Algerian Journal of Environmental Science and Technology
December edition Vol.5. N° 3.(2019)
ISSN : 2437-1114
www.aljest.org

Biodegradation tests for leachates from a technical landfill in Algiers

O.Balamane-Zizi[a], F.Atmani[b], N.Nasrallah[c].

a-Laboratory of Engineering Sciences of Industrial Processes. Faculty of Mechanical Engineering and Process Engineering. University of Science and Technology Houari Boumediene, USTHB, BP 32, El Alia, Algiers. Algeria.
b- Department of Process Engineering, University of Sciences, Blida1, Algeria.
c- Laboratory of Reaction Engineering. University of Science and Technology Houari Boumediene, USTHB, BP 32, El Alia, Algiers. Algeria.

*Corresponding author: ouafiazizi@yahoo.fr

ARTICLE INFO

Article History:

Received ***: 25/10/2018***
Accepted ***: 27/04/2019***

Key Words:

Biodegradation; biological treatment; COD; Landfill leachates.

ABSTRACT/RESUME

Abstract: *The purpose of this study is to test the biological treatment of leachates from Corso landfill (East of Algiers). These leachates are characterized by high concentrations of organic matter, (CODmax=6000 mg_{O2}/L; BOD_5 max= 3400 mg / L), which gives a ratio BOD_5 / COD of 0.56 showing that the leachate is young and has a good biodegradability, and confirming the fact that a biological treatment is possible. Similarly, high level of mineral matter was observed (Conductivity max= 43mS/cm), pH is neutral to basic tendency; values vary between 7 and 8.5. The results obtained after the kinetics of biodegradation allowed reducing the COD of 60% on average. In addition, a significant decrease in color after treatment was observed.*

I. Introduction

The establishment of landfills in unsuitable or undeveloped sites specifically for this purpose accentuates the risk of contamination of surface and groundwater, and therefore human health knowing that water is a source of life **[1, 2]**. Following a bio-physicochemical evolution of this waste so piled up and the action of the rains, it generates a juice called leachate. This juice is a source of pollution for the environment. In fact, in addition to the odors it emits, it causes an alteration for the quality of surface and underground due to its high pollutant load (organic matter, minerals and pollution bacteriological marked by the development of bacteria, viruses and algae) **[3]**. More generally, the problem of waste management is daily and planetary and the situation is dramatic in developing countries and especially in Algeria.
The controlled public landfill of Corso receives more than 1000 tons per day of waste of any kind. Fermentation of this waste generates a large amount of blackish leachate that may contain undesirable elements. Leachate can contain a lot of organic matter (biodegradable, but also refractory to biodegradation) consisting mainly of humic substances **[4]**, as well as ammonia nitrogen, heavy metals, organo-chlorines and inorganic salts **[5]**. Leachate is therefore a source of contamination of surface water and groundwater if not properly treated **[2, 6, 7]**
In Algeria, during the past few years, household and similar wastes were very poorly managed. Until 2011, all Algerian cities were equipped with one or more landfill sites; however, none of these sites were equipped with processing facilities and / or disposal of waste storage, namely biogas and leachates. These two residues constitute a real danger to the environment and to human life too **[1, 3]**. Effective management is therefore required in order to protect our health and environment.
The treatment of leachate from landfill sites is a sensitive technical issue facing landfill managers. As discharge standards are becoming more and more severe, it becomes essential to characterize very precisely the leachate to be treated in order to correctly size the treatment facilities. Leachates are complex effluents whose treatment requires special expertise. Even though most of the potentially applicable processes are derived from waste water

treatment, their implementation complies with specific constraints. Contrary to some other effluent types, there is no «standard» treatment for leachates. A broad variety of processes and techniques have been developed to meet the requirements of the diverse compounds present in leachates and that can be combined to achieve the desired result **[8]**.
The leachate studied was taken from the technical landfill of Corso (East of Algiers), it is very loaded in organic matter, indeed, the initial COD is around 6000 mgO_2 / L and the BOD_5 around 3400 mgO_2 / L. As a result, the COD / BOD_5 ratio is 1.86 confirming that these leachates are young and have good biodegradability, thereby implying the possibility of applying a biological process for their treatment.
Indeed, the biological process is among the methods to be applied for the treatment of leachates.
After the characterization of leachates from the center of Corso, we have undertaken biodegradability tests. The experiments carried out in batch, made it possible to determine the optimum parameters for the degradation of the organic matter contained in these leachates.

