

## THE USE OF NATURAL MATERIALS FOR THE TREATMENT OF LEACHATES OF THE AGADIR DUMP

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### Abstract

Within the perspective of adopting effective solutions to the problems related to the burial of urban waste and its resulting harmful effects on both the environment and the human health, suitable actions should be taken to remedy the shortcomings of this somehow primitive method of waste disposal, namely those of the generated leachates. Because of their high pollutant load, leachates have to undergo a treatment of purification before being discharged into the environment. The focus of our study is to develop a simple technique to reduce the pollutant load of leachates in the technical burying center (TBC) of solid waste in Tamellast, Grand Agadir. This technique is based on the treatment of leachates through aeration followed by a percolation-infiltration on sand. The sand used is raw titaniferous sand (RTS) which is very abundant in the region of Agadir. Young leachate samples issued from fresh urban waste were collected at TBC, Tamellast. The physicochemical analyses of the young leachates show that their pH is very acidic, the values of conductivity are very important and greatly exceed the normal limit value specified for the discharges (2.7 mS / cm). The levels of biodegradable organic matter are important (the COD and BOD5 values are 17800 mg of O<sub>2</sub> / L and 9100 mg of O<sub>2</sub> / L, respectively). The aeration of leachate by injecting air has increased electrical conductivity due to the different chemical and biological reactions involved in the treatment. However, the values of COD and BOD5 have decreased. This decrease shows the significant effect of aeration on the reduction of polluting organic matter. The technique developed in this study led to high abatement rates (96.96% for COD and 97% for BOD5) in organic matter and lower COD and BOD5 values.

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## 1.Introduction

Leachate originating from households and other waste constitutes a real threat for the environment in Morocco. Indeed, as soon as a controlled landfill is built, the leachates are no longer absorbed by the soil, as was the case with traditional landfills. Instead, they accumulate down at the impermeable pond at the bottom of the landfill. One of the major problems that the Grand Agadir Dump is suffering from is the massive increase in solid waste. The daily flow of household waste approximates 900 tonnes. Moreover, the elevated moisture level which can reach 70% of the weight of waste, has generated large amounts of leachate requiring treatment. The Agadir dump has allowed the production of huge quantities of the leachate liquid containing polluting substances dangerous for the environment. In 2014, the volume of this liquid has reached 90,000 m<sup>3</sup>. The treatment of the leachate is carried out according to several processes namely: biodegradation, chemical and thermal degradation, adsorption, reverse osmosis and coagulation / precipitation. Such treatment presents many problems and difficulties. On the one hand, at the level of transport. Beside its considerably high costs, transporting waste may lead to accidental spillage. On the other hand, setting up on-site processes has always been a difficult challenge. In order to improve the performances of leachate treatment, we can make use of combinations of biological processes (aerobic and anaerobic sequential treatments) or biological and physical processes[1]. Effective waste management is not only concerned with landfilling and waste storage, but more importantly with recovering and treating the effluents. Several options are available for leachate treatment. However, the degree of the required treatment depends on the nature of the waste leachate[2]. The most widely used method for reducing the pollution load of leachate is to use the biological treatment. The microbial communities existing in the systems of leachate treatment are sufficiently adaptable to break down the complex organic compounds contained in these effluents[3]. Aerobic biological systems offer several advantages over anaerobic systems [4]. The ventilation technique is a very simple, inexpensive technique that can be applicable on a large scale. It is also effective in the removal of organic matter. Nevertheless, the problem which arises is the increase of the electrical conductivity during the aeration ( $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $NH_4^+$  and  $Mg^{2+}$ ). This increase persists even after one month of ventilation [5]. To reduce the electrical conductivity, we proceeded to infiltration percolation on the RTS [6] The aim of the present paper is to study the efficiency of a system of aeration infiltration - percolation for the treatment of leachate in TBC Tamellast.

## 2. Materials and methods

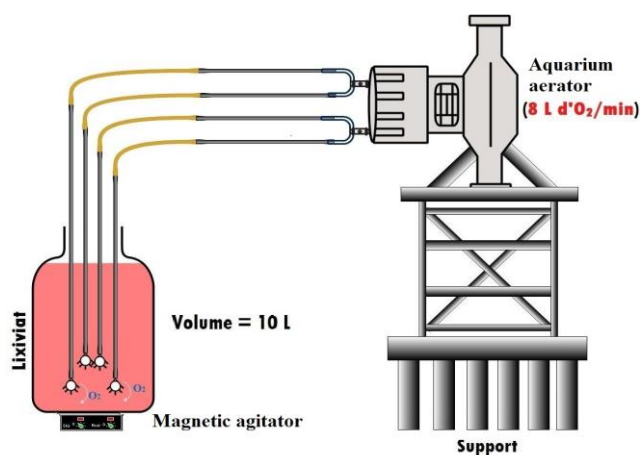
### *2-Material and methods*

#### *2.1- Leachate sampling*

Ten liters of young leachate were collected before unloading the trucks carrying household waste from seven districts of Grand Agadir (Morocco). The sampling took place in April 2018 in the Tamellast technical landfill. This center extends over an area of 41ha. It was put in operation in April 2010. Its Lambert coordinates are (X: 104 182 to 105 182 Y: 388 640 to 389 926) [5]

