Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

# THE ASSESSMENT OF COMPATIBILITY OF WASTEWATER TREATED BY NATURAL LAGOON WITH DISCHARGE AND IRRIGATION STANDARDS. CASE STUDY

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Received: 16 May 2019 / Accepted: 25 March 2020 / Published online: 01 May 2020

## ABSTRACT

In order to protect the environment and the groundwater against pollution, we dealt with one of the problems in the world, regarding the treatment of wastewater and the possibility of reuse with irrigation. We studied the case of the Kef Eddouken natural lagoon treatment plant in Ghardaia (southern Algeria). For this reason we studied the physico-chemical, bacterio-logical and parsitological parameter of waste and treated water. The results of the analysis show that all the previous parameters comply with the Algerian standard of rejection except electrical conductivity, suspended matter and $BOD_5$. On the other hand, despite the electrical conductivity exceeds the limit, but it corresponds to the SAR value; according to the Algerian and the international standard of irrigation, this quality of water can be used sub-irrigation for vegetable which eaten only cooked.

**Keywords:** Waste water; treated water; environment; groundwater; irrigation; Kef Eddouken WWTP

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doi: http://dx.doi.org/10.4314/jfas.v12i2.6

## 1. INTRODUCTION

Water is necessary for life and human activity but the demand for water is not uniform from one region of the globe to another and the availability of water resources even less [1]. Freshwater represents only 2.53% of all the water on the planet [2], groundwater in rural areas is a source of drinking water and irrigation, with the scarcity of fresh water, the protection and preservation of this source against all forms of pollution is the responsibility of all humanity.

Demographic, economic and urban increases are at the origin of different sources of environmental pollution (atmospheric pollution, surface and deep water pollution, soil pollution), particularly in developing countries. Among these sources of pollution the evacuation of wastewater into the environment without prior treatment since it contains many microbes, pathogens and other pollutants that can be the source of several diseases or contamination of groundwater [3], [4].

The treatment of wastewater by various techniques before being discharged into the receiving environment, one of the solutions for protecting groundwater and the environment and to reuse in many fields, including irrigation. Some processes are expensive, and they are generally effective and give good purification performance, we talk about classical intensive techniques (bacterial beds, biological disks and activated sludge). Other processes can be carried out with lower costs while maintaining the required purification standards in the treated effluent, in other words, extensive techniques such as the cultures fixed on fine support and free cultures (natural lagoon, macrophyte lagoon and aerated lagoon). The most targeted processes are those that give good purification performance and have the minimum costs in terms of energy consumption or expenses related to their commissioning and maintenance [5]

Algeria has taken the lead in ensuring sustainable development from the purification of domestic and industrial wastewater and the reuse of this treated water for irrigation, 153 wastewater treatment plants (WWTP) operating in different parts of the country (75 activated sludge stations, 75 stations by natural or aerated lagoon and 3 filters planted) [6].

This work aims to evaluate the effectiveness of one of the above-mentioned systems, treatment of wastewater by natural lagoon, case of Kef Eddoukhen in Ghardaia (southern Algeria) and to verify whether it is well adapted to the region studied. Amplest of raw and treated water were taken, respectively, at the entrance and the exit of the station throughout the period of study, to monitor the physicochemical parameters in order to calculate the elimination rates of the different pollutants and compared with those required by the standards.

## 2. EXPERIMENTAL

This experimental section can be divided into subsections, the contents of which vary according to the subject matter of the article. It must contain all the information about the experimental procedure and materials used to carry out experiments.

### 2.1. Station description of Kef Eddoukhen

The WWTP Kef Eddoukhen is located about 21 km southeast of Ghardaïa, downstream from the El Atteuf dike; it occupies an area of 79 ha. It is characterized by an average flow of wastewater: 46 400 m3/day[7]. The incoming water at the WWTP drained towards the receiving medium by a gravity flow, they first submit to a pretreatment (screen and sand trap), then they pass directly to the primary treatment which contains 8 anaerobic lagoons fed in parallel, of 3.5 m of height, water stagnates in the basins for three days, then is discharged by the distributor secondary to the secondary treatment which is characterized by 8 aerobic lagoon of 1.5 m height fed in parallel and a residence time of 10 days (Fig.1).

