ISSN : 0974 - 7451 Volume 9 Issue 1

Environmental Science
An Indian Journal
Critical Review

ESAIJ, 9(1), 2014 [37-43]

# Degradation of organic pollution in communal waste water by aerated lagoon system: Case of the waste water treatment plant of Oujda (Morocco)

**A.Rassam[1], A.Echchelh[2]*, A.Chaouch[1], M.Bourkhiss[3], B.Bourkhiss[1], A.El Malhi[3]**

[1]Laboratory of Biotechnology, Environment and Quality, (MOROCCO)

[2]Laboratory of Electrical Engineering and Energetic Systems, Ibn Tofail University, B.P 133 Kénitra, (MOROCCO)

[3]Department of Physic-Chemistry, Regional Centre for Careers Education and Training (CRMEF), BP 255 Meknès, (MOROCCO)

E-mail: echeladil@yahoo.fr

## ABSTRACT

In Morocco, as in all developing countries, sanitation and sewage treatment constitute certainly one of the biggest environmental problems. The lack of public network, lack of waste water treatment plants, and absence of control and of environmental awareness contribute to the spread of diseases, the degradation of landscape and the contamination of surface and groundwater. Wastewater is considered the primary sources of pollution for the ground water and surface water. Wastewater treatment by aerated lagoon is considering one of the important economic with high performance solution in Morocco.

The purpose of this study is the evaluation of the system treatment in term of removal efficiency. This study attempts to highlight the factors leading to the adequate performance of WWTP Oujda in removing organic matter, solids and nutrients. The efficiency of the different stages of the treatment process.

Collection and analysis of data revealed a constantly removal efficiency of chemical oxygen demand (COD), biochemical oxygen demand ($BOD_5$), total suspended solids (TSS) and nutrient (NTK).

Analysis of data showed that the combined system removal reached respectively 88%, 89%, 90% and 29% of the influent TSS, COD, $BOD_5$ and TKN, with effluent concentrations of 106 ± 22 mg/L of COD, 50± 6 mg/l of BOD5, 67 ± 21 mg/L of TSS and 52± 12 mg/L of TKN.

Biological analysis showed that the fecal pollution of this wastewater is human originate and that the reduction efficiency of fecal germs and pathogen germs is 100%. 

## KEYWORDS

Aerated lagoon;
WWTP;
COD;
$BOD_5$;
Waste water;
Oujda.

## INTRODUCTION

Morocco, like many Mediterranean countries, is experiencing a serious imbalance between demand and supply of water. It is mainly due to the uneven distribution of rainfall, high temperatures and increased demand for irrigation water. This imbalance must be compensated by the recovery and reuse of wastewater

Actually Morocco produces about 600 million m³ / year (900 million m³/year in 2020), and more than 50% of the wastewater is used directly for irrigation without treatment.

Although the construction of treatment plants sewage has started in Morocco since the fifties of this century, wastewater treatment still knows the further delay. Indeed there are 63 stations in Morocco, only 26 are still in working, including ten are managed by local communities. Only 20% managed by local stations are actually in working.

The aerated lagoon is the process aerobic biological treatment, with free cultures of microorganisms, it differs from the activated sludge by the absence of recirculation of the bacterial culture decanted before discharge of treated water.

The treatment capacity of the wastewater treatment plant of the city of Oujda is estimated at 500,000 population equivalents, 99% of theme are connected to the drinking water supply and sanitation, and reject 40,000 m³ per day of wastewater. Approximately 10% of the wastewater comes from two industrial areas and the municipal slaughterhouse. The technology used is the aerated lagoon followed by tertiary treatment that is not yet operational. The sludge will be dried in drying beds. The goal of treatment is to reduce the pollution caused by wastewater and clarified water reuse in agriculture.

In this work, we propose to carry out a chemico-physical and microbiological characterization and identification of major and global pollution parameters of wastewater and the analysis of treatment performance of aerated lagoons.

