ISSN : 0974 - 7451 Volume 9 Issue 10

Environmental Science
An Indian Journal
Current Research Paper

ESAIJ, 9(10), 2014 [345-351]

A treatment of djebelchékir landfill leachate tunisia by «BIOMEMBRAT®»process

Naoual Tchich[1], Adil Echchelh[2]*, Youssef Rannane[3], Cordonnier Cécile[3,4], Ahmed Rassam[1], Mohamed Ohssine[1], Abdelaziz Chaouch[1], Wienands Hubert[3]

[1]Laboratory of biotechnology environment and quality, (MOROCCO)
[2]Laboratory of electrical engineering and energetic systems Faculty of Sciences BOP: 133, Ibn Tofail University, Kenitra, (MOROCCO)
[3]WEHRLE Umwelt GmbH, BismarkstraBe1-11 79312 Emmendingen, (GERMANY)
[4]Laboratory at the Centre of landfill of DjebelChekir in Tunisia, (MOROCCO)
E-mail : echeladil@yahoo.fr

ABSTRACT

In this work we processed a considerate leachate from the landfill of DjebelChekir in Tunisia by the membrane bioreactor technology. Raw leachate analysis shows a high concentration organic as well as a very high concentration in salts especially chlorides and ammonium, controlled parameters are in the order of pH 8.4; 50.5 mS/cm for the conductivity; 14.000mg/lfor COD; 502 mg/l for $NH4^+$ and13.800 mg/lfor chloride.

The treatment system studies is "BIOMEMBRAT® technology "which consists of biological reactors associated with a unit of ultrafiltration for the retention of the biomass followed by a reverse osmosis filtration step in order to achieve the Tunisian discharge limits.

We conclude from our study that the performance of the biological treatment reactor can achieve the reduction in COD of the order of79 % and ammonium 99.6%.

Analysis of reverse osmosis permeatesin the outlet of the plant shows that the controlled parameters are below legal standards Tunisian of direct discharge in the nature. Values and the measured concentrations are in the range of pH 6.5, 1.4 mS/cm for conductivity, COD <15 mg/l and $NH4^+$ < 2 mg/l correspond to the reduction rate of about 99,5 %.

Chloride (Cl^-) is of the order of 270 mg/l in the outlet with the reduction rate of about 99,5 % about 98 % for chloride.

KEYWORDS

Jebel Chékir;
Landfill;
Leachate;
Tunisian standards;
BIOMEMBRAT ®.

INTRODUCTION

In Tunisia, 2.2 million tons of wasteis collected each year. The landfill is a fundamental step in the management of these wastes. DjebelChekirin Tunisia site receives daily about 2,000 tons of household waste from the capital Tunis. About 60 % eliminated waste are origin of organic material (food waste) and are characterized by high humidity between 60 % and 70%[1].

The leachates from landfills are considered to be

the most complex wastewater. It is not easy to determine the properties of the leachate as they evolve with time in landfills. European legislation sets the leachate as being "any liquid waste landfilled percolating through and flowing of a landfill or content therein"[2]. More commonly, the leachate is water that percolates through the waste taking bacteriologically, mineral and organic substances chemically dissolved or suspended[3].

The characteristics of landfill leachate can generally be represented by the parameters COD, BOD_5, conductivity, pH, suspended solids (TSS), ammoniacal nitrogen (NH 3 - N) and total nitrogen Kjeldahl (NTK)[4].

Several methods have been applied for the treatment of leachate such biological, membrane filtration, adsorption on clay and activated carbon, chemical oxidation, the process of oxidation advanced and methods combined[5].

The BIOMEMBRAT® process is a new concept which has emerged in leachate treatment technologies. It is an optimal method for the treatment of heavily polluted leachate; membrane bioreactors include biological treatment facilities the most effective for the treatment of wastewater with high pollutant load. Thus, the major components are two tanks (N1 and N2) nitrification, denitrification (DN) and aeration systems.