**Fig.1.** Photo view of the WWTP of Kef Eddoukhen of El atteuf (google Earth 2019)

**2.2. Experimental procedure**

Sampling was done at the inlet (raw water) and at the outlet of WWTP (treated water) for eight months (May to December 2018).Samples were taken three times per month for biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), total suspended solids (TSS), sodium ($Na^+$), calcium ($Ca^{+2}$), magnesium ($Mg^{+2}$), ammoniacal nitrogen ($NH_4^+$), nitrite ($NO_2^-$) once a month for faecal coliforms and nematodes and daily for hydrogen potential (pH) ,electrical conductivity (EC) and temperature (T).

The conservation of the wastewater samples was carried out in a cooler kept at 4 °C according to the general guide for the conservation and the handling of the samples ISO 566/3 [8].

The analysis was carried out at the mathematics and applied sciences Laboratory of Ghardaia University, who provided the necessary chemicals and equipment, while pH, electrical conductivity and the temperature were determined in situ using a multi- parameter analyzer type Hach LT2300, the $BOD_5$ was measured by the manometric method based on the Warburg principle using Oxi top WTW IS-6 and the COD was analyzed by oxidation in excess of potassium dichromate at 150°C, during 2h, in acidic medium[9] using behrotest COD workstation-6 samples, filtration on filter paper for the determination of TSS, parameters such as calcium and magnesium are analyzed by the titrimetric method with ethylene tetraacetic diammine, for sodium according to the ISO 14911 method [9] , using a PF-7 flame photometer.

Faecal coliforms are determined by the method of counting in liquid medium (MPN: most probable number) incubation at the temperature of 44 ° C for 24 hours, using Schubert's medium [9].

for the determination of the nematodes, one liter of water was taken for each sampling point, placed in test tubes in the laboratory, (Flotation method) which consists of the direct dilution of the pellet obtained after centrifugation in a solution of 33% zinc sulfate (density 1.18) at 1500 rpm/ min for 1 to 2 minutes. We then removed the surface layer of the supernatant in which the parasites are spread on a Malassez slide for counting [10]. The total number of nematode eggs per liter (N) present in the wastewater sample is calculated using the following formula:

$$N = X.V/P.S \qquad (1)$$

Were:

N: number of eggs per liter; X: the number of eggs counted; P: volume of suspension introduced into the counting cell in ml; V: total volume of the suspension in ml and S: volume of the waste water sample (1 liter).

The purification performance was evaluated according to the following formula [11]:

$$Abatement\ (\%) = (C_E - C_S).100/C_E \qquad (2)$$

where :

$C_E$ concentration of raw water in mg/L and $C_S$ concentration of treated water in mg/L.

The sodium adsorption ratio (SAR) which relates the concentrations ($meq^{-1}$) to sodium $Na^+$ (dispersion factor), calcium $Ca^{+2}$ and magnesium $Mg^{+2}$ (flocculants) [12] according to:

$$SAR = Na^+/\sqrt{\frac{Ca^{+2}+Mg^{+2}}{2}} \qquad (3)$$

The oxidizable matter (OM) was calculated by the following relation [13]:

$$OM = (2BOD + COD)/3 \qquad (4)$$

Where:

BOD concentration of biochemical oxygen demand in mg/L and COD concentration of chemical oxygen demand in mg/L

## 3. RESULTS AND DISCUSSION

Table 1 contains the values of all studied parameters of treated water (the output of WWTP).

**Table 1.** Characteristics of treated wastewater (year 2018)

| Paramètre | Unit | Min | Max | Moy |
|---|---|---|---|---|
| COD | mg/L | 53 | 89 | 70.25 |
| $BOD_5$ | mg/L | 31 | 62 | 42.87 |
| TSS | mg/L | 57 | 88 | 68.88 |
| $NO^{2-}$ | mg/L | 0.10 | 0.51 | 0.21 |

| | | | | |
|---|---|---|---|---|
| $NH^{4+}$ | mg/L | 23 | 37 | 32 |
| $Ca^{+2}$ | mg/L | 261 | 385 | 312.62 |
| $Mg^{+2}$ | mg/L | 158.3 | 182.56 | 179.8 |
| $Na^{+}$ | mg/L | 235 | 272 | 253.69 |
| T | °C | 14 | 28 | 24.87 |
| pH | - | 7.96 | 8.2 | 8.08 |
| CE | mS/cm | 2.76 | 3.98 | 3.36 |
| Fecal coliform | UFC/ 100ml | 3500 | 29000 | 26500 |
| Nematode | Eggs/L | | Absence | |

