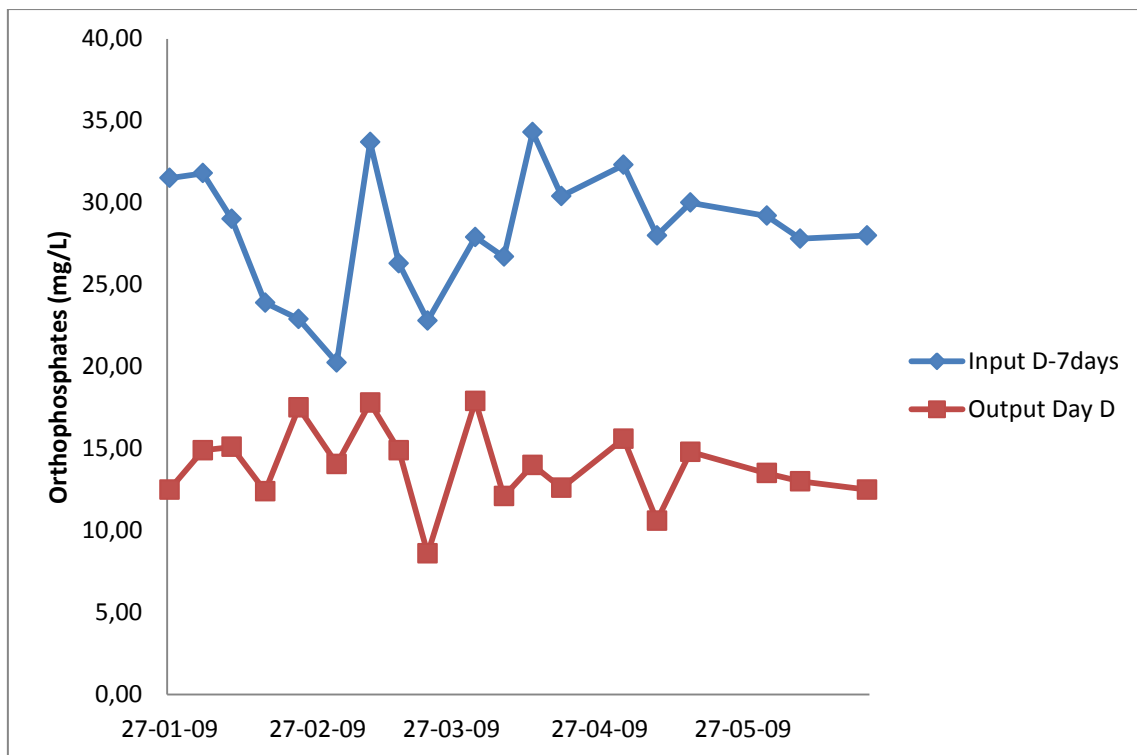


Fig. 8. Evolution of orthophosphate time at the input and at the output of the basin

Orthophosphates concentrations at the input of the basin fluctuate between 20.25 to 34.30 mg / L. At the exit of the basin are between 8.60 to 17.90 mg / L. Orthophosphates undergo significant depression, which was able to achieve a yield of 62.28 %. Our results are superior to those found by ABISSY (1999), a yield of 10 %.

The plant assimilates phosphorus for these fabrics favored by the significant increase in the rhizomatous root system of the plant and which therefore creates better conditions for assimilation (PETEMANAGNAN OUATTARA, 2008).

4. 5. Evolution of pathogen pollution

4. 5. 1. Evolution of total coliforms

The number of total coliforms was determined for the months of February, March, April, May and June. The results are shown in Figure 9.

The removal efficiency of total coliforms was able to reach the rate of 90 %.

This reduction of total coliforms may be the result of several factors: sedimentation, filtration, predation destruction, action exudates emitted by the plant roots (VINCENT et al., 1994), natural death with organic matter degradation.

