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Performance of the *Cana indica* Plant in Treatment of Waste Water by Vertical Flow Method for the Touggourt Region, Algeria

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***Abstract*:** The effectiveness of the *Canna indica* plant in treating waste water with a vertical flow system under dry and hot atmosphere was studied. This study included a comparison between a basin planted with *C. Indica* and a non-planted one (witness), with the study of the ability of the *C. Indica* plant to filter waste water. The study was carried out through an experimental model at the National Institute of Disinfection (ONA) in Touggourt, Algeria. This model consists of circular basins with a capacity of 52L filled from bottom to top on a thickness of 18cm with gravel (25/15) mm. The process of supplying the basins with urban waste water after primary treatment (physical treatment) with 15L per day at a regular rate once every week and the water obtained after Its stay in the tank for 5 days is collected through a container placed under the sink. After the study that lasted for six months from December 2019 to May 2020, obtained the removal of pollutants, with percentages of DCO (83.95%), N-NO_2^- (81.81%), P-PO_4^{-3} (90.49%), and bacteria *E. Coli* (99.86%).These percentages comply with the recommended standards for the safe use of this water in the agricultural field.

Keywords: Arid climate, Wastewater, Hydrophyte treatment, *Canna Indica,* Touggourt region

The scarcity of water resources, especially in arid regions, is a global issue (Yi L et al 2011) and some scientific studies on natural treatment of urban wastewater have shown that treatment by plants is the best technique that is simple and easy to use and requires few possibilities and a natural treatment method in removing pollution through artificial wetlands (Wu et al 2016). The use of this technology is widespread in different regions and under different climates (Bebba et al 2019) and depends on providing the same conditions as natural wet areas, called the lung of the earth, due to the ability to treat dirty water and this thanks to the activity and the great role played by plants and microorganisms (Wu et al 2015). The alternative for water in these areas is the use of treated wastewater (Cirelli et al 2012), where the treatment system consists of a thick layer of gravel or sand or a combination of both, where the environment is always full or saturated with water.

The effectiveness of the basin of treated water by plants depends on the time of setting the water inside this unit, and the preferred time for the water to remain inside the basin is from 5 to 4 days, and therefore it is desirable that the garden basin be large so that the water allows a residence time in order to obtain a high-quality treatment. In order to obtain positive results, need a method of ventilation, which increases the activity of microorganisms in the dismantling of pollutants, and it has also been shown that the use of treatment technology by plants is very satisfactory and the water purified by plants is considered to have roughly the same quality as that which comes out of a good traditional system equipped with nitrogenation units. (Bebba et al 2019). The aim of this study is to measure the efficacy of *Canna indica* in wastewater purification using a vertical flow system in a dry and hot atmosphere. and compare it to an uncultivated basin.

MATERIAL AND METHODS

Experimental protocol: The experimental gear consists of circular tubs of 52L capacity, filled from bottom to top at 18cm thickness with gravel (25 / 15mm) planted with young stems of the *Canna Indica* plant at densities (36 tiges / m^2) this criterion has been taken from previous studies(Tiglyene et al 2005). Basin I: planted with *Canna indica* and non-cultivated basin (as witness). The process of supplying the tubs with urban wastewater after the initial treatment (physical treatment) with 15L per day, by the method of vertical flow, at a regular rate once a week, and the water obtained after staying for 5 days in the tubs is collected through a container placed at the bottom of the basin.

Physiochemical properties of used packing materials: It is characterized by pH of pH = 14.7 neutral medium and conveyor CE = 3.88ms / cm. *Canna indica*, a plant species belonging to the Canna species, from the Cannaceae family (Choudhary et al 2011) was used. This plant was taken from the Model basin which is located in Tamasin - Touggourt. The aim is to treat urban wastewater, exploit wastewater and reuse it for irrigation.*Canna*can be used to treat industrial wastewater through artificial wetlands and it is effective to remove organic loads, color and chlorinated organic compounds from wastewater (Charge) from paper factories, for example(Choudhary et al 2011). The study took place over a period of six months, from December 2019 to May 2020. The analyzes were performed for physiochemistry at the laboratory of the National Office for Disinfection (ONA) in Touggourt, Algeria and Bacteriology in the laboratory of food and water analysis at Soliman Amirat Hospital, Algeria.