II. Materials and methods

II.1. Location and characteristics of the study area

The CORSO technical landfill was received in January 2014. It is located about 4.5 km southwest of the chief town of Boumerdes (East of Algiers). It is in the municipality of Corso, on the left limit of the river of Corso.
The site is centrally located in relation to the main waste generating centers of the Boumerdes wilaya, namely Boumerdes, Thenia and Boudouaou. The distance between the inhabitants closest to the landfill is 500 m. The surface of the site is 35 to 40 hectares (ha) around, and its height is of the order of 20 to 25 meters. Landfill capacity is estimated at 6.7 million tones. The site has five (05) lockers. Only the first bin is equipped, it has a capacity of 1.8 million m^3, it serves as a settling basin, the other lockers are not arranged at the moment.

II.2. Nature of waste discharged into the Corso Landfill

Only garbage is allowed to be dumped at the site. For the accepted waste we can note:
• Agricultural waste that does not pose a threat to public health and the environment.
• Commercial, artisanal or industrial garbage waste.
• Cumbersome household waste (bulky object or hollow) that should be dismantled before being placed in the landfill.
• dung, manure, dead leaves ...

The produced leachates are accumulated in a settling basin. The retention capacity of this basin is about 2500 m^3 (Figure 1).

Figure 1. *Settling basin*

From the settling basin, the leachates are treated in the landfill treatment plant; they are then dumped into the Corso river which empties into the sea.

II.3. Sampling and analysis

The (Figure 2) shows the point from which the samples were taken. After collection, the samples were immediately transferred to the laboratory and stored at 4 °C. Leachates samples were removed from the cold storage and placed under room temperature for 2 h prior use.
It should be noted that the samples were taken at separate locations in the storage basin to obtain anhomogeneous composition ofthe solution. Some tests are done directly after sampling such as temperature and pH.

Figure 2. *Sampling point*

II.4. Analytical methods

All the samples were collected, preserved, and analyzed according to the Standard Methods for the Examination of Water and Wastewater (ISO 6060-1989). In landfills, leachate pollutant measurements included organic contaminants [measured as Biochemical Oxygen Demand (BOD) or Chemical Oxygen Demand (COD)], ammonia, nitrates, total nitrogen, suspended solids, heavy metals and soluble inorganic salts **[6]**.
The analytical methods used for each parameter analyzed and their concentrations are summarized in Table 1.

Table 1: *Physicochemical, biologicalcharacteristics and standards*

Parameters	Sampling date		Average Value	Standards (ISO 6060-1989)
	08/03/2017	09/05/2017		
Temperature (C°)	23	21	22	30
Salinity %	16.5	16.5	16.5	/
pH	7.0	7.4	7.2	6.5-8.5
Conductivity (mS/cm)	27.5	57	42.25	/
dissolved O_2 (mg O_2 /L)	1.70	2.00	1.85	/
SS (mg/L)	73	180	126	35
Kjeldahl Nitrogen (mg/L)	240	250	245	30
Total Phosphorus (mg/L)	26	21	23	10
COD (mg o_2/L)	5600	6400	6000	120
BOD_5 (mg o_2/L)	2500	4300	3400	35
COD/BOD_5	2.24	1.48	1.86	2

II.5. Experimental device

The batch tests were run in a 2 L Erlenmeyer flask. The reactor was seeded with sludge from a wastewater treatment plant in Algiers which contains a rich variety of microorganisms, it would provide for co-metabolic and syntrophic supplementation of the metabolism of certain microbial groups and for the synergetic accomplishment of, for example, hydrolysis, fermentation, and biological removal **[8]**.