## MATERIAL AND METHODS

### Description of the treatment system

### Presentation of wastewater treatment plant in Oujda

The wastewater treatment plant of the city of Oujda (eastern Morocco) is located in seven kilometers north of the city. It contains a total of 28 tanks in series, 12 of them are aerated lagoons, 8 anaerobic lagoons and 8 lagoons of maturation (see Figure 1). The dimensions of these basins are 100 meters long, 66 meters wide and 3.2 meters deep, that correspond to 21,120 m³ in volume, the aeration basins are deeper (5 m and 3.5 m depth with a useful volume of 23,100 m³). Depending on the flow rate, the aerated basins have a retention time of 15.4 days. 12 aeration tanks are equipped with surface turbines.


**1: Anaerobic basins; 2: Aerated basins; 3: Maturation basins; 4: Aerated Bassins; 5: Drying beds**

**Figure 1 : Synoptic scheme of WWTP of Oujda**

This station is intended to treat domestic and industrial wastewater of the city of Oujda.Parameters and analytic methods During the study period, which lasted one year, it was adopted a composite sample with weekly measurements for biochemical oxygen demand in 5 days ($BOD_5$) and daily measurements for other parameters : temperature, pH, $O_2$, chemical oxygen demand (COD), suspended solids (TSS) and total Kjeldahl nitrogen (TKN ). Samples are taken at the entrance and the exit of each treatment phases.

The chemic-physical parameters (temperature, pH, dissolved $O_2$) were measured in situ using a multi-parameter probe on grab samples taken regularly three times during the day. The parameters of organic pollution (TSS, $BOD_5$, COD) were measured daily composite samples during the day. $BOD_5$ was measured by

the manometric method based on the principle of Warburg. COD was analyzed by oxidation with excess potassium dichromate hot (150 ° C) for 2 hours in acidic medium (AFNOR method). For suspended solids, the method used was the differential weighing with direct separation by filtration on GFC filters and drying the residue for 1h30 at 105°C in an oven (AFNOR T90-105). The total Kjeldahl nitrogen is measured on bulk samples by the colorimetric method using spectrophotometer HACH DR/2010.

The study of bacteriological parameters focused on the quantification of fecal parameters: fecal coliform (FC). Total coliforms (TC) and fecal streptococci (FS). The samples were collected once a monthly. Counting CF and SF was performed according to the indirect method of multiple tube fermentation in lactose broth, the number was then subtracted statistically using the method of the most probable number (Rodier, 1984). Regarding pathogens, only Salmonella and Staphylococcus were determined, given the epidemiological risk associated with their presence in water for reuse.

## RESULTS AND DISCUSSION

The evaluation of pollution from raw waste water is based on determining a number of chemico-physical parameters characterizing this wastewater. The variation of major and global parameters of wastewater from the city of Oujda during the year is shown below in Figures 3-10.

### Temperature

A difference of 15 degrees was observed between summer and winter values. There is no difference between the input and output values. The average temperatures recorded (Figure 2) is less than 30°C which is considered as the limit value for direct discharges into the receiving water and wastewater using for irrigation of crops[1]. This range should be considered optimal for the conduct of biological processes.

### pH

The pH of the raw wastewater to the inlet of the treatment station varies between 7.5 and 8.3 (Figure 3). These values are slightly alkaline and almost similar to those found in the city of Kenitra and city Mechraa Belksiri (Morocco)[2] and[3], they are in the range of Moroccan standards of water quality for irrigation and the interval limits direct discharges, which is between 6.5 and 8.5[1]. The passage through the station tends to stabilize the pH in the bicarbonate buffer. The diurnal photosynthetic cycle also tends to raise the pH, but as long as it is not too much more than the optimal value for the bacteria (about 8) no negative consequence is to be feared. We will see later that a high pH in the final against tanks is very favorable for the removal of coliforms.