Physiochemical and Bacteriological Parameters

Identification of suspended matter MES: The amount of suspended matter MES (NF T90-105) was estimated according the filtration method and was used when the water is low in suspended matter. The centrifugation method when the water is of high density with suspended matter. The centrifuge has a rate of speed 3200-2800 revolutions per minutes.

Determination of the chemical demand for DCO: DCO was determined by oxidation by potassium picromate in an acidic environment with heating for two hours in the presence of AgSO4 and HgSO4 by spectrophotometer DR3900. By using the Digestion par réacteur method, in r measurement of DCO, used capsules containing a previously prepared commercial reagent.

Biochemical oxygen: This was quantified using a manométrique DBO-meter

Nitrite NO_2^-: The amount of NO_3-nitrate was determined with Diazotation spectrophotometer DR3900

Artphosphate: This was quantified with the spectrophotometer DR3900 as per the Phos Ver3 method (ascorbic Acid).

Dissolved oxygen: This was measured by the Ampérométrique method According to (AFNOR; T90-106) Oxymétrie BPL Inolab meter.

pH: pH was measured with a pH meter of the type PH meter sension1 (AFNOR, X31-103)

Electrical conductivity: This was measured with a condictiveté sension5 conductivity meter.

Counts of *Coliformes totaux et Fécaux* and *E. Coli)* : Thèse in culture were estimated in liquid environment (AFNOR T90-433)

Purification yield: This was determined the purification efficiency of the measured environment by the following equation:

R% $= (C_E - C_S) / C_E \times 100$

R: the payoff of the purification, C_E: Media concentration in the wastewater entering the basin (mg / l), C_S: The concentration of the used existing environments in wastewater out of the basin (mg / l). The results presented for each medium represent the mean values measured and obtained from the two independent basins (culture and control). Characteristics of wastewater used in feeding tubes are given in Table 1.

RESULTS AND DISCUSSION

Evolution of temperature T (c°): The average values of the temperature decrease in the treated water in the various basins compared to the used water (Fig. 2). The highest was 27.7°C in May and the lowest 20.7°C in December, that is, the temperature is sandwiched between the two 20.7 ≤ T (°C) ≤ 27.7. The decrease in temperature in the treated basins is explained by the decrease in the number of bacteria and the lack of biochemical reactions. As for the treated water in the cultivated basin and the non-cultivated basin, they are close to the length of the study period at the bottom of the tubs at a depth of 20 cm. This difference in temperature does not affect the selection of the microorganisms responsible for purification.

Dissolved oxygen (DO**):** The average dissolved oxygen increase in the treated tubs compared to the wastewater, 0.04 mg / l in April in the wastewater and 5.74 mg / l in March in treated water.

The dissolved oxygen (DO) increases gradually in the used water lowest inApril, and this reflects the huge number of microorganisms (bacteria, fungi) that consume a large amount of oxygen and in addition to an increase in turbidity that impeded the permeability of air oxygen in the wastewater. Generally, dissolved oxygen changes in contrast to the organic density of the wastewater and in the depth of the treated tubs, and there is a difference in the amount of dissolved oxygen for the plant-grown tub and the non-cultivated tub and this is due to the presence of the plant as it works to transport oxygen from air into the tank from the leaves to the stems and roots (Almuktar et al 2018). The young plants are more effective in delivering oxygen through their roots to the bottom of the tub compared to older plants, whose roots form a fatty layer that prevents oxygen leakage.

pH: The average PH decreases in treated water in various

Fig. 1. Components of a vertical flow pretreatment basin

basins compared to wastewater, it decreases by a rate of 7.73 to 07.2 for the tub cultivated with plants and 7.70 for the non-cultivated pond (witness) compared to the national standard set at 6.5-8.5 (Fig. 4).