750 mL of leachates and 250 mL of sludge (corresponding to a sludge quantity of 2.95 g / L) were mixed in the Erlenmeyer flask. As soon as the totality of both liquids came into contact, agitation started and the first sample was taken at time 0. The COD concentration was immediately measured. Agitation was constant and slow, using a magnetic agitator set on minimum. The aeration was made by a fine bubble aquarium diffuser placed at the bottom ofthe receptacle (the Dissolved oxygen concentration was set at 4 mgO_2/L). Samples taken at different time periods allowed us to follow the evolution of pH and COD. The dissolved oxygen concentration and pH were measured thanks to a laboratory oxymeter HI 2400 Hanna and pH meter IC 3510 Jenway respectively. The COD concentrations were measured in each collected sample according to a colorimetric method by HACH DR 2010 spectrophotometer.

III. Results and Discussion

III.1.Physical and chemical characteristics of leachates

According to the results of analyzes of the composition of leachates taken from the landfill of Corso (**Table 1**), we can observe that:
pH was ranged from 7.0 to 7.4, similar results were obtained by **[6]** who found that leachate samples had a slightly high pH and remained in the range of 7.0–8.0. On the other hand **[9]**found that the average value of pH was 6.7 for the municipal landfill leachate in Malaysia indicating the young leachate and the waste degradation was at its late stage of acidic phase. **[10]** found that pH values were ranged from 5.8 to 6.9.
[6]evaluated landfill leachate characteristics and found that the values of conductivity were extended from 35260 to 42857 µs/cm. This finding confirmed the results of the present study where the range of conductivity extended from 27500 to 57000 µs/cm. Lower results were obtained by **[9]**who found that the conductivity of the leachate from the landfill in Malaysia was 31.68 µs/cm.
BOD is used as an indicator of the organic matter in a wastewater sample subject to biological oxidation. Engineers and operators often use the BOD_5/COD ratio to assess the degree of organic matter stabilization in landfill leachate.

In the current study, BOD_5 ranged between 2500 and 4300 mg/L and COD values ranged between

5600 and 6400 mg/L. The values of the ratio BOD_5/COD vary between 0.045 and 0.675.
According to **[11]**, BOD_5/COD ratios which are higher than 0.3 characterize the young biodegradable leachates, while older or stabilized leachates are distinguished by ratios less than 0.1.
According to **[8]** biological treatments, especially effective on young or unstabilized leachates, are among the treatments that reduce pollutants. Organic compounds are either aerobically degraded in the form of CO_2 with sludge production, either under anaerobic conditions in the form of biogas (CO_2, CH_4) that it will be possible to value.
As a general rule, leachate is characterized by high values of COD, pH, ammonia nitrogen and heavy metals, as well as strong color and bad odor. Regarding the collected samples, landfill leachates color was dark brown. The characteristics of a leachate vary with regard to its composition and volume; the biodegradable matter present in a leachate also varies with time. All these factors make leachate treatment difficult and complicated [**7**].
Many different methods are currently in use to treat landfill leachate. Most of these methods are adapted from wastewater treatment processing and can be divided into two main categories: biological and physicochemical treatments.
In the present study, the variation in different parameters values may be attributed to the fluctuations in waste type and characteristics.

