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EVALUATION OF THE PURIFYING PERFORMANCE OF THE WWTP WITH AERATED LAGOONS OF WASTEWATER OF THE CITY OF OUJDA (MOROCCO)

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Abstract

The objective of this work is to analyze the purification performance of the WWTP of the city of Oujda (Morocco) for reuse of treated wastewater for agricultural irrigation. The flow measurements are carried out at the entrance to the Oujda WWTP via an ultrasonic flow meter permanently installed. The daily flow of wastewater varies between 33,867 m^3 / d and 30,737 m^3 / d with an average of 31,926.37 m^3 / d. This hydraulic load is significant, it represents 79.81% of the nominal hydraulic design load (40,000 m^3 / day).

The raw wastewater at the entrance to the station complies with the characteristics of domestic wastewater for large cities (BOD5 =357.18 mg/l; COD=698.58 mg/l and suspended matter SM=493.14 mg/l).

The results of the physicochemical analysis of the sewage into and out show that:
*Most of the parameters studied respond well to the expected treatment plant wastewater Oujda by aerated lagoon such as pH, temperature, dissolved oxygen, conductivity, BOD5 and suspended matter SM;

* The rate of reduction of BOD5, COD and SM are 84 %, 85 % and 80% respectively;
* The report COD/BOD5 wastewater entering the treatment plant is between 1.75 and 1.95.

These values are below the limit values that are 2, indicating that the effluent to be treated is a domestic wastewater therefore biodegradable kind. Thus the system of wastewater Oujda aerated lagoon waters is well suited for this type of effluent.

Keywords: Wastewaters, Physico-chemical, aerated lagoons, WWTP, biodegradability, Oujda, Morocco.

Introduction

Water resources constitute a fundamental and necessary element for the development of all human, economic and social activity.

The key to sustainable development, water control is more of a global challenge than ever. Indeed, the rapidity of demographic growth, the development of the industrial sector and the slowness of the improvement in coverage rates have meant that the number of people without access to drinking water or sanitation is stops increasing (WHO, 1989).

As a result, the volume of wastewater continues to increase following the intense development of urbanization and industrialization and the evolution of consumption patterns which are the main origins of the various sources of environmental pollution. Among these sources, the production of wastewater and discharges into the receiving environment (sea, river, soil, etc.), without prior treatment, generates numerous water-borne diseases and the spread of epidemics (WHO, 1989).

These waters carry pollutants in solution or in suspension of a chemical (organic molecules, heavy metals, nutrient salts, etc.) or microbiological (bacteria, parasites) nature which, exceeding certain thresholds, lead to an imbalance in the natural functioning of aquatic ecosystems. To cope with this situation, wastewater must undergo treatment before being discharged into the receiving environment (OUSLATI et al., 2000).

The applied process is mixed lagoons (with mechanical aeration), which is considered to be the most adopted technology meeting the needs of Morocco by the National Master Plan for Liquid Sanitation (SDNAL, 1998).

In this work, we will examine the operating mode and performance of the Oujda (Morocco) wastewater treatment plant in order to determine its main characteristics, issues as well as the main issues.

Materials and Methods

General on the study site

The city of Oujda is located at the north - eastern limit of Morocco. It is located 12 km from the Algerian border and 60 km from the Mediterranean coast.
According to the General Population and Housing Census (RGPH) of 2004, the population of the Prefecture counts 477,100 inhabitants made up of 410,808 urban (86%) and 66,292 rural (14%). Thus, the density exceeds 245 ha / km ² High Commission for Planning, 2004.
The sanitation network of the city of Oujda is a unitary system, it is made up of nine collectors which evacuate wastewater and rainwater to the treatment plant (El Halouani, 1995).

The RADEEO (Autonomous Distribution Authority for Water and Electricity) has been managing the liquid sanitation network since October 4, 2001. The scope of the sanitation network extends to the entire urban area of the city of Oujda at about 890 km, and which serves almost 96% of the city's districts.

Description of Oujda WWTP

The Oujda wastewater treatment plant, located approximately 2.7 km north of the city's urban perimeter limit, was filled on May 23, 2010. It is designed for 530,000 inhabitants equivalent, which corresponds to the reception of a nominal flow rate of 40,000 m^3 / d.

The purification of wastewater at the Oujda WWTP is provided by a series of basins which have all the following characteristics in common:

• Earthen construction;
• Watertightness of the dikes (internal part) and the bottom is ensured by a layer of 40cm of compacted clay;
• The dikes have a slope of h / v = 2/1 for the exterior and interior facings;

• The width of the dikes at the crest is 5 m and surmounted by a layer of everything from 40 cm thick to be drivable;

Figure 1 shows the different basins that make up the WWTP.