Several factors explain this decrease in the pH (acidity of the environment), including oxidation of nitrite and DCO (Münch et al 2004, Labed et al 2014) . The oxidation of DCO that produces CO_2, which in turn leads to acidity of the environment and oxidation of nitrites leads to nitrate, and the reason for this is hydrogen pool as a result of the activity of the bacteria responsible for nitrification, CO_2 accumulation as a result of plant metabolism or the breakdown of organic matter by bacteria (Bebba et al 2020), production of H^+ ions by the plant to replace some of the cations involved in the mineral nutrition of the plant and production of some secretions (organic acids) by the roots of the plant (Bebba et al 2020)

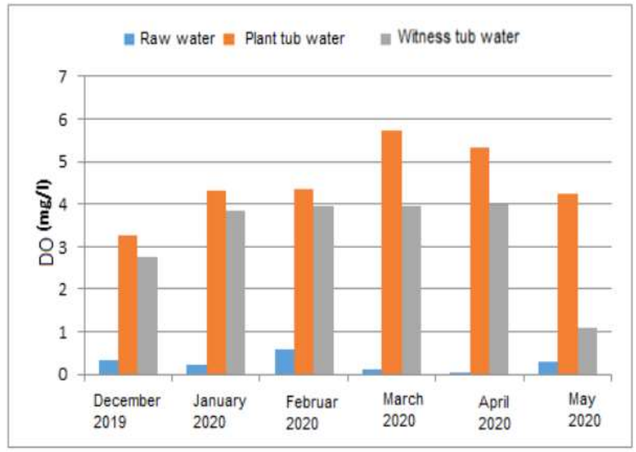

Fig. 3. Dissolved oxygen at the inlet and outlet for both the culture and control

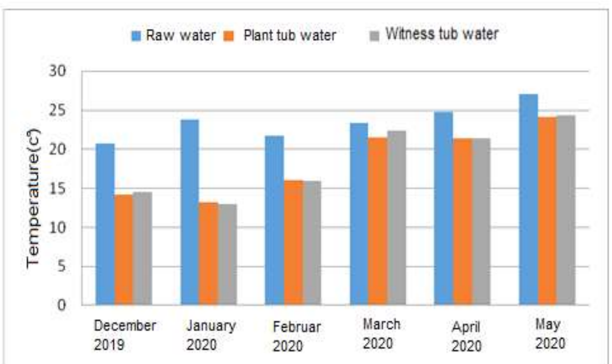

Fig. 2. Time evolution of the temperature T (°C) at the inlet and outlet for both the cultivated tub and the control

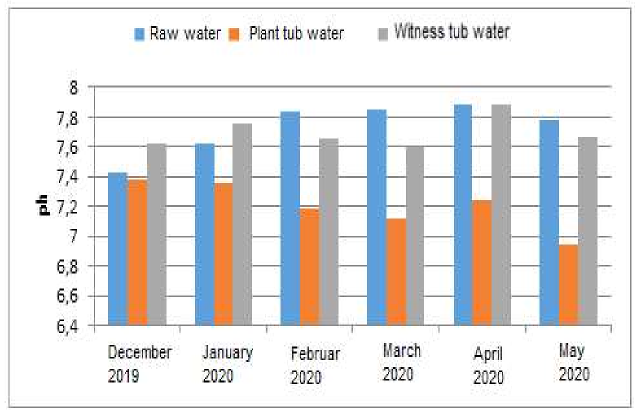

Fig. 4. Time evolution of the pH of the inlet and outlet for each of the cultivated ponds and the control

Table 1. Parameters of wastewater used in ponds

Parameters	Number of samples	Minimum value	Maximum value	Average values
T(C°)	12	20.7	27.1	23.58
pH	12	7.43	7.88	7.73
Conductivities (ms/cm)	12	5.88	6.57	6.25
Dissolved oxygen (DO) (mg/l)	12	0.04	0.58	0.26
MES (mg/l)	12	121.6	548	298.43
DCO (mg/l)	12	109.8	322	202.5
DBO_5 (mg/l)	12	50	140	87
NO_2^- (mg/l)	12	0.092	0.122	0.110
NO_3^- (mg/l)	12	15.8	39.4	29.6
Po_4^{-3} (mg/l)	12	7.10	39.6	30.48
Coliformes totaux (UFC/100ml)	12	1.2E^{+6}	E^{+6}4.0	2.3E^{+6}
Coliformes fécaux (UFC/100ml)	6	E^{+6}1.0	E^{+6}2.5	1.6E^{+6}
E. coli (UFC/100ml)	6	3.2E^{+6}	E^{+6}2.4	1.4E^{+5}

Electrical conductivity (CE): The electrical conductivity of treated water in the cultivated basin is always greater than the electrical conductivity of treated water in the non-cultivated basin (the witness) and the wastewater (Fig. 5). The electrical conductivity is high in the basin planted with plants compared to the witness basin and the electrical conductivity is high due to plant sweating and the change of organic materials to mineral substances (Amiri et al 2019).