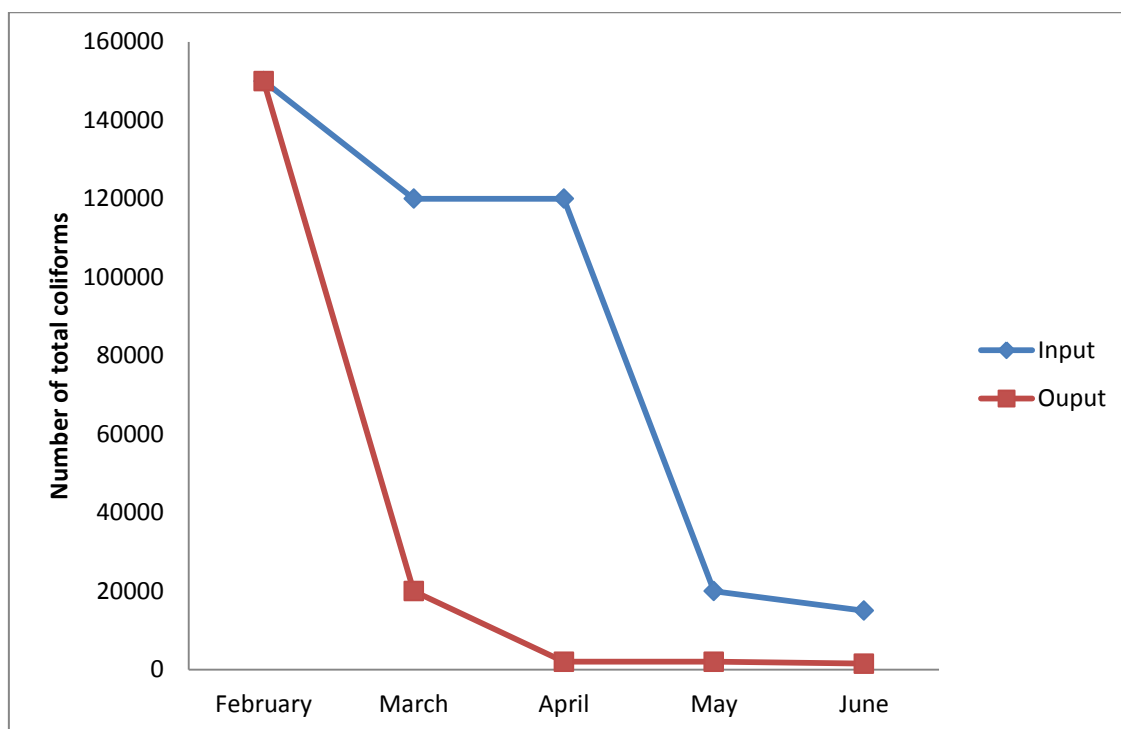


Fig. 9. Temporal evolution of total coliforms at the input and the output of the basin.

5. CONCLUSION

This study assessed the purification performance of a treatment system wastewater phytopurification in an arid region. The performances obtained show that the method is an effective alternative for the treatment of domestic sewage in the case of an arid climate.

The results are very encouraging abatement of organic pollution could reach a rate of 93.64 % in term of COD. Treated water by plants are basically of the same quality as those emerging from a conventional system equipped with denitrification and phosphorus removal.

Analyses also revealed a good performance of the systems studied in the elimination of pathogens. Our work also shows that macrophytes used are well adapted to the pollutant load applied.

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REFERENCES

- [1] Abbisy M., Mandi L., *Journal of Water Science* 12(2) (1999) 285-315.

- [2] Armstrong J., Armstrong W., *New Phytologist* 108(4) (1988) 373-382.
- [3] Armstrong J., Armstrong W., *New Phytologist* 114 (1990) 121-128.
- [4] Brix H., *Wat. Sci. Tech.* 29(4) (1994) 71-78.
- [5] Dommergues Y., Mangenot F., *Ecologie microbienne du sol. Masson and Cie*, 1970, p. 796.
- [6] Finlayson C. M., Chick A. J., *Water Research* 17(4) (1983) 415-422.
- [7] Gesberg R. M., (et al.), *Water Research* 20(3) (1986) 363-368.
- [8] Münch C., (et al.), *La stimulation racinaire de l'élimination de l'azote concerne-t-elle des zones limitées ou l'ensemble d'un marais artificiel*. Ingénieries N° spécial 2004, 5-11.
- [9] Petemanagnan Ouattara J. M., (et al.), *Eur. J. Sci. Res.* 23(1) (2008) 25-40.
- [10] Ranjani K., (et al.), *Treatment of maize processing industry wastewater by constructed wetlands*. Proceeding of 5th International conference on wetlands systems for water pollution control, Vol. 1, Vienna 1996, Sept. 15-19, p. 9.
- [11] Rejsek F., *Analyse des eaux aspects réglementaires et techniques CRDP d'Aquitaine*, Bordeaux 2002.
- [12] Rivera F., (et al.) (1996). *The application of the root zone method for the treatment and reuse of high strength abattoir waste in Mexico*. Proceeding of 5th International conference on wetlands systems for water pollution control, Vol. 2, Vienna 1996, Sept. 15-19, 8 p.
- [13] Tiglyene S., (et al.), *Journal of Water Science* 18(2) (2005) 177-198.
- [14] Urbanc-Bercic O., *Wat. Sci. Tech.* 29(4) (1994) 289-294.
- [15] Vincent G., (et al.), *Antimicrobial properties of roots exudates of three macrophytes: Mentha aquatica L., Phragmites australis (Cav.) Trin. And Scirpus lacustris L.* Proceedings, 4th International Conference Wetlands Systems for Water Pollution Control, Guangzhou 1994, China.