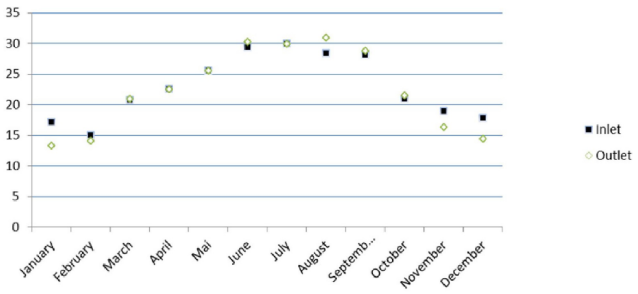


**Figure 2 : Mean values of Temperatures in C°**

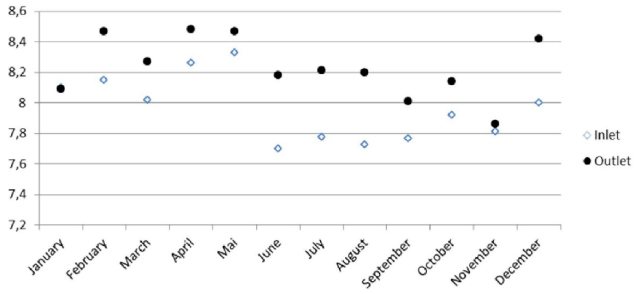


**Figure 3 : Mean values of pH**

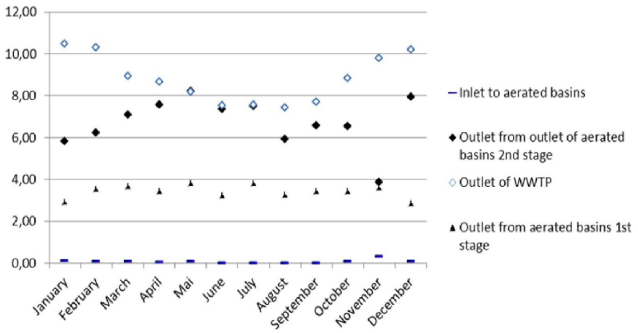


**Figure 4 : Mean values of dissolved oxygen respectively at the inlet aeration tanks, aeration tanks output 1st and 2nd floor and out of the WWTP Oujda.**

### Dissolved oxygen

The average levels of dissolved oxygen concentrations at the output of the treatment plant system and the entrance to the treatment plan is about 0.01 mg/L, as

can be expected because of the temperatures. The measured values at the output of the aeration basins is varied between 7,5 and 8,3 mg$O_2$/L, which is a favorable beach for economic use of aerators. The concentrations of oxygen at the exit of the treatment plant vary between 6 mg/L and 8 mg/L (Figure 4). The concentration of saturation oxygen depends strongly on the temperature. It was found that the water at the exit facilities is saturated with + / - 80% and even 100% of oxygen for three months.

The aeration tanks are equipped with floating aerators working for 14 h/d. The chosen model guarantees a transfer of 0.9 kg $O_2$/kWh and a mixing energy of 2.6 W/m.

## Suspended solids

The suspended solid (TSS) represents the mineral and organic particles in the effluent. The average value of the TSS at the entrance to the treatment plant is about 655 mg/L (Figure 5), these results are lower than those found in Sanaa (Yemen) (813 mg/L)[4], more or less similar to those found in Kenitra (Morocco)[2] and above those encountered in Marrakech (Morocco) (194 mg/L)[6] and (167 mg/L)[5] and Souk Elarba Gharb (Morocco) (224 mg/L)[7].

The mean concentration of TSS at the outlet of the treatment plant is very stable in the value of 67 mg/L, this value is below the Moroccan standards indirect discharge (600 mg/L) and standards water for irrigation (2000 mg/L), in contrary, this value is slightly higher than the concentration of Moroccan direct discharge standards (50 mg/L)[1]. However, it is known that it is difficult to obtain lower values by the method of lagoons, especially if the output basins are the seat of intense photosynthesis.

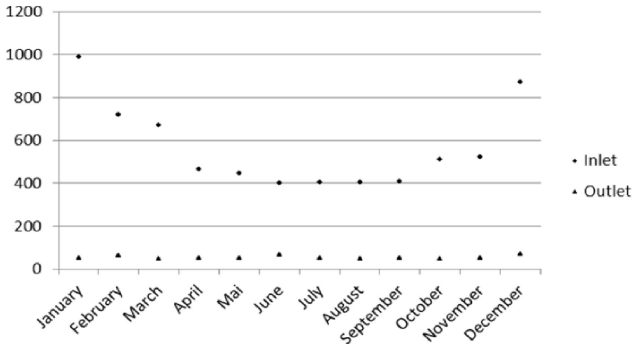


**Figure 5 : Mean values of concentrations and treatment efficiency of suspended solids**

The treatment efficiency of the treatment basins in TSS is 88%.