III.2. Influence of the reaction time on the removal efficiency of organic pollution

To demonstrate the importance of reaction time required for organic matter (expessed as COD), 3 reaction times were retained: 1h; 4h and 24h. Samples taken at different time periods allowed us to follow the evolution of COD concentrations and pH.
The effectiveness of the treatment will be evaluated in relation to the reduction of COD. This elimination will be calculated according to equation (1)

$$R = \frac{Ci - Ct}{Ci} \times 100 \ \% \qquad \text{(Eq 1)}$$

Where: C_i= Concentration at time t=0 (COD or Turbidity)
C_t = Concentration at a time different from t = 0.
The variation of the COD of the treated leachates, and the elimination yields according to the different reaction time applied are shown in Figure 3 (a, b and c).
The results obtained are shown in Figures 3a, 3b and 3c. The operating conditions for these first tests are: DCOi = 6200 mgO_2 / L; mass of sludge = 2.95 g / L, pHi = 7.4.
The tests were carried out at ambient temperature T = 22 ° C.

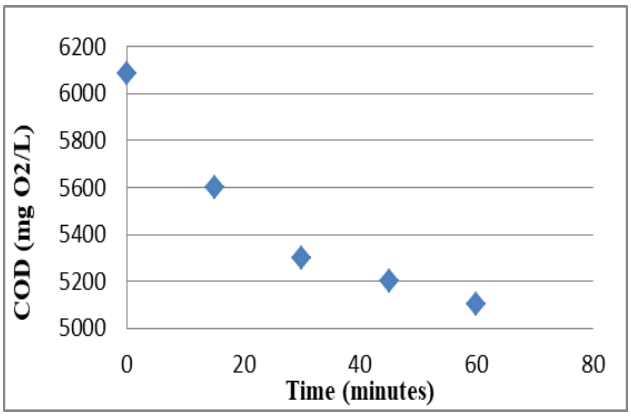

Figure 3a. *COD removal during one hour of treatment.*

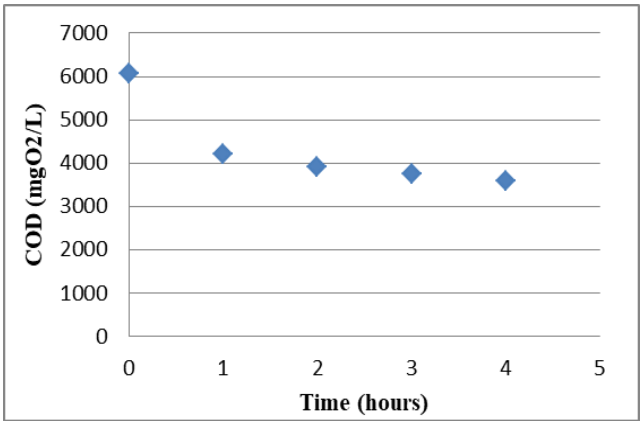

Figure 3b. *COD removal during 4 hours of treatment.*

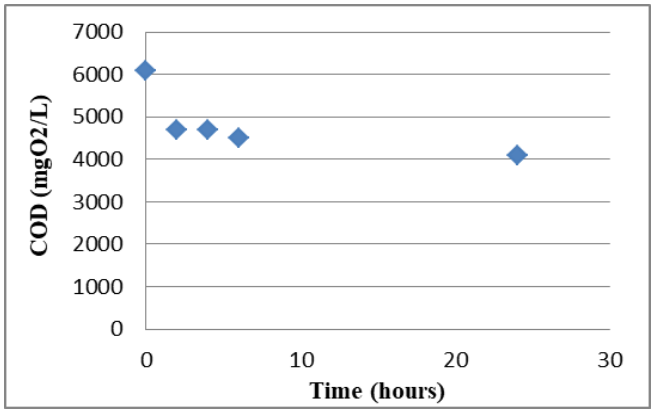

Figure 3c. *COD removal during 24 hours of treatment.*

Regarding the pH, in all the tests, the pH is neutral with a basic tendency; it varies between 7.4 and 8.5. It is compatible with the pH required for biological treatment **[12]**.