As a result, this research was conducted to study the DjebelChekir landfill leachate treatment using the BIOMEMBRAT® process with external filtration loop. The following work was carried out in the laboratory of the Center of landfill of DjebelChekir in Tunisia. The information collected is derived from analyses of different physico-chemical parameters such as pH, conductivity, COD, BOD5, chloride, ammonium and total Kjeldahl nitrogen and have been used to characterize the overall performance of treatment system.

MATERIEL AND METHODS

Description of the djebelchekir landfill leachate treatment process:

The sector of the center of technical DjebelChekir landfill leachate treatment is based on the technology of the biological reactor (MBR) membranes of type «BIOMEMBRAT ®» The treatment plant is generally consist of the following units:

- Storage Tank and homogenization of leachate.
- Pretreatment with screening andflotation
- A processing unit with biological reactor membranes (BIOMEMBRAT®): a biological reactor together with a unit of ultrafiltration for total biomass retention.
- Two cooling towers with heat exchangers for regularization of the temperature of biology.
- Centrifugation to maintain the liquid part in the system and evacuation of foaming in excess of the system.
- A reverse osmosis unit for the complementary treatment to achieve the direct discharge standards.

Theoretical data on the progress of biological treatment: the raw leachate crosses - after the preprocessing step - an anoxic environment followed a ventilated environment the non-aerated bioreactor allows anoxic conditions in absence of dissolved oxygen to support the process of denitrification, in this stage the incoming organic load plays a role of source of energy for biomass (microorganisms) denitrifying. In this process will be the organic reduction of the substances, and especially nitrates into nitrites and ammonium and molecular nitrogen. The reduction of nitrate to nitrogen gas in the denitrification basin can be expressed by the following (I) reaction:

4H (aq) + 5C-(s) + 4NO3-(aq)
5CO2 (g) + 2N2 (g) + 2H2O (I)

after the stage of denitrification leachate are pumped to the aerated basins of nitrification. This process occurs in two stages: the oxidation of ammonium to nitrite and then the oxidation of nitrite to nitrate. These oxidations are performed by nitrifying bacteria, according to reactions (II) and (III) following:

Nitrification is divided into two stages: the oxidation of ammonium to nitrite and the oxidation of nitrite to nitrate. These oxidations are performed by nitrifying bacteria, according to the following relationships:

$$2NH_4^+{}_{(aq)} + 3O_{2(g)} \rightarrow 2NO_2^-{}_{(aq)} + 2H_2O_{(1)} + 4H^+{}_{(aq)} \quad (2)$$

$$NO_2^-{}_{(aq)} + O_{2(g)} \rightarrow 2NO3^-{}_{(aq)} \quad (3)$$

The air necessary for biomass for nitrification and degradation of organic materials is injected using boosters piston coupled to a system of hydro-ejecteurs installed in aerated basins[6]. The leachate biologically treated in the bioreactor pass through external ultrafil-

tration membranes in order to separate biologically activated sludge and the effluent. Any bacteria and any COD due to materials and macromolecules suspended and colloidal materials will be retained securely in the system are continuously recirculated as retentate of ultrafiltration and will be returned to the bioreactor for more advanced biological treatment[6]. The ultrafiltration permeate is pumped to a reverse osmosis unit to retain non-biodegradable COD and salt below the statutory requirements.

Parameters and analytical methods

During the period of study, the samples shall be taken simultaneously and repeat every day at the same time in a representative way. Sampling points are marked by the symbol x in the Figure 1. Samples are taken in September of 2012 and focused on pH, conductivity, applications chemical and biological oxygen (COD and BOD), suspended matter (MLS), ammonium, total nitrogenKjeldahl (NTK) and chloride (Cl^-).