- No data

### 3.1. Physicochemical parameters

#### 3.1.1. pH evolution

Measuring the pH of wastewater gives an indication of the alkalinity or acidity of these waters. It is important for the growth of microorganisms [14]. The observed values reveal that the pH is slightly alkaline for all the analysis carried out this is due to the composition of the water entering the WWTP (soap water, stool, urine, etc) [15]. Light variation of pH values was observed in the treated water, it ranged from 7.96 to 8.2; these pH values are within the normal range recommended by the Algerian regulations [16]; which is likely to favor the bacterial growth necessary for the biological degradation of organic pollutants [17]. According to our study we noticed that the pH of the treated water higher than that of the raw water, this is what we can justify by photosynthesis, consume the dissolved $CO_2$ in the water resulting in alkalization, according to Eq. 5 below [18].

$$HCO_3 - H + H_2CO_3 \rightarrow H_2O + CO_2 \quad (5)$$

#### 3.1.2. Temperature of water

The temperature values of the treated water range from 14 to 28 °C, which represents an average of 24 °C during the study period, the variation of values related to the climatic conditions of the studied region; the maximum value recorded in summer ( in August) and the minimum value in December (in winter). We also note that the temperature of the water treated is still lower than that recorded at the level of the raw water, this decrease is due to the stagnation of the treated water in the basins, on the other hand the raw water can be due to the use of hot water as well as the movement of wastewater in the sewer pipes which increase its temperature. This variations influence the rate of evapotranspiration and the biological activity of microorganisms [19] and it has a significant impact on nitrogen removal [20]. It should also be noted that in an aquatic ecosystem, thermal fluctuation has an impact on the development and repetition of algal populations [21] and to note also that recorded values are consistent with national and international irrigation standards [16], [22] respectively.

### 3.1.3 Evolution of electrical conductivity

The recorded values show excessive mineralization (> 1000µS/cm) of the treated water; the values oscillated between 2.76 and 3.98 mS/cm are due to the salinity of the water entering the WWTP (domestic water).The values of CE are very high during the month of May until September and we recorded the greatest value in the month of August.This we concluded that the conductivity is directly proportional to the temperature. According to our results, we note that the EC of treated water remain lower than those of the input.

At the WWTP level the degradation of organic matter by bacteria contributes to the production of nutrient salts such as nitrogen and phosphate; this results in an increase in electrical conductivity. Following the assimilation of these salts by algae, there may be a decrease in conductivity [23].

### 3.1.4. Sodium ($Na^{+}$), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$) and alkalain risk

The alkaline risk is characterized by the sodium adsorption ratio which relates the concentrations (meq/L) to sodium $Na^{+}$ (dispersion factor), calcium $Ca^{+2}$ and magnesium $Mg^{+2}$ (flocculation agents) [12]. From our results the average values are 312.62 mg/L, 179.8 mg/L and 253.69 mg/L for $Ca^{+2}$, $Mg^{+2}$ and $Na^{+}$ respectively, this values give SAR values between 2.8 and 3.38 with an average of 3.05, this SAR values leads us to a class of fable alkaline hazard (SAR <10) [12] (Fig. 2). As can be seen in the FAO standard, for very low salt water with low SAR should be avoided, an excessive relative concentration of sodium (alkaline risk) can cause the dispersion of clay minerals and lead to degradation of the soil structure, but very salty water with high SAR needs to be carefully managed.

On the other hand the sodium concentrations that are lower than 1000 mg/L meet the Algerian standard of irrigation [16].