Evolution of suspended matter MES: Evolution of suspended matter MES ranged between 121.6 mg / l and 548 mg/ lat a rate of 298.43 mg / l in urban wastewater, and for treated water the MES value in the basin cultivated with plants 54.5mg / l*Canna Indica* with a yield of 81.73% and in the non-cultivated pond (witness) 72 mg/l with a yield of 75.87% compared to the national standard set at 30 mg / l. The decrease in the concentration of MES in the various treated waters is mainly a result of a physical treatment such as filtration, where coarse materials remain suspended and fine materials are trapped in the filter pores.

Evolution of chemical demand oxygen (DCO): The chemical demand for DCO oxygen in wastewater changes between 109.8 and 322mg/ l, and through the time evolution of DCO (Fig. 7). The evolution of the chemical demand for DCO shows that its concentration decreases in treated water compared to wastewater, as it changes in the wastewater at a rate of 202.5mgo$_2$ / l, as for treated water, DCO values: 32.58Mgo$_2$ / l in the *Canna Indica* cultivated tub (83.95%), and 48.4Mgo$_2$ / l in the non-cultivated tub (control) (76.09).

The cultivated basin and the witness basin gave water with less DCO concentration than the wastewater. This is due to the physical absorption of organic materials in the wastewater of the filter and the aeration of the environment by the bacterial organisms. This cultivated tub gave better yield compared to the non-cultivated tub. This decrease is due to the presence of the plant that provides physiochemical conditions that provide oxygen to the filtered environment through the leaves to the stems and then the roots and rhizomes by the bacterial organisms that cause DCO oxidation (Yi L et al 2011,Randerson et al 2012,Stefanakis 2019).

Biochemical demand for oxygen DBO$_5$: The biochemical demand for DBO$_5$ varied between 50 and 140mg / l in wastewater. Through the time evolution of DBO$_5$ the highest removal amount was in December and May, with a yield of 86.20% for the tub cultivated with plants, and the lowest

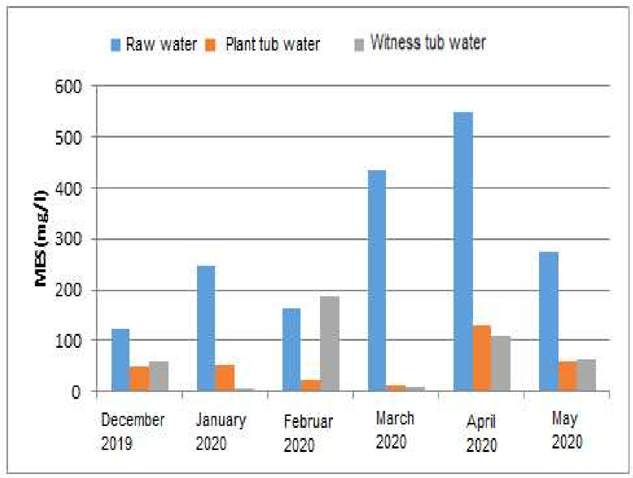

Fig. 6. Time evolution of the MES suspended material for the inlet and outlet for both the cultivated tub and the witness

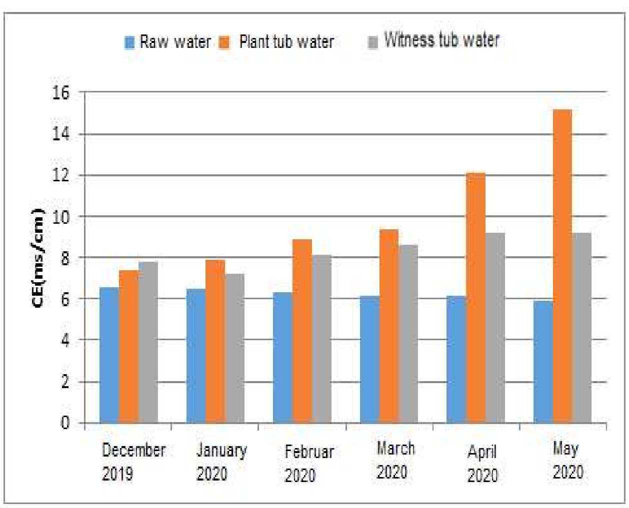

Fig. 5. Time evolution of the CE electrical conductivity of the inlet and outlet for both the control basin and the witness