The physical parameters such as temperature, electrical conductivity and pH were measured using conductivity and pH-meter multi settings. All chemical parameters leachate were determined using standard methods for analysis of wastewater. The chemical demand oxygen (COD) is analyzed by the method of acid sulphuric Chromo (ISO 6060-1989, DIN 38409-H41-H44) and oxygen biological demand (BOD_5) is measured by electrochemistry; Addition of an agent blocking the nitrification. (NF EN 1899-1 (1998). For suspended solids, the method used was the Filtration filter brand glass microfibres Sertorius MGC (NBN EN 872 (2005)). Ammonium and total Kjeldahl nitrogen have been measured by titration (NF EN 25663 (1994)) and finally chlorides are measured by the method of Thiocyanate by iron (III).

RESULTS AND DISCUSSION

Quantitative evolution of physicochemical parameters

Monitoring of physico-chemical parameters in the different stages of treatment of leachate of DjebelChekir is shown in Figures 3 to 11 below:

There is no difference between the input and output values. The average recorded temperature (Figure 3) is above 25 ° C which is the limit value for direct

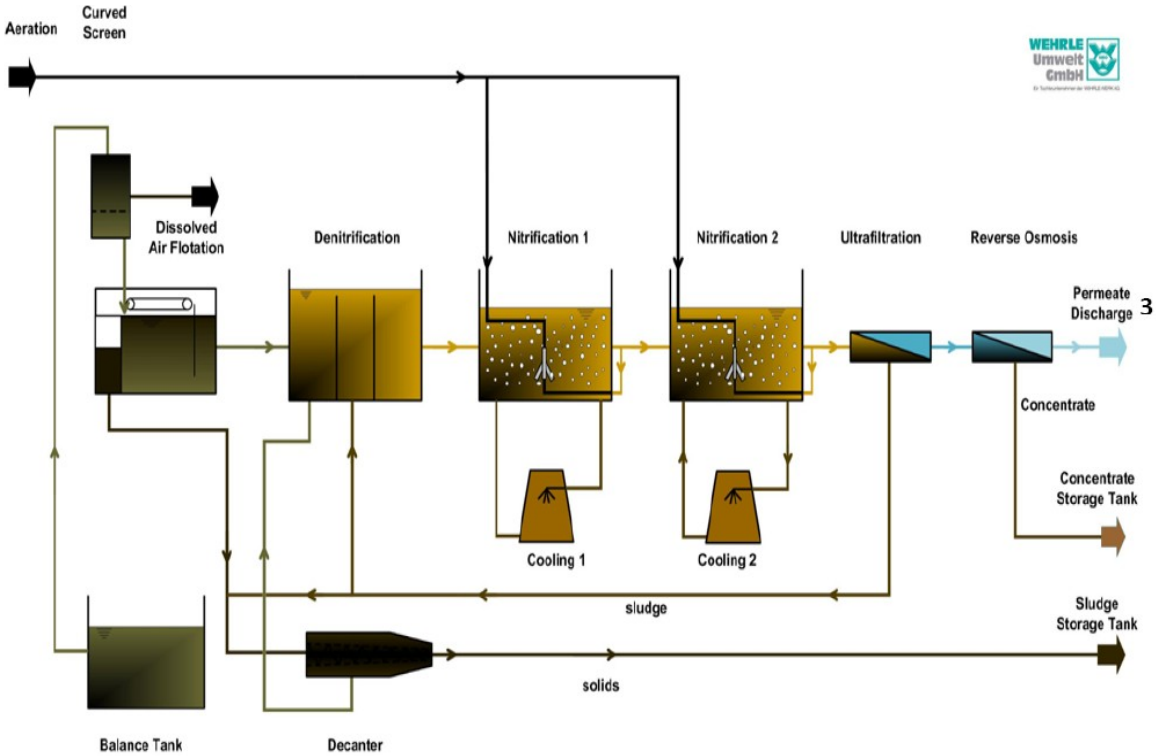

Figure 1: Schematic representation of the MBR and osmosis reverse of the DjebelChekirlandfill leachate treatment 1, 2, 3: Points of sampling for laboratory analysis