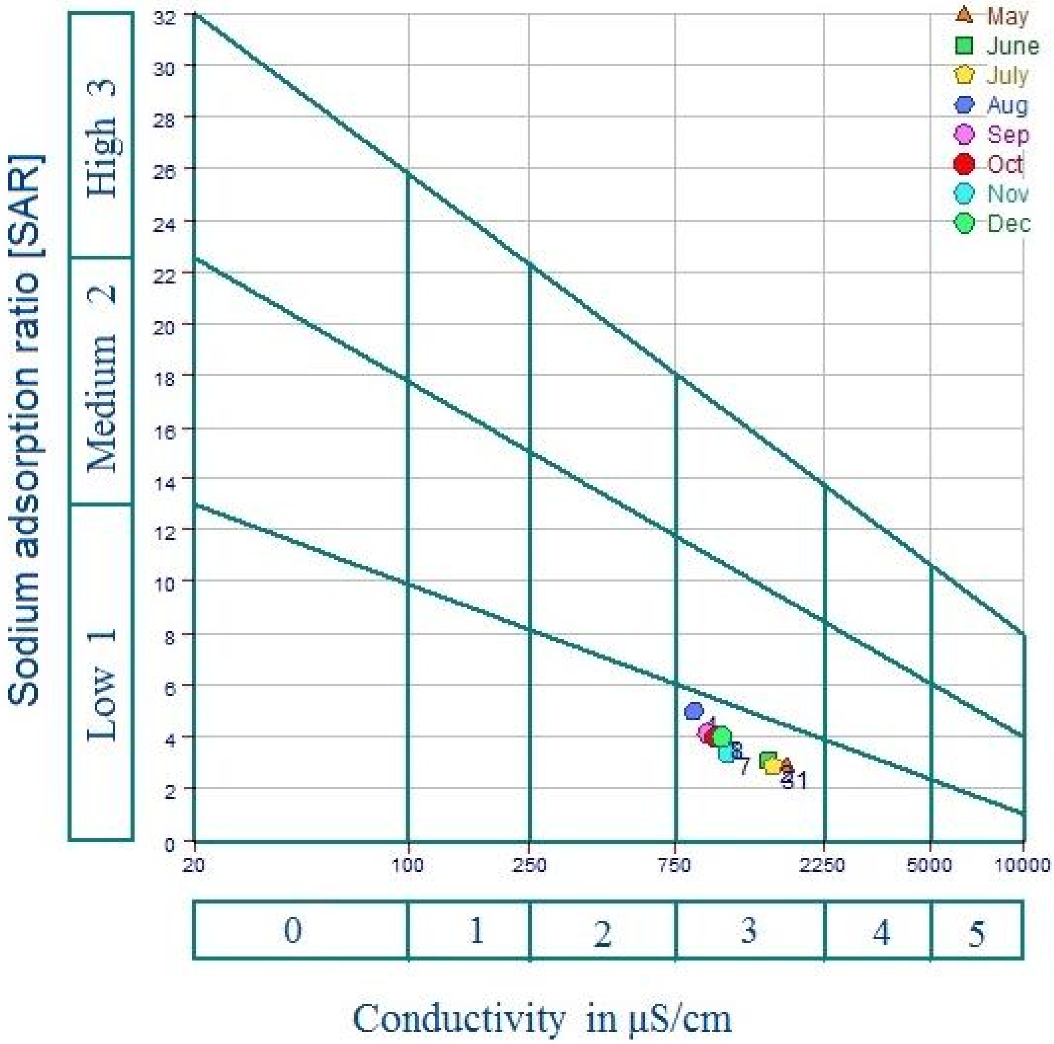


**Fig.2.** Classification of treated water according to the Riverside diagram

### 3. 1.5. Evolution of ammoniums N–$NH_4^+$

The ammoniacal nitrogen concentration of the raw effluent varied between 13 and 53 mg/l and oscillating between 23 and 37 mg/L for the treated water.

We note that the concentration of $NH_4^+$ increases from the month of September to the end of 2018, but remains similar to that found by the natural lagoon of Sidi Senoussi (Algeria) [24], on the other hand it decreased in the months of very high temperature where we recorded the highest efficiency of elimination 40% in me june. Therefore we can be said the concentration of ammoniacal nitrogen is not proportional to the temperature.