the elimination of the organic matter (OM) contained in the leachates of the Corso landfill.
Observed values regress from 6000 to 5100 mgO_2 / L for the first test (1 hour of treatment) with a removal of 15%. For the second test (reaction time = 4 hours), we notice a degradation of the OM which results in a decrease of the COD from an initial value of 6000 mgO_2 / L to 3600 mg O_2 / L to achieve a return of 40%.
For the 3rd test, we observe a decrease of the COD which goes from 6000 to 4100 mgO_2 / L after 24h of treatment with a removal of 31.66%.
The analysis of these results, allows us to note that the 2nd test gave us the best efficiency of removal of the OM which is 40%, it means that the long duration of treatment does not necessarily give good results because the microorganisms do not find enough substrate to degrade thus explaining the reduction of the COD removal efficiency which goes from 40% in 4 hours to about 32% in 24 hours.
Note, therefore, that the optimum time for degradation of the leachate COD is 4 hours. This reaction time will be adopted for the rest of our tests.

III.3. Influence of the initial concentration of organic matter

In order to examine the influence of the initial organic matter concentration on the removal efficiency, another series of tests was undertaken.
The operating conditions in this case are:
Reaction time = 4h; Mass of sludge = 2.95g / L, ambient T = 22 ° C
The different concentrations of COD tested are: 329; 6000 and 13848 mgO_2/L.
The results obtained are shown in Figures 4a, 4b and 4c.

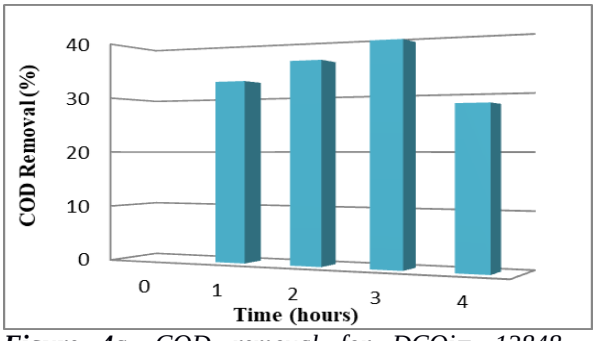

Figure 4a. *COD removal for DCOi= 13848 mgO_2/L*

The analysis of the obtained results allows us to note that the biological treatment is applicable for 950.