Figure 2 : DjebelChekir landfill leachate treatment plant

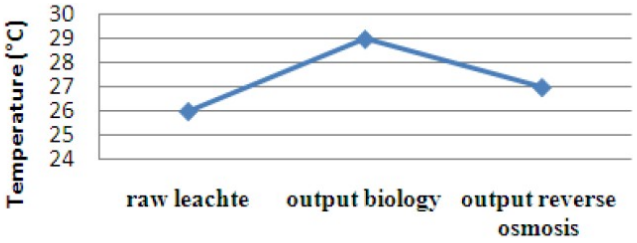

Figure 3 : Mean values of temperature in ° C

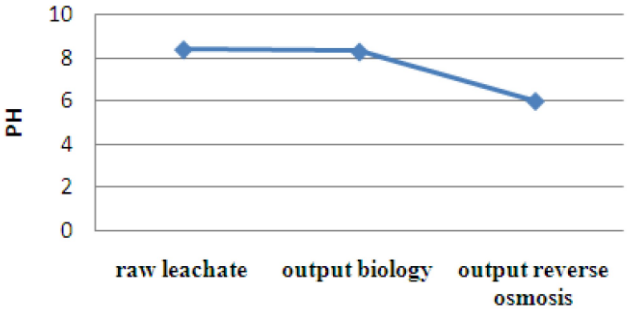

Figure 4 : Mean values of pH

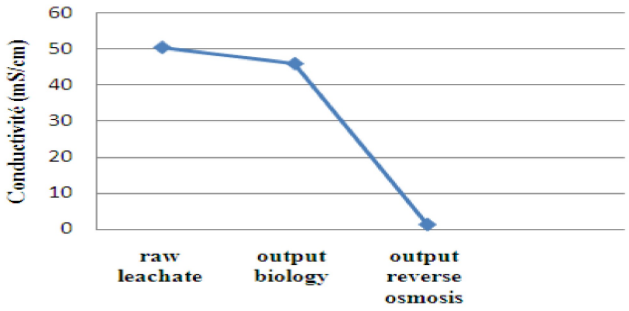

Figure 5: Mean values of conductivity in mS/cm

discharges. This temperature is acceptable since it is the values of the month of September. The average temperature recorded during the biological treatment is 29 ° C it is an optimum temperature for the proper conduct of biological processes.

The average value of the pH of the leachate at the entrance to the plant is approximately 8.4. This value is slightly alkaline and almost similar to that found in the city of Oujda (Morocco) (pH=7.9)[7] and El-Kerma of Oran (Western Algeria) (pH=8.19)[8]. The variation of pH at different stages of treatment is presented on the (Figure 4). The pH values varies between 8.4 and 6.5; These values are in the range of Tunisian standards for direct discharges which is between 6.5 and 8.5.

DjebelChekir leachate is characterized by very high conductivity values that reach 50 mS/cm (Figure 5) due to presence of different salts. These values are much higher than those found at Kenitra 22.92 mS/cm[9] and Oujda 26.07 mS/cm (Morocco)[10].

After treatment and the reverse osmosis unit output, permeate analyses showed that the conductivity values are between 1.6 and 1.8 mS/cm which is clearly below the Tunisian legislative requirement. Figure 6 shows a slight reduction of conductivity after biological treatment about 3 mS/cm, part of this decline may be due to the elimination of ammonium and the racking of excess sludge, which are discharged regularly out of the processing system. The total reduction of the conductivity until the Tunisian release limit is at the level of reverse osmosis.