The variation of $NH_4^+$ in the treated water is not very strong because of the continuous transformation of the nitrogenous organic matter into ammoniacal nitrogen by an ammonification process.

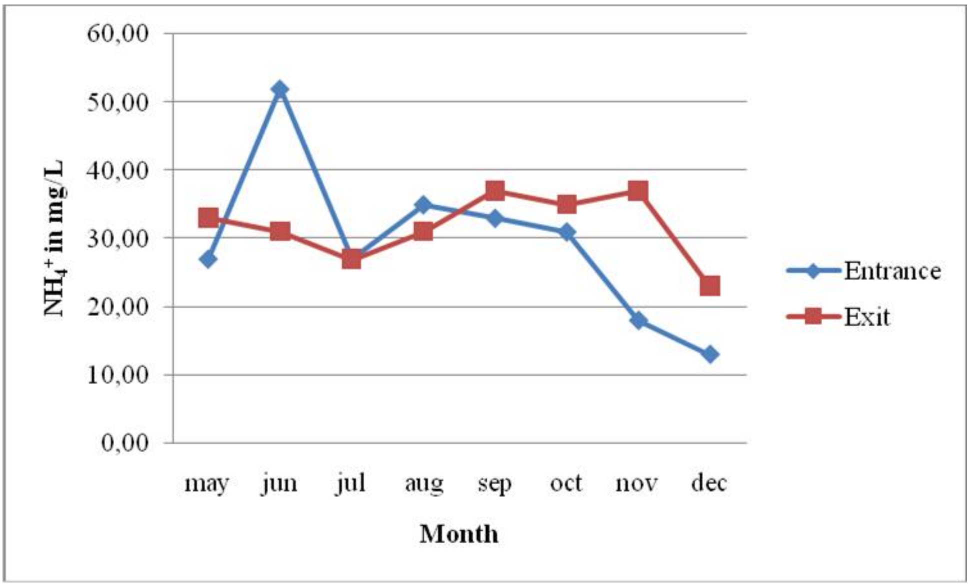


**Fig.3.** Temporal evolution of ammonia N–$NH_4^+$ in mg/L, during the monitoring period 2018

### 3.1.6. Evolution of nitrites N–$NO_2^-$

Fig.3 presents the evolution of nitrite during the period of our study. The results obtained in nitrite are low, concentrations of treated water between 0.10 and 0.51 mg/L, with an average concentration of 0.21 mg/L. Nitrites represent only an intermediate stage between ammonia and nitrates in the nitrogen cycle and are easily oxidized to nitrates, their presence in water is therefore rare and in small quantities and the nitrite content is quite variable according to the origin of the waters [9]. When the temperature increases the concentration of N-$NO_2^-$ treated water higher than that of the raw water.

From Fig. 2 and 3 we notice that the concentration of N-$NO_2^-$ increases with the increase of N-NH4+, and we obtained better nitrite elimination yields in the months at low temperature (November and December) where it reached 59%.

The slight recorded increase of $NO_2^-$ in the treated waters observed times is due to the bacterial oxidation of ammonia, ie to the reduction of nitrates, each of these reactions depends on the state of the medium oxidation and the availability of dissolved oxygen [25].

The recorded concentrations meet the international standards for irrigation water according to OMS ($NO_2^-$ <01mg/L).