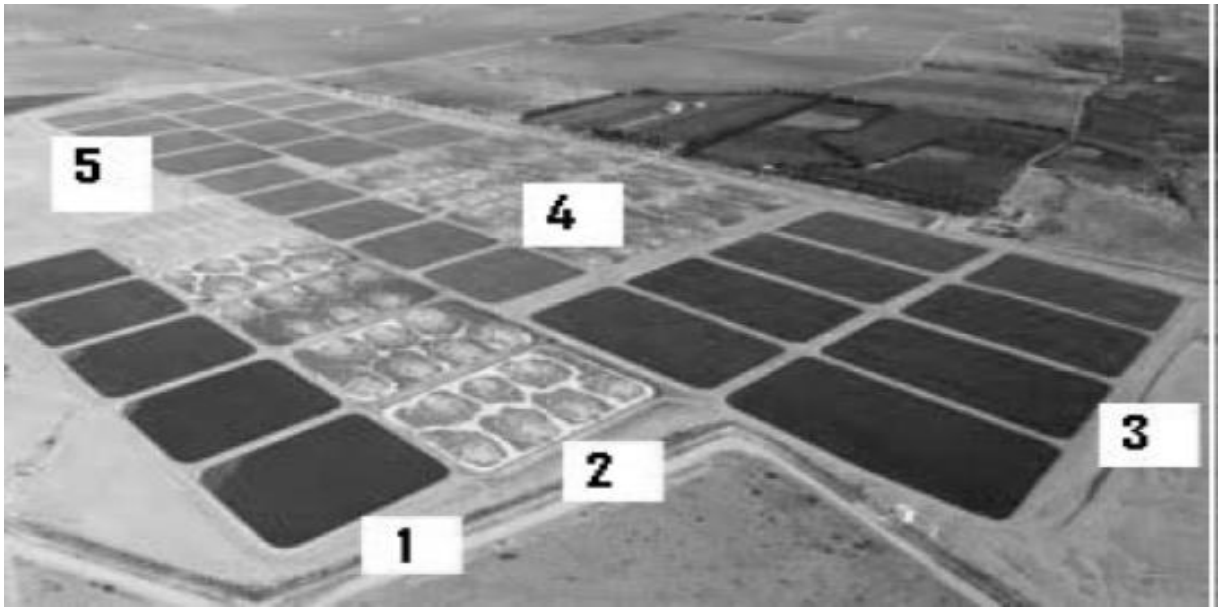

Figure 1: Synoptic diagram of Oujda WWTP. 1- Anaerobic basins; 2- Aerated basins; 3- Maturation ponds; 4- Aerated basins; 5- Drying beds.

Sampling method

Samples were taken in specific locations (Figure 2), from the pre-treatment works, from the anaerobic basin, from the aeration basin and at the outlet of the maturation basin.

The results of analyzes carried out in the RADEEO laboratory were used to evaluate the purification performance of the WWTP for a period of 8 months from August 2012 until March 2013.