The concentrations of the COD of raw leachate arein the order of 14.400 mg O_2/l (Figure 6). It is less than those found in EL-Kerma of Oran (Western Alge-

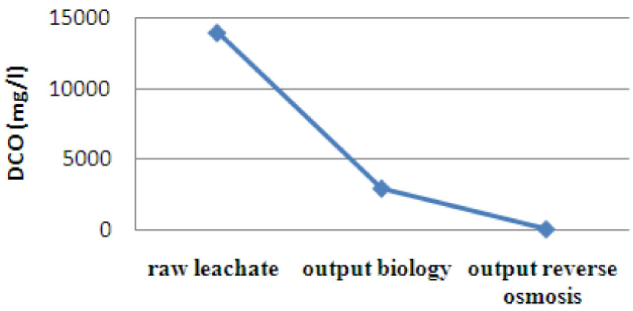

Figure 6 : Mean values of COD mg O_2/l

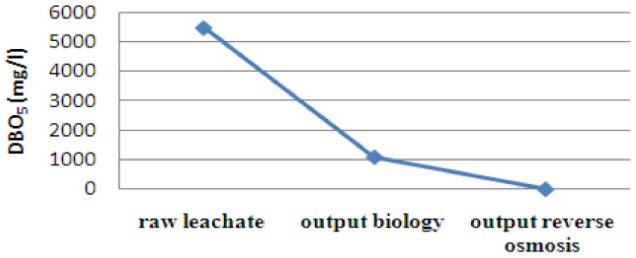

Figure 7 : Average values of BOD_5ino$_2$mg/l

ria) 19.333 mgO_2/l[8] and superior to those found in Oujda (Morocco) 1.091 mgO_2/l][7].

The performance of reduction of COD by the MBR treatment system is about 79 %, which shows a high efficacy of the biological treatment of the system in the treatment of leachate heavily loaded with organic matter in comparison to other systems. Remaining COD consists of non-biodegradable organic materials, which will be eliminated at the next level. Reverse osmosis filtration stage to achieve concentrations below 15 mgO_2/l which is below the limits of Tunisian releases (90 mgO_2/l.

Analysis of the concentrations of BOD_5 of leachate at the entrance to the plant leads to an average of 5.500 mgO_2/l (Figure 7). This value is higher than that found in Oujda (Morocco) 511 mgO_2/l[7], in Kenitra (Morocco) 764 mgO_2/l[9] and EL-Kermaof Oran (Western Algeria) 3.301 mgO_2/l[8].

Treatment with MBR allows reducing more than 80 % of BOD_5, this performance is typical for MBR plants. The reverse osmosis permeate analysis shows that the content of BOD_5 at the outlet of the plant is in order of 2.3 mgO_2/l which is below the Tunisian standards of discharge (30 mgO_2/l).

The concentration of chlorides in raw leachate is 13.800 mg/l (Figure 8). It is almost similar to that found in EL-Kerma of Oran (Western Algeria) 3.379 mg/l[8]. It is superiorthan that found in Kenitra (Morocco) 6.231 mg/l[9] and Al Hoceima (Morocco) 2.770 mg/l[11]. The

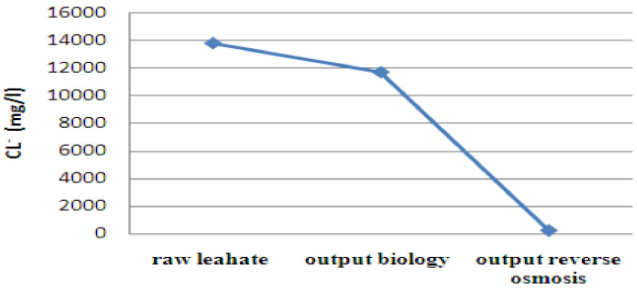

Figure 8 : Mean values of chloridesin mg/l

decrease of approximately 1000 mg/l out of biology is due to the regular bottling of excess sludge that is evacuated out of the processing system.

The reduction of the concentration of chloride is principally done by the reverse osmosis treatment in the form of concentrate. The concentration of chloride in the outlet of the plant is in the order of 270 mg/l. that are inferior to the Tunisian standards of discharge 600 mg/l.