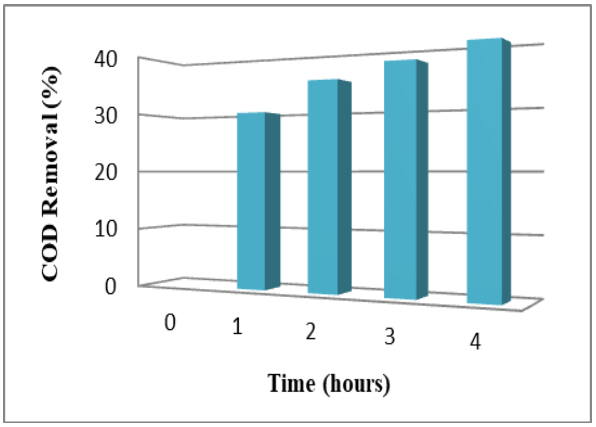

Figure 4b. *COD removal for DCOi= 6000 mgO_2/L*

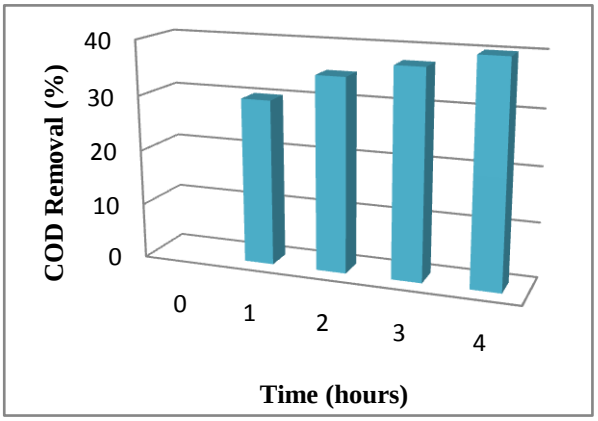

Figure 4c. *COD removal for DCOi= 329 mgO_2/L*

Analysis of the results obtained shows that the best removal efficiency of organic matter was obtained with a COD = 329 mg / L. Indeed, for a COD of 13484 mg / L, the removal efficiency of the OM did not exceed 28 %, whereas for 329 mg / L, the yield obtained was around 44%.
The low yield observed for the large amount of COD (13848 mg / L) could be explained by the fact that the quantity of sludge (2.95 g / L) is insufficient to degrade such a quantity of OM. This leads us to undertake another series of tests in which we will examine the effect of the amount of sludge on the removal of OM. Note, however, that this concentration in OM will not be retained for the rest of our tests, although the elimination yield obtained is the most important. In fact, this concentration is far lower than that which is

generally present in landfill leachates **[2, 6, 9, and 11]**.

III.4. Influence of the initial mass of sludge

This series of tests allows us to examine the effect of the initial amount of sludge on the OM removal efficiency. For this, the operating conditions adopted are as follows:
Reaction time = 4h; CODi = 6000 mgO_2 / L; pH = 8, T = 22 ° C
We then vary the mass of sludge, the masses tested are: 1.12 and 4 g/L.
Figures 5a, 5b show the results obtained.
Regarding the pH, it remains constant during both tests (pH= 8.15).

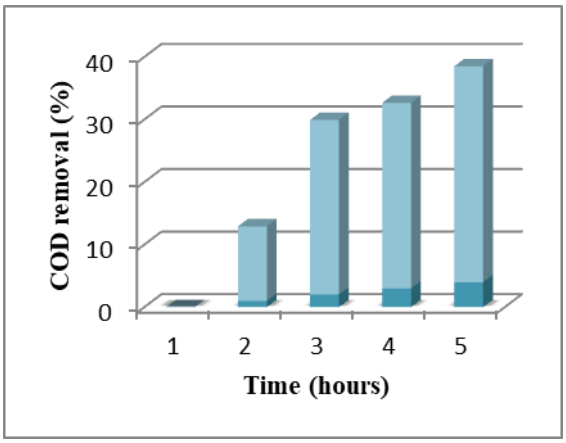

Figure 5a. *COD removal for a sludge mass = 1.12 g/L*

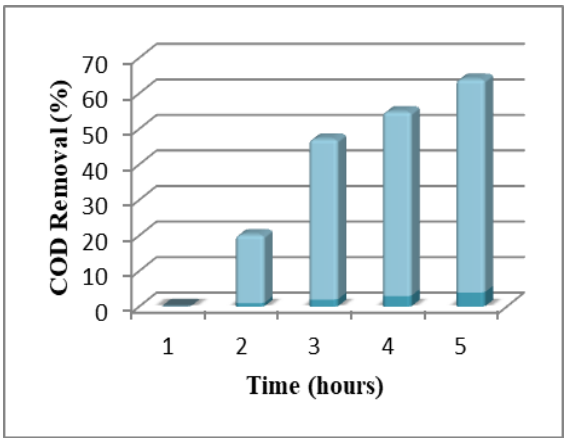

Figure 5b. *COD removal for a sludge mass= 4g/L*

The results obtained indicate that there is an elimination of the MO for the two masses of sludge tested. Note, however, that the best yield (60 %) was obtained for a sludge mass of 4 g / L. A removal of 35.5% was obtained for a mass of sludge of 1.12 g / L, this low yield can be explained by the fact that the quantity of microorganisms contained in the sludge is not sufficient to degrade the organic matter contained in the leachate.
Regarding the pH, it varies between 8 and 8.5 for all the tests and remains compatible with the pH required for a biological treatment.

IV. Conclusion

In this study, the treatment of leachate from the landfill site of Corso (East of Algiers) by a biological process was evaluated. Several experiments have been carried out in order to determine the optimal conditions for eliminate organic pollution expressed in COD. .
The effectiveness of the biological treatment undertaken was evaluated in terms of the elimination of organic pollution.
The main results obtained allowed us to conclude that:
-These leachates are young in view of the results of the characterization;
-That the application of a biological treatment is possible taking into account the biodegradability of these leachates.