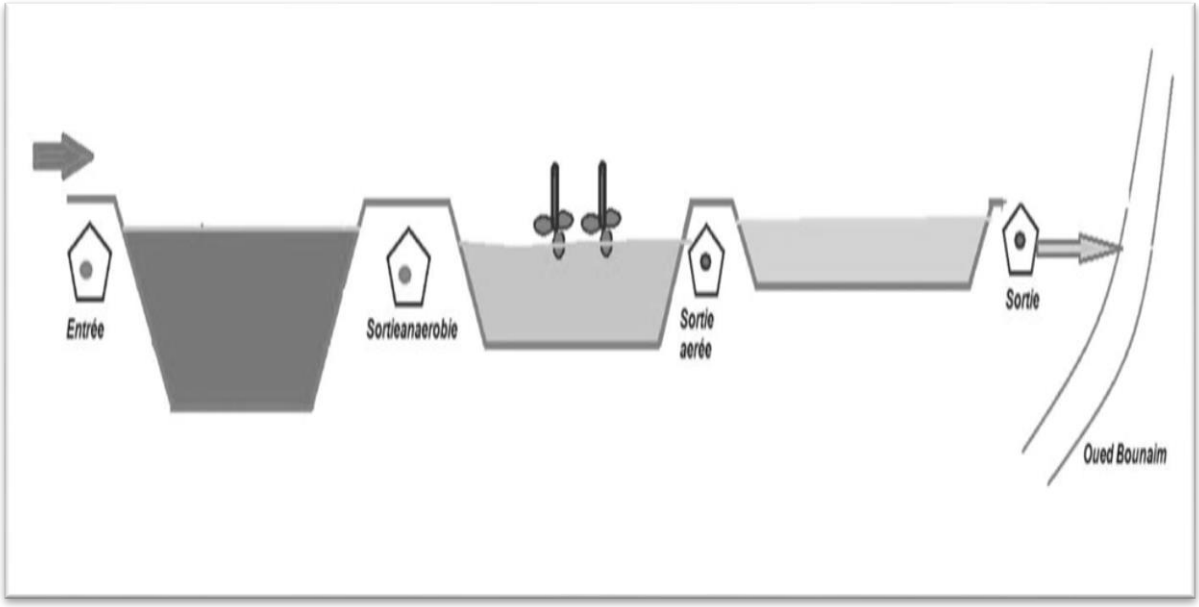

Figure 2: Different sampling points

Parameters analyzed

All the analyzes and measurements necessary to quantify organic pollutants are standardized according to Moroccan standards, similar to French AFNOR standards, according to the techniques recommended by RODIER et al., (2009). Table 1 groups together the methods of analysis of the various pollution parameters studied.

Table 1: Techniques for analyzing the physicochemical parameters of water pollution.

Paramètres	Méthodes
Temperature of water in °C	Mercury Thermometer 0.1°C
pH	Field pH meter type WTWHI 991003, Membrane filtration
SM Suspended Solids (mg/l)	Millipore (0.45 µm), oven passage and weighing (AFNOR T90-105)
COD (mg O_2/l)	Potassium dichromate oxidisability (AFNOR T90-101)
BOD5 (mg O_2/l)	(AFNOR T90-103)
Conductivity (µS/Cm)	Conductivity meter type WTW LF 330
Dissolved O_2 (mg O_2/l)	Oximeter type WTW Oxi 315i/SET

Results and Discussion

Operating parameters

The flow

The flow measurements are carried out at the entrance to the WWTP using ultrasonic flowmeters permanently installed after the pre-treatment. Fig. 3 represents the results obtained.

Figure 3: Variations in inflow and outflow at the treatment plant during the period from August 2012 to March 2013

Figure 3 shows that the daily flow of wastewater is variable, it varies between 33,867 m^3 /day and 30,737 m^3 / d with an average of 31926.37 m^3 / d. This hydraulic load is significant, it represents 79.81% of the nominal hydraulic design load (40,000 m^3 / d).

Quality parameters characterizing the raw wastewater at the entrance to the station

The results of the analysis of raw water quality parameters at the entrance to the Oujda WWTP are shown in Table 2.

Table 2: Values of the main parameters of organic pollution of wastewater at the entrance to the Oujda WWTP.

Parameters (mg/l)	Values at the entrance to the wastewater treatment plant	Characteristic of domestic wastewater in large cities (>100,000 inhabitants)
COD	698.58	850
BOD5	357.18	300
SM	493.14	300

Table 2 shows that the values of the main quality parameters characterizing the raw wastewater entering the station comply with the characteristics of domestic wastewater for large towns, which were well defined in 1998 by ONEE-Water Branch. and adopted during the study of the typology of Moroccan urban wastewater (ONEP, 1998).

Purification performance evaluation parameters

- pH

Figure 4 shows that the monthly change in the pH of raw wastewater at the inlet and outlet of the Oujda city wastewater treatment plant during the period from August 2012 to March 2013 varies between 8.05 and 7.86 with an average of 7.94 in raw wastewater, and 8.36 and 8.12 with an average of 8.23 in treated water.

Figure 4: Evolution of the pH by each stage of treatment during the period 2012 - 2013.

It is interesting to note that the anaerobic treatment step is accompanied by a slight drop in pH, and as you go through the process, the pH increases slightly. This increase is more marked at the exit of the maturation tanks.

The average pH of the water at the outlet is 8.23, complying with the discharge standard delimited between 6.5 and 8.5. Analysis of these results showed that the raw sewage water in the city of Oujda is generally close to neutral and acceptable for irrigation Official Bulletin 2002.

- Dissolved oxygen

The amount of dissolved oxygen in a body of water is an indication of how healthy the water is and its ability to support a balanced aquatic ecosystem.