CODThe average value of the COD concentration in the inlet registered in WWTP is 1091 mg $O_2$/L (Figure 7). They are lower than those found in Sanaa (Yemen) (1888 mg / L)[4] and Marrakech (Morocco) (2983 mg/L)[8]. However, this value is higher than those obtained in Ouarzazate (571 mg/L)[9], Kenitra (Morocco) (501 mg/L)[2], and Souk Elarba Gharb (Morocco) (235 mg/L)[7].

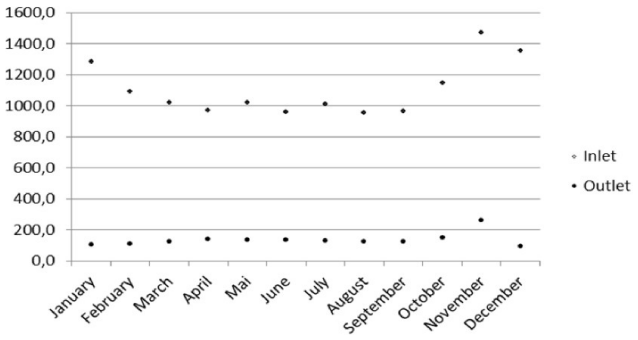


**Figure 6 : Mean values of the concentrations and treatment efficiency of COD**

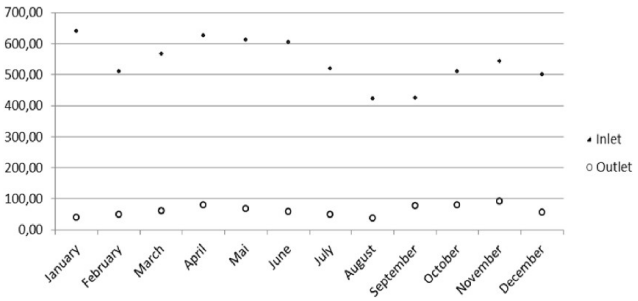


**Figure 7 : Mean values of concentrations and treatment efficiency of $BOD_5$**

The concentration of clarified water in COD is about 106 mg/L, which is below the Moroccan standards of water reuse for irrigation and direct discharge standards (500 mg/L)[1]. The reduction efficiency of COD was 89%, this value is higher than that recorded in the wastewater treatment plant of the city of Ouarzazate (Morocco)[9].

The average concentration of COD of the clarified water outlet of WWTP Oujda is about 106 mg/L, this concentration is below the Moroccan standards indirect discharge, direct discharge and norms for irrigation[1]. It is thus consistent with the expected value of aerated lagoon treatment value. We can indeed calculate the mean load received at the treatment plan in taking in consideration the monthly average flow (see

TABLE 1). Thus correspond to 38,688 kg COD per day. 12 aeration tanks gives additionally a total volume of 277,200 cubic meters, this gives an average volume load of 139.56 ~ 140 g COD/m³. d. For this load and German facilities Schleypen (1985) provides a lower value of 150 mg/L COD.

## $BOD_5$

Analysis of the concentrations of $BOD_5$ wastewater at the entrance of the station leads to an average of 511 mg/L (Figure 7). This is higher than that found in Marrakech (240 mg/L)[8], at Souk Elarba Gharb (Morocco) (162 mg/L)[7] and Kenitra (Morocco) (335 mg/L)[2]. However, it is less than that found in Sanaa (Yemen) (1137 mg/L)[4].