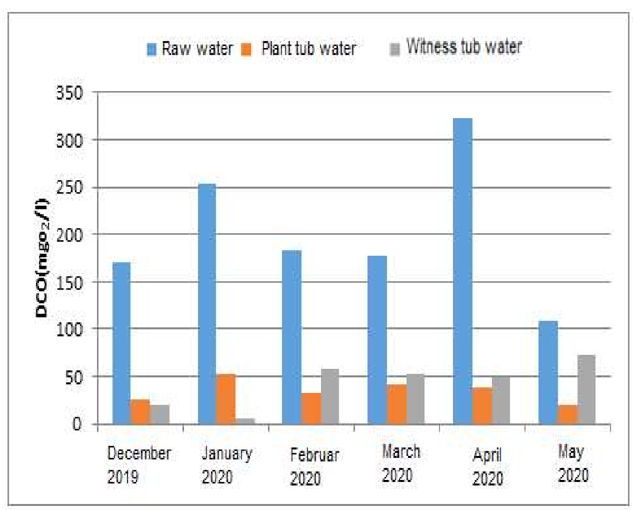

Fig. 7. Time evolution of the chemical oxygen demand (DCO) at the inlet and outlet for both cultivated and witness tubs

removal rate for DBO_5 was in March, with a rate of 65.51% for the tub planted with plants (Fig. 8) in general the concentration of DBO_5 in wastewater. Urban is greater than DBO_5 as the wastewater 87mg / l concentration of DBO_5 is reduced to 21 and 21.5 mg / l for cultivated pond and control pond, respectively. The removal of DBO_5 in the cultivated tub of plants was 75.86 and 75.28% for witness. The difference in removing DBO_5 between the planted tub and the witness tub is due to the presence of aquatic plants that have the property to absorb oxygen from the air to release it through their roots in the area surrounding the roots. This oxygen activates the bacteria, as they work to oxidize and break down organic materials (Feigin et al 2012).

No_2^- nitrite: Through the time evolution of NO_2^- nitrite in the wastewater changes with time, and it is greater than the concentration of NO_2^- in the treated water as the NO_2^- concentration decreases (0.110 mg / l) in the wastewater and 0.12 mg / l in the *Canna indica* plant tub and 0.0263 mg/l for the witness tub (Fig. 9).

There were contrasted difference between witness cultivated with plants and the witness one. The yield of nitrite removal NO_2^- is 81.81% for the *Canna Indica* tub, and 76.09%) for the witness tub. The difference in removing NO_2^- between the cultivated tub and the witness one is due to the presence of an aquatic plant that has the property of absorbing oxygen from the air and is transported through the leaves and then the stems to the roots and rhizomes. This oxygen activates the bacteria that convert NO_2^- into NO_3^- nitrite in the root zone. This process is called nitrification (Jan Vymazal 2007).

Nitrate $N\text{-}NO_3^-$: Through the time evolution of $N\text{-}NO_3^-$ nitrate decreases in all treated tubs compared to wastewater, as the nitrate concentration decreases from 29.6 mg / l to6.38 mg / l in the *Canna Indica* tub and 2.41 in the non-cultivated tub (witness) (Fig. 10).

The concentration of nitrates after treatment in the plant basin is higher than its concentration in the basin of the witness, and this is due to the availability of oxygen during the vertical flow of water and the presence of the plant helps to transfer oxygen to the basin, which leads the dissolved oxygen to oxidation of nitrite into nitrate (Białowiec et al 2012). This change in the amount removed from $N\text{-}NO_3^-$ nitrate is caused by the use of nitrates by the plant is during the day or in the presence of photosynthesis. The development of nitrates gives a decrease in the amount after filtering with plants. Plants absorb the removed organic nitrogen (Jan Vymazal 2007), and the remaining nitrogen is removed by nitrification, denitrification and aerial oxidation of ammonium (Ling et al 2009).