Figures 5 illustrate the evolution of the dissolved O2 concentration in the various basins during the period from August 2012 to March 2013.

Figure 5: Evolution of dissolved O2 during the period August 2012 to March 2013

It is clear that dissolved O2 is almost zero at entry and in anaerobic ponds (Figure 5). It is also important to note that the aerobic treatment step is accompanied by an increase in dissolved O2 as a result of the aeration system.

The comparison of the dissolved oxygen values in the wastewater, analyzed with the surface water quality grid (Bernier, 2001), allows us to deduce that this wastewater is of very poor quality. In wastewater treatment networks, the complete disappearance of dissolved O2 is

accompanied by the appearance of H2S in the air, resulting from the reduction of sulfur compounds present in the effluents, and correlatively by the phenomenon of acid attack on concrete in pipes (Breuil, 2004).

- Electrical conductivity

The electrical conductivity (EC) value is probably one of the simplest and most important for wastewater quality control. The results obtained are shown in figure 6.

Figure 6: Evolution of conductivity during the period August 2012 to March 2013.

It is noted that the variation in the amplitude of the conductivity is low, which appears normal since there is little or no reduction in soluble ionic compounds during the various treatment processes. The average value of the conductivity recorded at the exit of the WWTP is 2610 µs / cm. This result is well within the Moroccan discharge standard for irrigation 8.7 ms / cm (Official Bulletin, 2002).

The results obtained highlight more or less significant monthly average values of the raw wastewater mineralization of the city of Oujda, the maximum value is 2.68 ms / cm and the minimum value is around 2 , 12 ms / cm. These increases in the electrical conductivity of wastewater could be explained on the one hand by the discharge of wastewater from industrial units connected to the city's sewerage network (slaughterhouses, 2 industrial areas). On the other hand, the value of the electrical conductivity in drilling water and drinking water is high and is of the order of 1.82 ms / cm.

This high salinity observed in Oujda's wastewater can be explained by the inflow of deep salty water from the Lias lands. In addition, the increase in the growth of the flows withdrawn for the production of drinking water and for agriculture is accompanied by the decrease in the water level of the aquifer which is restored by a large inflow of deep salt water. . It can also be added the decrease in precipitation in the region in recent years, this precipitation feeds the water table (Rassam et al., 2012).

- DCO

The COD makes it possible to assess the concentration of organic or mineral matter, dissolved or suspended in water, through the quantity of oxygen necessary for their total chemical oxidation. The results are shown in Figure 7.

Figure 7: Evolution of the COD value monitoring from August 2012 to March 2013

From Figure 7, the recorded average COD value of raw sewage from Oujda is 698.58mg / l. This value is very close to that recorded in 1995 by El Halouani, which is of the order of 710 mg / l. These concentrations are higher than the Moroccan standards for direct discharge (500 mg / l) (Official Bulletin, 2002).

-Evolution of BOD_5

OD5 expresses the quantity of oxygen necessary for the degradation of the biodegradable organic matter of water by the development of microorganisms for 5 days. It is measured at a temperature of 20 ° C and protected from light and air.

BOD5 is one of the physico-chemical parameters for estimating biodegradable organic carbon in water. In a polluted environment, carbon is used by bacteria as a source of energy. It should be noted that this degradation can occur in the presence or absence of oxygen (Samudro et al., 2010). The evolution of BOD5 in the WWTP basins is illustrated in Figure 8.

Figure 8: Evolution of BOD5 during the period from August 2012 to March 2013

The BOD5 contents of raw wastewater from the city of Oujda vary between 337 mg / l and 443 mg / l with an average of 357.18 mg / l (figure 8). This value is lower than the content recorded in 1995 by El Halouani, on the other hand it is higher than the change in the average BOD5 content of Oujda wastewater between 1977 and 1991 (250 mg / l and 330 mg / l). This content has tended to stabilize in recent years. The values at the outlet of the WWTP vary between 42 mg / l and 69 mg / l with an average for treated wastewater of 56.65 mg / L.

- MES

C’est la concentration en masse contenue dans un liquide normalement déterminée par filtration ou centrifugation puis séchage dans des conditions définies et exprimée en mg/l. La figure 9 représente l’évolution de la MES durant la période d’Août 2012 au Mars 2013.

Figure 9: The evolution of SM during the period from August 2012 to March 2013

The average SS value at the outlet of the wastewater treatment plant is of the order of 97.31 mg / l (Figure 9). This value is much lower than the Moroccan standards for indirect discharge (600 mg / l) and the standards for water intended for irrigation (2000 mg / l), on the other hand it is slightly higher than the concentration of Moroccan standards for direct discharge (50 mg / l) (Narasiah, 1988).