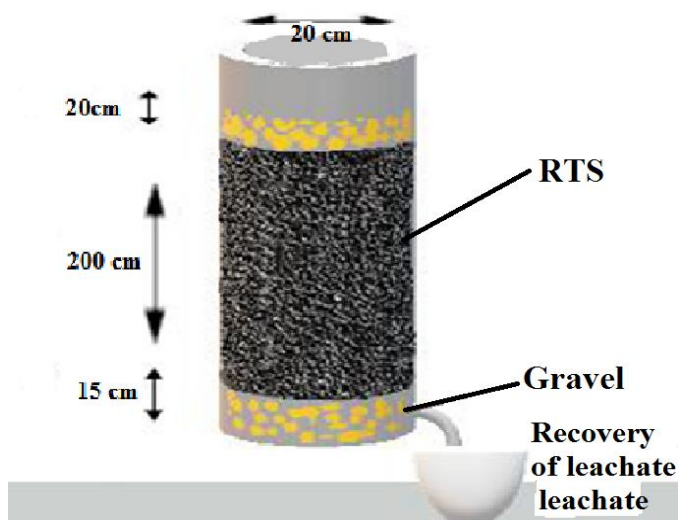
#### *2.2. Experimental device*

The young leachate is aerated by the introduction of four air distributors. These air distributors were powered by an air generator with a capacity of 8 liters per minute in total. The experimental protocol used is schematically shown in Figure.1. The aeration of the leachate is carried out through regular stirring and shaking.



**Figure 1:** Outline of leachate treatment through aeration

We have monitored the development of the physicochemical characteristics of the leachates every 5 days during the period of one month. After a month of pretreatment by aeration, 5 liters of the sample is filtered on a PVC column of 20 cm in diameter and 200 cm in height filled with titaniferous sand. Figure 2.



**Figure 2:** Experimental mechanism of infiltration percolation on sand

The treatment of effluents with high organic loads by air injection is a technique that has given variable results depending on the importance of the pollutant load and the chemical nature of non-organic constituents. The leachates were injected with air at a rate of 8 L / min accompanied by magnetic stirring for 30 days. The sand filter is filled to a depth of 200 cm of sand and 20 cm of gravel at the top and 15 cm at the bottom. The dynamic approach can be used to determine the retention capacity of the pollutant that is not being oxidized by aeration by the sand through percolating the effluents and through following the levels of COD, DBO5 and the turbidity in purified leachate recovered in the bottom of the column.

## 2.3. Methods of analysis

### 2.3.1. Characterization of leachate

Several analyses were conducted on the young leachate sampled. Measurements of electrical conductivity and pH were made at the time of sampling. The temperature was measured by an AD 1030 pH / mV multimeter. The pH was

measured using an AD 1030 pH / mV multimeter. The conductivity was determined using a multi-parameter. CONSORT type C864. The other parameters were determined in the laboratory, namely: biological oxygen demand (BOD5), chemical oxygen demand (COD) and turbidity. The COD is determined using a thermo-reactor type DCO-meter and BOD 5 using a BOD-meter (Incubator cooled to FOD 215F). Turbidity was determined by Thermo Scientific ORION AQ4500. The measurement of all these parameters was performed according to the AFNOR standard methods [7].

### 2.3.2. Characterization of titaniferous sand

The morphology and elemental composition of titaniferous sand were observed using a scanning electron microscope (SEM supra 40VP, France) equipped with a dispersive X-ray spectrometer (EDX). The crystalline structure of the samples was characterized by X-ray diffraction (Bruker AXS D8 Bragg-Brentano equipped with a copper anode fed at 30 kV and 10 mA) The molecular structure was analyzed by a Fourier transform infrared spectrometer (FTIR dual-beam Hitachi I-2001 device, over the 400 to 4000 cm<sup>-1</sup> range) The BET (Brunauer-Emmett-Teller) surface measurements were performed on a Micromeritics ASAP 2020M surface analyzer. X-ray (XRF) was performed on an Axios type wave length dispersion spectrometer.