The NTK concentration in raw leachate DjebelChekir average is about 971 mg/l (Figure 9). This value is highly superior to that found in Oujda (Morocco) 72.8 mg/l[7] and less than that found in EL-Kerma of Oran (Western Algeria) 1.142 mg/l[8]. Treatment with MBR only allows achievingtreatment performance of NTK up to 85%

Reverse osmosis filtration to achieve a concentration of 1,3 mg-N/l which is below the Tunisian standards of discharge.

Concentration of NH_4^+ in raw leachate is in the order of 501 mg/l (Figure 10). This concentration is lower than that found in EL-Kerma of Oran (Western Algeria) 2.726 mg/l[8] and to that found in AL Hoceima (Morocco) 2.000 mg/l[11]. Leachate treatment with MBR allows reducing almost all of this pollution through the nitrification and denitrification processes.

Analyses of the reverse osmosis permeate shows that NH_4^+ concentration at the outlet of the plant is in the order of 1.7 mg/l.

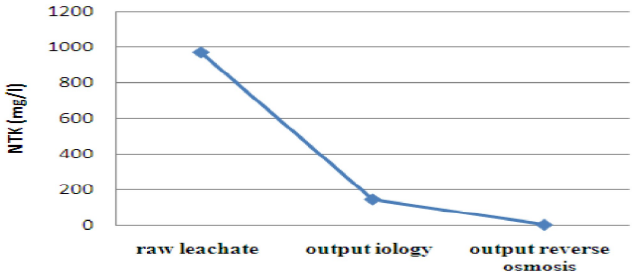

Figure 9 : Mean values of NTKmg/l

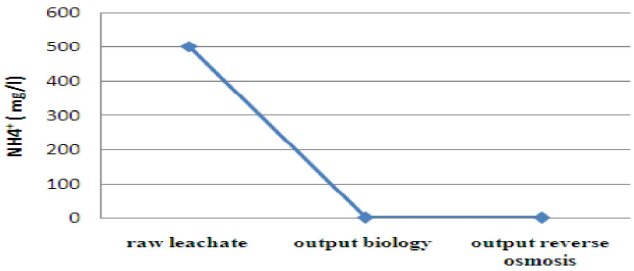

Figure 10 : Mean values of NH4 + in mg/l

Suspended matter represents the mineral and organic particles contained in the leachate. The average concentration in the entrance of the plant is in the order of 211 mg/l (Figure 11). These results are lower than those found in Oujda (Morocco) 655 mg/l[7] and those found in EK - Kermain Oran (Western Algeria) 1.149mg/l[8]. This is due to the leachate pretreatment by a curved screens over the dissolved air flotation.

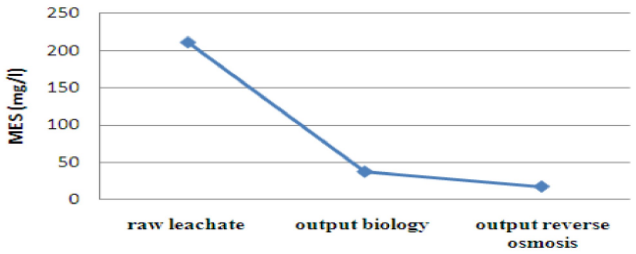

Figure 11 : Mean values of TSS in mg /l

The treatment by MBR allows to reduce the majority of the MLS and to reach a concentration of 37 mg/l with a performance of 83% which clearly shows the good treatment performance of the System. The rest of the MLS is in form of salts such as chlorides and hard COD passing by Ultrafiltration. These are held at the level of reverse osmosis. The average content in MLS in the outlet of the plant is in order of 17 mg/l. They are lower than the Tunisian standards of discharge which is in the order of 30 mg/l.

CONCLUSION

The results of this study have highlighted the degree of high pollution generated by landfill leachate and particularly those of the DjebelChekir landfill and the performance of biological pretreatment by MBR system with reverse osmosis.