Removal of suspended solids from the raw wastewater effluent on the one hand protects natural aquatic environments and on the other hand minimizes agricultural expenditure due to plowing.

Discussion and Conclusions

Comparison of results to design goals

During the design of the Oujda treatment plant, the designers defined the discharge objectives (Table 3).

Tableau 3: Planned performance of Oujda WWTP

(Operations manual version 04, December 2010, BEFESA-STAIP)

Parameters	Content	Yield
BOD5 average at exit	<120 mg/l	>70 %
COD average at exit	<250 mg/l	>75%
SM average at exit	<150 mg/l	>72%

Table 3 shows that the values at the outlet of the WWTP are lower than that fixed during the design of the station.

Tableau 4: Design values and values at the exit of Oujda WWTP

parameters	**Design values**	**Values at the exit of the station**	
		Follow-up from August 2012 to March 2013	Analysis results of 06/05/2013
DCO	<250 mg/l	99,25	60
DBO5	<120 mg/l	56,65	20
MES	<150 mg/l	97,31	50

Comparison of results to domestic discharge standards

The average values of treated water and the specific limit values for domestic discharge are summarized in the table below.

The values of the average concentrations of SM, COD and BOD5 in the treated lagoon water are much lower than the specific limit values for domestic discharge.

Table 5: Comparison of average values of treated water with domestic discharge standards

Parameters mg/l	Average values of treated water from the station	Specific limit values for domestic discharges
COD	99.25	250
BOD5	56.65	120
SM	97.31	250

The COD / BOD5 report

The D.C.O / D.B.O.5 report assesses the biodegradability of wastewater. For a predominantly domestic effluent, this ratio is generally between 2 and 3.

The mean values of the ratios (COD / BOD5) of the wastewater entering the station are 1.95 (followed from the period from August 2012 to March 2013). This value indicates the biodegradability of the raw water, which explains the yields high purifications in the sector.

On leaving the sector, this ratio is around 1.75 (RADEEO), which is abnormally high. This result can be explained by the presence of algae, since the analyzes are carried out on unfiltered samples.

Raw and purified water loads and purification yields

The purification efficiency (reduction rate) of a parameter, expressed as a percentage, is calculated by the following formula:

$$R\% = \frac{(\text{concentration in raw wastewater} - \text{concentration in purified wastewater})\text{x}100}{\text{The concentration in raw wastewater}}$$

The raw and purified wastewater loads from the WWTP as well as its calculated purification yields are summarized in the table below. The pollutant load (CP) is calculated according to the following formula:

CP (kg / d) = flow (m^3 / d) x COD (kg / m^3)

CP (kg/j) = flow (m^3/j) x DCO (kg/m^3)

Tableau 6: Raw and purified wastewater loads and the station's purification yields

Parameters	The polluting load entrance Kg/day	The polluting load at the outlet kg/day	The yield %
COD	22 284,60	3 088,27	85,793%
BOD5	11 403,46	1762,72	84,14%
SM	15 739,518	3027,91	80,272%

The oxidizable matter is calculated by the following formula:

$$\text{Mox} = \frac{(2\text{DBO5} + \text{DCO})}{3}$$

It is 703.82 at the entrance to the station and 85.36 at the exit. Thus aerated lagooning is recognized as an effective purification process, particularly in terms of reducing oxidizable charges (90%).

The significant reduction in BOD_5 and COD (84.14% and 85.79% respectively) is interpreted by the activity of purifying microorganisms which ensure the degradation and transformation of organic matter, thus allowing the elimination of organic pollution.

CONCLUSION

The evaluation of the physico-chemical parameters of the wastewater treatment plant in the city of Oujda shows that SS, COD and BOD5 place this wastewater in the high concentration range (Curtis, 1994). This is linked to the low dilution of organic matter due to the more or less limited water consumption per capita, in comparison with developed countries. The reduction yields of the overall parameters (dissolved O2, suspended solids, COD, BOD5) are greater than 88% and those of major parameters such as pH, EC of the order of 29%. These values show a good purification performance of the station, due to the correct sizing of the basins, the aeration systems and the adaptation of microorganisms that biodegrade organic matter as well as the residence times and the surfaces of the basins which favor the sufficient exposure to sunlight. The quality of the effluents produced makes them suitable for reuse for irrigation of land (Blumenthal et al., 1996).

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