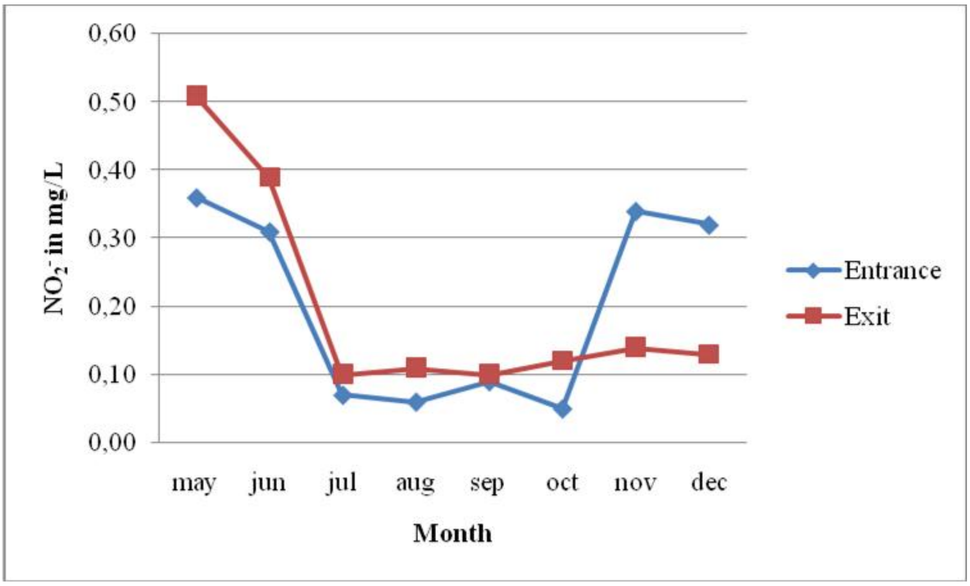


**Fig.4.** Temporal evolution of N–$NO_2^-$ in mg/L, during the monitoring period 2018

### 3.1.7. Evolution of Total Suspended Solids

The reported raw influent content is between 73 and 124 mg/L and between 57 and 88 mg/L for treated water. These concentrations are superior to the normal range of allowable loads by Algerian regulation of irrigation and domestic rejection [16], [26]. But the TSS in the treated water remains lower than that of the raw water. The change in TSS content of incoming water at the WWTP according to the quality of the waste water produced by the population. On the other hand we noticed slight variations of these contents in the treated waters that are due to the presence of the algae in the basins where the green color of the water appears in the final rejection.

The treatment rate during the monitoring year (2018) is limited between a maximum value of 42% observed in December and a minimum value of 4% observed in August, with an average of 22%. The TSS values of the gross and processed influent are given in Fig. 5.