Raw leachate is of the order of 14.000 mg/l for COD, Chloride values 13.800 mg/l, the ammonium concentration is about 470 mg/l. This work has shown that the biological treatment with reverse osmosis stage has enables a significant reduction of biodegradable organic matter and nitrogen compounds, including reductions of 80 % COD, BOD_5 85%, NTK 85 % and NH_4-N of 99%. In the biological treatment stage, there is an reduction of the sustainable organic pollution, without by-products, but until this point the biologically pretreated leachate does not achieve the requirements of Tunisian direct discharges, then a final step of reverse osmosis is essential. The effluent from the BIOMEMBRAT, which is well preprocessed biologically, passes through a final stage of reverse osmosis that loads (conductivity and chloride) salts and organic pollution and non-biodegradablereduction, to fulfil the requirements of Tunisian direct discharge. At the level of reverse osmosis see an over-concentration of elements permeate that passes through membranes is poor in organic pollution and mineral, this pollution is concentrated in the form of concentrate that a by-product of reverse osmosis.

The treatment by MBR process followed by reverse osmosis can degrade the polluting material and salts to achieve discharge limits which are of the order of 90 mg/l for COD, 30 mg/l for ammonium and 600 mg/l for chloride. The results of the analyses show that the adapted treatment process meets Tunisian standards discharges requirements.

REFERENCES

[1] ANGed national waste management agency, **(2007)**.

[2] European Landfill Directive, adopted on April 27, **(1999)**.

[3] S.Trabelsi; Studies of leachate treatment of municipal waste by the processes of oxidation advanced electrochemical and photochemical. Application to the Tunisian discharge "Jebel Chakir" leachate. University of National CarthageInstitut of Applied Sciences and technology, **(2011)**.

[4] S.Renou, J.G.Givaudan, S.Poulain, F.Dirassouyan, P.Moulin; Landfill leachate treatment: Review and opportunity J.Hazard.Mater, **150**, 468–49 **(2008)**.

[5] I.Trabelsi; Cascade bioreactor with submerged biofilm for aerobic treatment of Tunisian landfill leachate, Bioresource Technology, **102**, 7700–7706 **(2011)**; BioresourceTechnology, **102(17)**, 7700–7706 September **(2011)**.

[6] User manual, DjebelChekir, WEHRLE Umwel GmbH, leachate treatment plant, **(2012)**.

[7] Ferchich, Solid waste management in Tunisia. International workshop landfill leachate: state of the art and new opportunities, **(2005)**.

[8] M.Collignon; Jebel Chakir landfill leachate. Workshop on Landfill Leachate: State of the Art and New Opportunities, INRST, BorjCedria, Tunis, Tunisia,

(2005).

[9] A.Rassam; Performance degradation of organic matter by lagoon aerated in sewage treatment of wastewater from the city of Oujda (Eastern Morocco), **(2012)**.

[10] T.Begum; characterization and physico-chemical treatment of leachate from dump of El-Kerma (Algeria) batch adsorption on natural and chemically activated wood sawdust. Water Qual.Res.J.Can., **45(1)**, 81–90 **(2010)**.

[11] M.Elmarkhi, S.Sadek, K.Elkharrim, F.Benelharkati, D.Belghyt; Physico-chemical characterization of Landfill Leachatede'ouledBerjal (Kenitra, Maroc), **(2012)**.

[12] S.Saadi, M.Sbaa, M.EL.Kharmouz; Physico-chemical characterization of landfillleachate fromthe city centerof Oujda (Morocco Oriental). ScienceLib Editions Mersenne, 5, **130517(2111-4706)**, 30605 **(2013)**.

[13] A.Rassam; Characterization of leachatecontrolled Morocco andprocessing solutionslandfills: leachatecaseof the city of Al Hoceima.03-06-2012, **4(120602)**, **(2012)**.