The mean concentration of $BOD_5$ clarified wastewater at the exit of WWTP Oujda is about 50 mg/L, this value is below the Moroccan standards indirect discharge, direct discharge and the norms for irrigation[1]. It correspond to we would expect in a treatment with aerated lagoon. We can indeed calculate the mean load received at the treatment plant, in taking in consideration the monthly average flow (see TABLE 1). Thus correspond to 19,358 kg $BOD_5$ per day, gives additionally a total volume of 277,200 cubic meters, this gives an average volume load of 69.83 ~ 70 g $BOD_5$/m³. J. For this load and German facilities Schleypen (1985) provides a range of 30 to 75 mg/L $BOD_5$: our average result is exactly in the center of this range.

The rate of reduction of $BOD_5$ is 90%. This treatment efficiency value is higher than that recorded in the treatment plant Ouarzazate (Morocco)[9].

## TKN

The concentration average value of TKN in WWTP Oujda is approximately 72.8 mg/L. This value is significantly higher than that found in Kenitra (Morocco)[3]. TKN concentration recorded at the exit of the WWTP is 51.74 mg/L The average grade is slightly higher than the Moroccan standard direct discharges[1]. The treatment efficiency for TKN does not exceed 30 %, which is low compared to the performance at the WWTP of Ben Slimane (Morocco)[15]. The aerated lagoon process cannot itself remove nitrogen: it can at most mineralize organic nitrogen into ammonia, and possibly oxidize a portion of it into nitrate. However, this is not a problem if the treated water is used for irrigation, since this nitrogen is then used as fertilizer. In this case it would be useful to refine the knowledge of the nitrogen balance, determining systematically ammonia and nitrate nitrogen in the effluent because the TKN provides only the sum of the reduced forms of nitrogen.

## Fecal germs

The bacteriological results to the input of the WWTP reveal the presence of indicators of fecal contamination, as well as certain pathogens. The average load of total coliform (TC) is about 2.9 $10^8$ organisms per 100 ml. The mean concentration of fecal coliform (FC) are $310^7$ organisms per 100 ml. Fecal staphylococci (SF) represent 4.3 $10^6$ cells per 100 ml. The CF / SF ratio is greater than 1, meaning that fecal pollution of wastewater of the city of Oujda is of human origin. For pathogens, biochemical analysis has identified five Salmo-

**TABLE 1 : Chemico-physical parameters of WWTP of Oujda measured monthly**

| Les mois | Flow | T° | pH | EC | COD | TSS | $O_2$ dis. | $BOD_5$ | NTK |
|---|---|---|---|---|---|---|---|---|---|
| January | 35450,4 | 17,04 | 8,1 | 2,57 | 1285,0 | 988,17 | 0,09 | 639,79 | 79,08 |
| February | 33714,3 | 14,98 | 8,15 | 2,6 | 1089,52 | 720,08 | 0,09 | 510,26 | 72,80 |
| March | 30050,2 | 20,65 | 8,02 | 2,59 | 1020,20 | 670,76 | 0,08 | 567,89 | 80,54 |
| April | 14880,6 | 22,43 | 8,26 | 2,67 | 970,43 | 467,35 | 0,02 | 625,19 | 88,22 |
| Mai | 29602,6 | 25,51 | 8,33 | 2,58 | 1020,54 | 445,54 | 0,07 | 611,82 | 94,40 |
| June | 40748 | 29,33 | 7,7 | 2,50 | 961,78 | 403,08 | 0,00 | 603,40 | 92,07 |
| July | 45119 | 29,91 | 7,78 | 2,59 | 1010,61 | 404,37 | 0,01 | 520,27 | 86,83 |
| August | 44697 | 28,36 | 7,73 | 2,57 | 955,57 | 405,35 | 0,01 | 423,23 | 91,65 |
| September | 33744 | 28,06 | 7,77 | 2,50 | 963,93 | 408,15 | 0,01 | 424,92 | 98,13 |
| October | 40256,6 | 20,87 | 7,92 | 2,49 | 1145,3 | 512,67 | 0,06 | 509,42 | 98,07 |
| November | 35296,3 | 18,9 | 7,81 | 2,50 | 1470,44 | 523,91 | 0,30 | 543,89 | 98,20 |
| December | 32713,8 | 17,78 | 8 | 2,52 | 1354 | 871,7 | 0,06 | 500,59 | 76,25 |

nella. Furthermore, the presence of staphylococci was detected with a frequency of 75%.