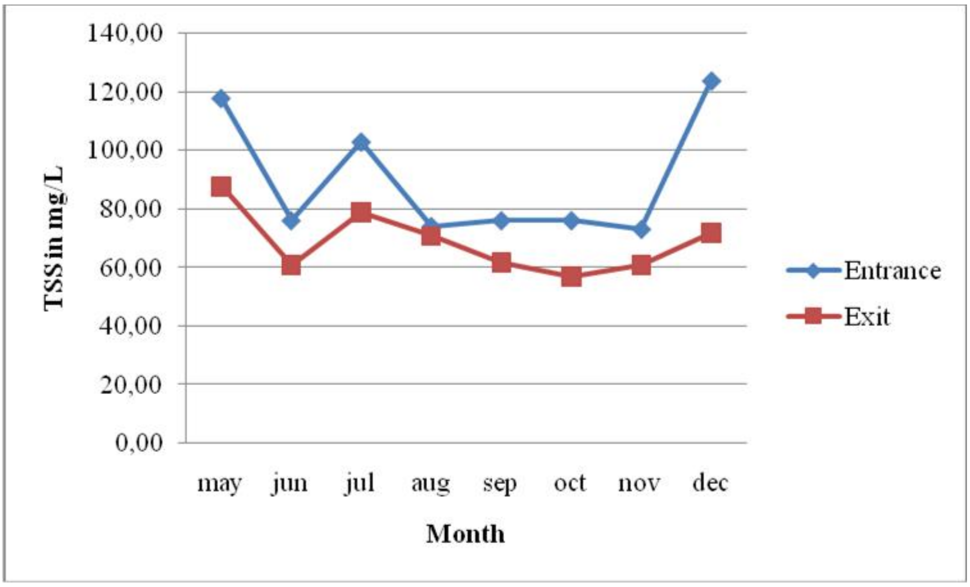


**Fig.5.** Temporal evolution of TSS in mg/L, during the monitoring period 2018

### 3.1.8. Biological oxygen demand at five days

The biological oxygen demand expresses the amount of oxygen required for the degradation of the biodegradable organic matter of water by the development of microorganisms [27]. The observed values of $BOD_5$ do not comply with Algerian standards [16], [26]. For raw water they are between 71 and 203 mg/L with an average of 143.63 mg/L, these values remain within the reference range for domestic wastewater (100 to 400 mg/L) [28]. The high value of the $BOD_5$ at the entrance to the station is quite understandable, because domestic wastewater is loaded with biodegradable organic matter, and the variation of $BOD_5$ of the raw is due to the amount of incoming wastewater at the WWTP. For treated water the $BOD_5$ values between 31 and 61 mg/L. The decrease in $BOD_5$ for treated water is due to the degradation of organic matter by aerobic bacteria (the secondary treatment ponds). Regarding the purification rate, it oscillate between 56 and 81%, with the average yield during this period is about 69%. We give in Fig.6 the variation of the $BOD_5$ during the period of our study.

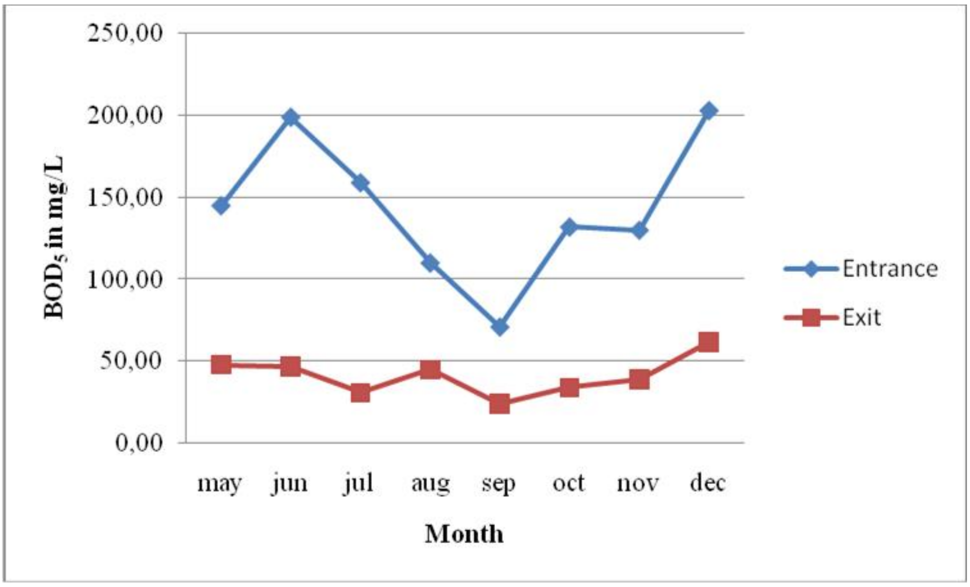


**Fig.6.** Temporal evolution of $BOD_5$ in mg/L, during the monitoring period 2018

### 3.1.9. Chemical oxygen demand

COD values range from 80 to 185 mg/L for raw water, from 53 to 89 mg/L for treated water. These raw water values remain within the reference range for domestic wastewater (300 to 1000 mg/L) [28]. The COD values of raw water show a significant variation over the study period, which can be explained by a variation in the quality of the wastewater produced. These domestic waters (laundry, dishes and wastewater) are generally loaded with more or less biodegradable substances, cleaning products, disinfectants and descaling agent as well as fertilizers, pesticides. These waters may also contain cosmetic and medicinal pollutants.

The COD content of treated water meets national and international irrigation standards [16], [22] respectively. The elimination yield varies between 34 and 61% and the best recorded in June and July.