Arto-phosphorous $P\text{-}PO_4^{3-}$: In general, the concentration of $P\text{-}PO_4^{3-}$ for wastewater changes with time and is greater than the concentration of $P\text{-}PO_4^{3-}$ in the treated water, where the concentration of $P\text{-}PO_4^{3-}$ in the wastewater decreased by 30.48mg / l in the wastewater to, 2.89mg / lfor *Canna indica*

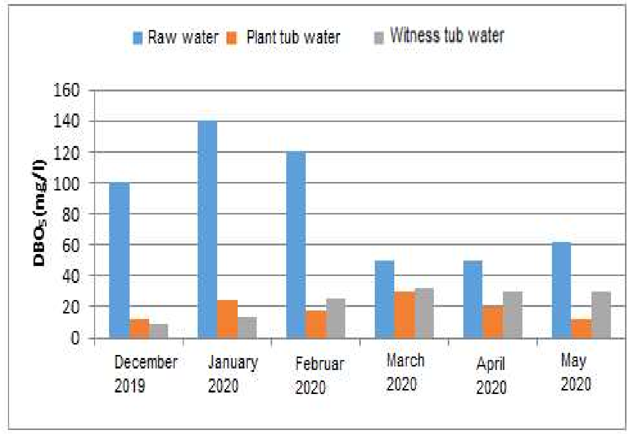

Fig. 8. Time evolution of the DBO_5 biochemical oxygen demand in the inlet and outlet for both the witness and cultivated tubs

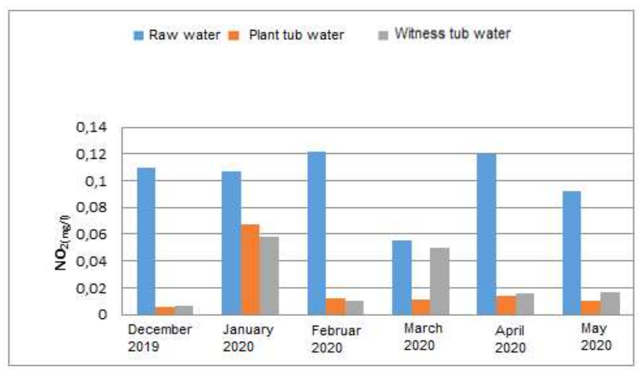

Fig. 9. Time evolution of NO2-nitrite of the inlet and outlet for both the cultivated and witness tubs

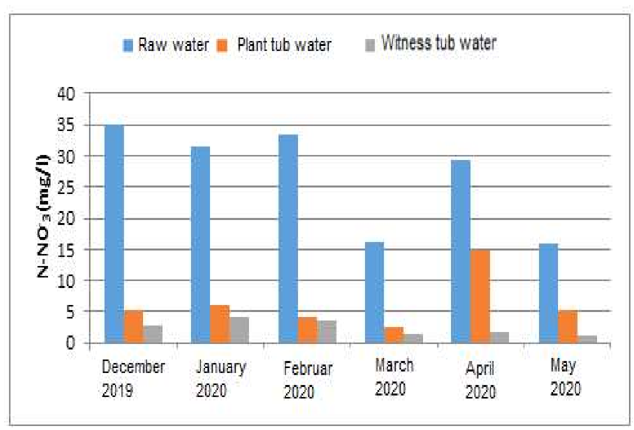

Fig. 10. Time evolution of the $N\text{-}NO_3^-$ nitrate to the input and outlet for both cultivated and witness tubs

and 4.49 mg / l in the non-cultivated tub (witness) (Fig. 11). The filtration yield in the *Canna indica* tub is 90.49 and 85.26 mg / l for the non-cultivated tub. The concentration of orthophosphorous in the treated water in all basins is caused by the absorption of $P\text{-}PO_4^{3-}$ in the filter (filter), as well as the quality of the gravel favors the absorption of $P\text{-}PO_4^{3-}$(Vohla et al 2011). The high removal of arto-phosphorous in the cultivated tub is caused by the interaction of bacteria and plants and the absorption of $P\text{-}PO_4^{3-}$ by the plant to its physiological needs (Jan Vymazal 2007, Białowiec et al 2012, Verma and Suthar 2018, Al-ani et al 2019).