At the exit of the treatment plant, the mean concentrations of (CT) of (CF) and (SF) are 300 organisms per 100 ml. Pathogens are totally absent in the outlet of the plant. These values are comparable to those found in wastewater treatment plants of Drargua and Ben Slimane (Morocco)[15] and these values do not exceed the Moroccan standard waters for irrigation[1]. The treatment efficiency is close to 100%, but this should not be misled because just a few germs are sufficient to contaminate water. The elimination of CF takes place by photo-oxidation (Curtis & Mara, 1994) and is highly favored by the presence of oxygen and high pH. The effect of pH is for the values between 7.5 to 9.0 net, it accelerates more strongly at pH 9.5 but this pH is normally never met in the lagoons.

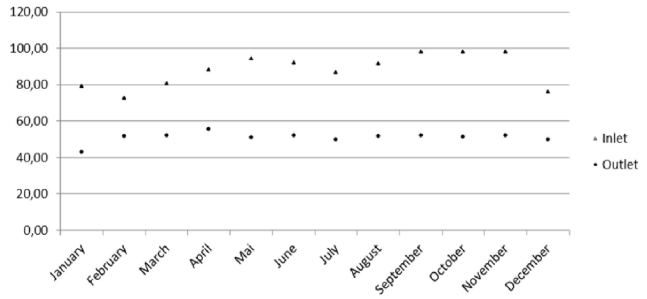


**Figure 8 : Mean values of concentrations and treatment efficiency of TKN**

## SYNTHESIS

The volumetric load discharged in aeration basins is easily calculated as the following: 19,358 kg $BOD_5$/d sent to a volume of ~ 277.200 69,8 $m^3$ give 70 g/$m^3$.d. This value is certainly very high when compared with European practices: 15 in France and 20 to 30 in Germany. Correct performance is nevertheless obtained, given the guaranties that they benefits constantly from high temperatures.

Aerated lagoons have an undefined hydraulic configuration and it forbidden to offer a rigorous modeling. Assuming the simplest model (that of a perfectly mixed reactor and a kinetics 1st order) and knowing that the average retention time in the aeration tanks is 7.72 d, we can calculate the removal global constant $K_t$ which is equal to 1.27 $d^{-1}$.

Finally, we can try to determine the value of the population-equivalent. The official values are 150 L/d - 30 g $BOD_5$/d - 75 g COD/d - 40 g TSS/d. Since we do not have the exact number of people connected, it will be based on the value of project, 500,000 population-equivalents. Although this value is probably greater than the reality, we find for Oujda very different values of the standard, 72 L/d instead of 150, and 38.7 g $BOD_5$/L instead of 30. It is logical that the $BOD_5$ increases if the water consumption per person decreases, however this may increase the value of the population equivalent. If we adopt this official value, we can find rather than calculating the load received by the WWTP corresponds to a population of 500,000 x 30/38,7 = 388.000 people really connected with a daily water consumption of 72 x 38, 7/30 = 93 L/d. These results seem more comparable.

## CONCLUSION

Evaluation of chemico-physical parameters of the wastewater treatment plant of the city of Oujda shows that TSS, COD and BOD located this wastewater in the range of high concentration[16]. This due to the low dilution of organic matter due to the more or less limited consumption of water per person in comparison with developed countries.

The treatment efficiency of global parameters is more than 88% and those of major parameters are 29%. The reduction of bacteria indicator of fecal contamination and fecal germs is about 100%.

These values show a good performance of the treatment plant, due to the good dimensioning of tanks of treatment, ventilation systems and the adaptation of microorganisms responsible of treatment of organic matter. The quality of the effluent after treatment makes them suitable for reuse for irrigation purposes.

## REFERENCES

**[1]** Ministère de l'environnement du Maroc, Normes marocaines, Bulletin officiel du Maroc, N° 5062 du 30 ramadan 1423. Rabat, **(2002)**.

**[2]** S.Oulkheir; Caractéristiques physico-chimiques et microbiologiques des eaux usées de la ville de Kènitra. Mémoire de 3ème cycle. Faculté des Sciences, Kénitra, 79 **(2002)**.