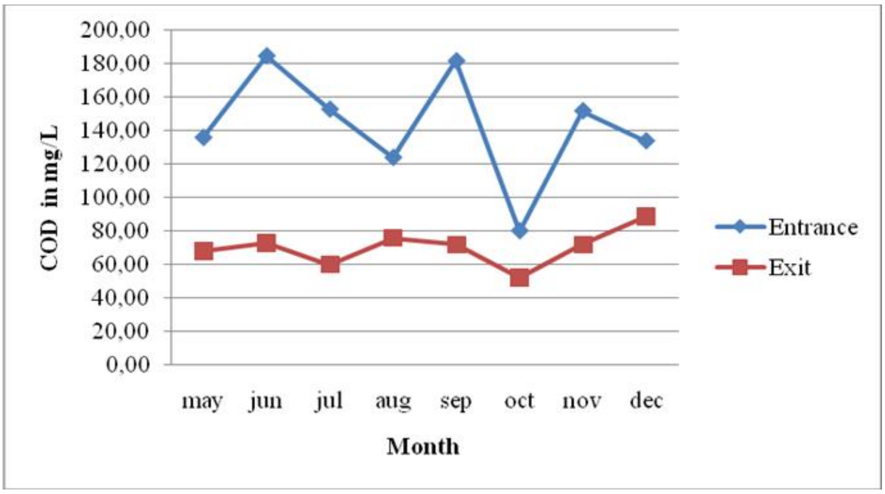


**Fig.7.** Temporal evolution of COD in mg/L, during the monitoring period 2018

The significance of the biodegradability of wastewater evaluated by COD/ BOD ratio. Our results show that the values of this ratio vary between 1.41 to 2.31 with values of the oxidizable matter ranged between 108 and 194.33 mg/L. These results indicating wastewater entering the WWTP (M'zab Valley water) is moderately biodegradable [14].

### 3.2. Bacteriological and parasitological parameters

#### 3.2.1. Faecal coliforms

The study of bacteriological parameters focused on the quantification of parameters of faecal origin. The average fecal coliform load is 200 CFU/100ml.This recorded value led us to a culture of class B (coliforms ≤250 / 100 ml) [16].

The elimination of faecal coliforms in the lagoon is due to the combination of several conditions that are unfavorable to them.

The temperature of the medium has a direct effect on the survival of microorganisms and the rate of elimination of bacteria would increase, with temperature (the increase of their metabolic activity) [29]. The dissolved oxygen factor influences the viability of the bacteria in the water, as well as UV radiation can have a direct action on the elimination of indicator germs by their photochemical action, inducing damage in the genetic material of the cells and thus preventing their reproduction [23].

#### 3.2.2. Nematodes

It is important to count nematodes in treated water of irrigation.The Algerian norm sets their non-existent value (absence) to less than 1 eggs/L according to the groups of crops to be irrigated with the treated wastewater. From our study eggs of nematodes is not present in the treated water, against their number in raw water varies between 0.03 and 0.24 eggs/L, the variation of eggs is due to the amount of water entering the WWTP of Kef Eddouken.

Many physical and chemical factors have a direct influence on nematode eggs. The optimal value between 16 and 34 °C for the development of eggs and it is faster when the temperature increases, It has the highest at 31 °C, whereas that a temperature of 37.8 °C for 15 days kills larvae, and eggs for 8 days [30] . And the presence of ammonium hydroxide in the water kills the eggs for 3 days.Stevenson also indicated that a temperature below 15 °C was inconvenient and fatal [31]. This is recorded their absence in winter when the temperature is below 15 °C.

Other research shows that sedimentation is the most effective process for eliminating nematode eggs. The percentage of elimination of nematode eggs in lagoons ponds was associated with residence time and is very high in WWTPs that contain many pools [32].

## 4. CONCLUSION

The results of the physicochemical parameters of the treated water by the kef Eddoukhen treatment plant, during the period study (from May to December 2018) which allowed the conclusion that most of parameters respond to the standards except for TSS (because the existing of algae in pools) and the $DBO_5$ where the values exceed 30 mg/L. Through this study which recommend the adding of pool filtration to reduce the load of TSS.

Whence the quality of water used in agricultures and according to national and international recommendations of irrigation [17], [21] respectively. So, the water not suitable for sprinkler irrigation but can be used for sub irrigation for vegetable which eaten only cooked.

Finally, it’s obligatory to inform the farmers about each change of the treated water quality because it changes according to year’s seasons.

## 5. ACKNOWLEDGEMENTS

We sincerely thank and express our gratitude to the staf members of the WWTP of Kef Eddoukhen; professeur Abd Elkhader Hadj Seyd and Hocine Hammoum who rendered their help during the period of this project work.

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**How to cite this article**:
Djaani M, Baba amer Z. The assessment of compatibility of wastewater treated by natural lagoon with discharge and irrigation standards. Case study. J. Fundam. Appl. Sci., 2020, *12(2), 607-623.*