V. References

1. Al Wabel, M. I.; Al Yehya, W. S.; Al Farradj, A. S.; Al Maghraby, S. E.Characteristics of landfill leachates and bio-solids of municipal solid waste (MSW) in Riyadh City, Saudi Arabia.*Journal of the Saudi Society of Agricultural Sciences*, 10 (2011) 65–70.
2. Al Gohary, F. A.; Kamel, G. Characterization and biological treatment of pre-treated landfill leachate. *Ecological Engineering*. Volume 94 (2016)268-274. http://dx.doi.org/10.1016/j.ecoleng.2016.05.074
3. Naveen, B.P.,Mahapatra, D. M.; Sitharam, T.G.; Siva pullaiaih, P. V.; Ramachandra T.V. Physico-chemical and biological characterization of urban municipal landfill leachate, *Environmental Pollution*, Volume 220 (2017) Part A1-12.
4. Khalil, F., Bouaouine, O.; Chtioui, H.; Souabi, S. ; Aboulhassan, M. A. ; Ouammou, A. Treatment of Landfill Leachate by coagulation-flocculation. *Journal of Materials and Environmental Science*. 6 (5)(2015) 1337-1342.
5. Chemlal, R. ; Azzouz, L. ; Kernani, R. ; Abdi, N. ; Lounici, H. ; Grib, H. ; Mammeri, N. Drouiche, N.Combination of advanced oxidation and biological processes for the landfill leachate treatment*Ecological Engineering*. (2014) 281–289.
6. Abd El-Salam, M.M.; Abu-Zuid, G. I;. Impact of landfill leachate on the groundwater quality: A case study in Egypt. *Journal of Advanced Research*, 6 (2015) 579-586.
7. Raghab, S. M.; Abd El Meguid, A. M.; Hegazi, H. A. Treatment of leachate from municipal solid waste landfill. *HBRC Journal*, 9 (2013), 187-192.http://dx.doi.org/10.1016/j.hbrc journal. 05. 007.

8. Aluko, O., Sridhar M. K. C., Oluwande, P.A. Characterization of leachates from a municipal solid waste landfill site in Ibadan, Nigeria. *Journal of Environmental. Health Research*. 2(1) (2003) 32−37.
9. Bahaa-eldin, E. A. R.; Yusoff, I.; Samsudin, A. R.; Yaacob, W. Z. W.; Rafek, A. G. M. Deterioration of groundwater quality in the vicinity of an active open-tipping site in west Malaysia. *Hydrogeological Journal*. 18 (2010) 997-1006.
10. Moody, C.M.; Townsend, T. G. A comparison of landfill leachates based on waste composition. *Waste Management*, Volume 63 (2017) 267-274.
11. Bakraouy, H.; Souabi, S.; Digua, K.; Dkhissi, O.; Sabar, M.; Fadil, M. Optimization of the treatment of an anaerobic pretreated landfill leachate by a coagulation-flocculation process using experimental design methodology.*Process Safety and Environment Protection*.Volume 109 (2017) 621-630.http://dx.doi.org/10.1016/j.psep.2017.04.017.
12. Balamane-Zizi, O.; Ait-amar, H. Biological phosphorus removal from dairy wastewater by alternating anaerobic and aerobic conditions. *African Journal of Biotechnology*. Vol. 11(46), pp. 10575-10581, 7, (2012), DOI: 10.5897/AJB11.4214. ISSN 1684-5315 © 2012 Academic Journals.

Please cite this Article as:
Balamane-Zizi O., Atmani F., Nasrallah N., Biodegradation tests for leachates from a technical landfill in algiers,***Algerian J. Env. Sc. Technology*,*5:3* (2019) 1072-1078.**