**[3]** Y.El Guamri et, D.Belghyti; Etude de la qualité physico-chimique des eaux usées brutes de la commune urbaine de Saknia, rejetées dans le lac Fouarat (Kénitra, Maroc). Journal Africain des Sciences de l'Environnement, N° 1, Décembre **(2006)**.

**[4]** S.Raweh, D.Belghyti, A.Al Zaemey, Y.El Guamri et, K.El Kharrim; Qualité physico-chimique des eaux usées de la station d'épuration de la ville de S'Anaa (Yemen), **(2011)**.

**[5]** L.Bouarab, N.Ouazzani, B.Oudra, J.Darley, B.Picot et, J.Bontoux; Evolution des formes d'azote dans la station expérimentale de lagunage naturel de Marrakech. Actes Quatrième Conférence Internationale des Limnologues d'Expression Française. Marrakech, 25-28 Avril. Tome II, **(1994)**.

**[6]** M.Abissy et, L.Mandi; Approche expérimentale de potentialités épuratrices du réseau commun (Phragmites communis) sous climat aride. Actes Quatrième Conférence Internationale des Limnologues d'Expression Française. Marrakech, 25-28 Avril. Tome II **(1994)**.

**[7]** A.Kbibch, D.Belghyti, K.Elkharim, El Khokh Khalid; Analyse de la pollution de l'oued Mda par les eaux usées domestiques de la ville de Souk Elarba du Gharba. Maroc. Science Lib. Editions Mersenne : Février, **110203**, **(2011)**.

**[8]** L.Gerbati et, A.Nejmedine; Traitement photocatalytique et biodégradabilité des effluents textiles de la ville de Marrakech. Actes Colloque International sur l'eau dans le bassin Méditerranéen : Ressources et Développement Durable. Monastir (Tunisie), (80-85), 330-334 **(2002)**.

**[9]** B.El Hamouri, M.Mekrane, K.Khallaayoune, M.Merzouki et, M.El Maroufy; Performances de stabilisation de la station de Ouarzazate. Actes du séminaire : la recherche nationale dans le domaine Eau et Environnement, LPEE – Casablanca (18-19), **(1993)**.

**[10]** N.N.Schéma Directeur National d'Assainissement Mai. Mission II– Epuration Instruction Technique; Editeur : Royaume du Maroc, Ministère de l'Intérieur, Direction Générale des Collectives Locales, Direction de l'Eau et de l'Assainissement, **(1998)**.

**[11]** ONEP Août; Capitalisation des expériences marocaines dans le domaine de l'épuration par lagunage, Rabat, Maroc, **(1994)**.

**[12]** H.El Haïti, V.Laforest, J.Bourjois; Des réservoirs opérationnels pour la valorisation des eaux d'épuration urbaines. Colloque Eaux et Déchets et Développement Durable, Alexandrie, Egypte, 28–30 mars **(2010)**.

**[13]** N.Ouazzani; Traitement extensif des eaux usées sous climat aride en vue d'une réutilisation en agriculture. Thèse d'Etat de l'Université Cadi Ayyad, Marrakech, 221 **(1998)**.

**[14]** CEMAGREF; Traitement de l'azote dans les Stations d'épuration biologique des petites collectivités, 79 **(2004)**.

**[15]** http://doc.abhatoo.net.ma/doc/IMG/pdf/eaux_usees.pdf

**[16]** Metcalf et Eddy; Inc. Wastewater engineering : Treatment, Disposal and Reuse. 3ème Ed., Library of Congress Cataloging in publication data TD. T34, 645 **(1991)**.

**[17]** Schleypen; Rapport II/2, 5/85, Bayer, Landesamt fürWasserwirtschaft, 13 **(1985)**.

**[18]** T.P.Curtis et, D.D.Mara; The Effect of Sunlight on Mechanisms for the Die-off of Faecal Coliform Bacteria in Waste Stabilization Ponds, Research Monograph N°1, University of Leeds, Dept of civil engineering **(1994)**.