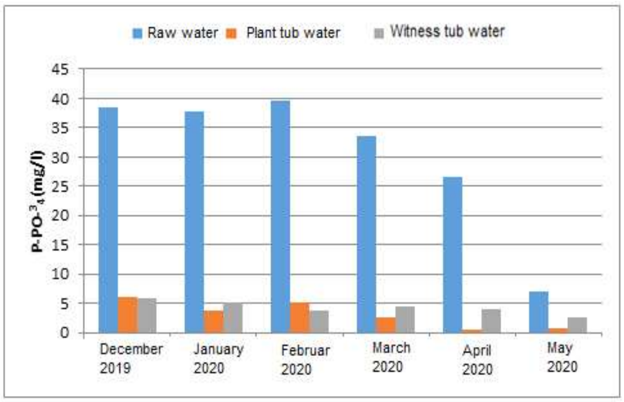

Fig. 11. Evolution of arto-phosphorous $P\text{-}PO_4^{3-}$ inlet and outlet for both cultivated and witness tubs

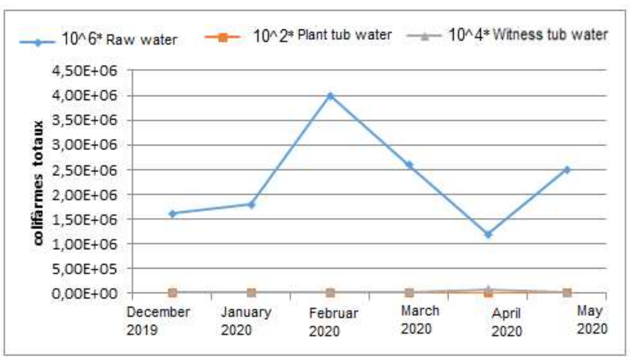

Fig. 12. Chronological evolution of *Coliformes totaux* for the inlet and outlet inlet and control tubs

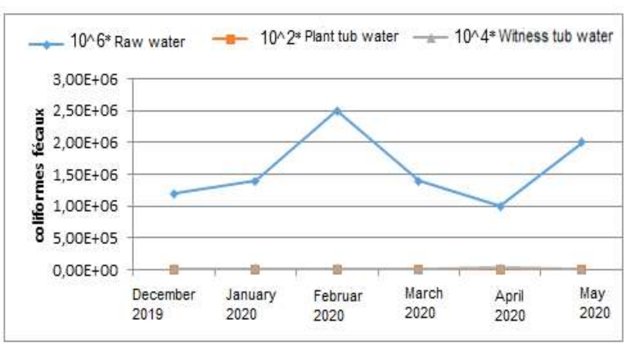

Fig. 13. *Coliformes fécaux* chronological evolution of the inlet and outlet for both the cultivated and the witness basins

Bacterial removal (*E. Coli, Coliformes Fécaux ,Coliformes totaux*): The chronological evolution of the bacteria in the shapes shows the number of colonies (*E. Coli, Coliformes Fécaux, Coliformes totaux*) in wastewater is greater than the treated water in the cultivated basin and the non-cultivated basin.

The removal of the bacteria *E. Coli, Coliformes fécaux, Coliformes totaux* almost completely after treatment in cultivated ponds and may reaches 100%. These results are similar to the study of Duggan and Bates (2001). Therefore, the decrease in bacteria is in compliance with the WHO 2012 standards for unrestricted watering. Vymazal (2005) also noted that the purification tubs in 1and 2 m area are better in cultivated tubs than in non-cultivated tubs. Confirmed by (Oueslati et al 2000) that it obtained in Tunisia.

During this study, the plant treated tub showed that there is a significant decrease in the removal of bacteria and pathogens, and this is explained by the natural death of bacteria as a result of a change in the living environment or destruction with organic materials, and the difference in removing bacteria between the pond cultivated with plants and the control basin Is that the roots of the plant secrete biological acids (toxic substances) that work to kill bacteria. Vincent (1994) explained that *E. coli* decreased in cultivated ponds compared to the control by the probability that the roots secrete inhibitors (toxic substances) "exudats" that contribute to the eradication of *E. coli*.

CONCLUSION

The preset study demonstrated the ability of the plant *Canna indica* to purify wastewater, as the results indicated significant reduction in the main types of pollution organic, nitrogen, and phosphorous. In the aquarium planted with plants, it was better than in the unplanted aquarium (the witness), where the water staying for five days inside the basin was sufficient to remove pollutants in an acceptable manner. The presence of the plant has a positive effect on biological activity using vertical irrigation , so that the plant began to adapt and coexist by using this water in the semi-arid climate of the region, and reaching the permissible limits for the use of water resulting from the treatment basins of plants in agriculture (watering trees, fruits and grains), which has the ability to withstand the salinity of this water.

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