## 3. Results and discussion

### 3.1. Characterization of young leachate

Leachate analyses have been performed before and after the aeration pretreatment. The parameters analysed after this pretreatment, which was followed by an infiltration on titaniferous sand are: pH, EC, COD, BOD5 and turbidity. Table 1 below shows some physico-chemical parameters of young leachate:

**Table 1:** Physico-chemical analysis of young leachate

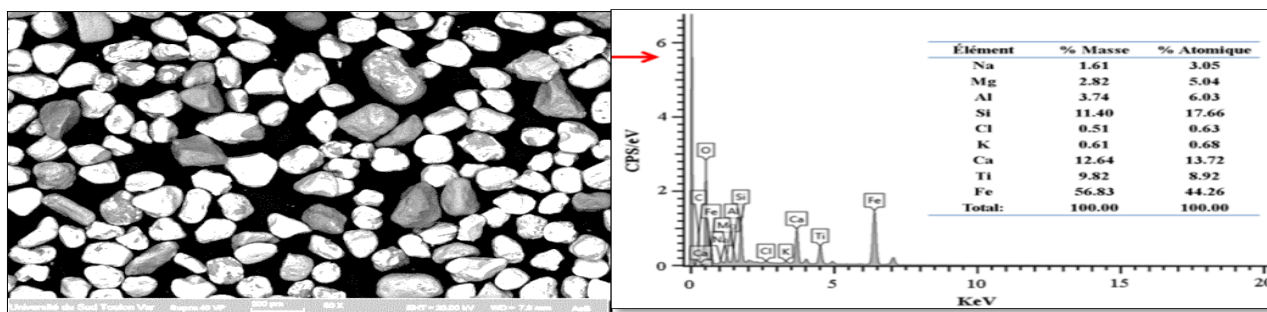
Ph	T	EC	MES	DCO	DBO5	DBO5/DCO
	(°C)	(mS/cm)	(mg/L)	(mg of O <sub>2</sub> /L)	(mg of O <sub>2</sub> /L)	
3,6	20,4	15,37	886	17800	9100	0,51

From the results of Table 1, we find that the young leachate collected is characterized by:

- A very acid pH due to the presence of volatile fatty acids.
- A high concentration in turbidity that does not meet the Moroccan standards of discharge. This is explained by the high organic and mineral load caused by the nature of the waste.
- A high load in COD (17800 mg / l) and BOD5 (9100 mg / l) which does not meet the Moroccan standards of discharge and which is consistent with previous studies [8].
- The BOD5 / COD ratio is 0.5, which makes it possible to classify the analyzed effluent among the most biodegradable young leachates.

### 3.2. Characterization of titaniferous sand

The SEM analysis coupled with EDX allows, respectively, to estimate the morphology and the identification of the chemical elements of the sample area targeted by the electron beam, resulting in a characterization of the composition of certain pluri-metallic materials. Figure 3 shows the SEM images obtained for different magnifications and the EDX spectra with the atomic concentration (%) at the grain surface of the RTS



**Figure 3:** SEM images of RTS with the EDX spectrum

The observation at the SEM of RTS reveals a quite different size and geometry of the particles along with a weak agglomeration of the grains, ranging from a hundred micrometers to more than 300µm. This is consistent with sieve analysis (Table 2).

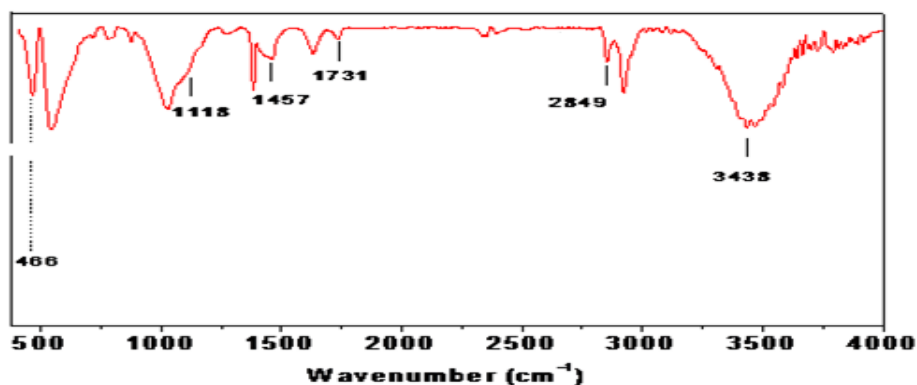
**Table 2:** Granulometric parameters derived from RTS laser diffraction analyses.

Size range (µm)	Consistency	Surface Area (m <sup>2</sup> /g)	*D <sub>v</sub> (10)	*D <sub>v</sub> (50)	*D <sub>v</sub> (90)	**D[3,2]
50-350	0,251	0,041	104,0	151	227,0	146,0

\* D<sub>v</sub> (x) is defined as the diameter in µm as x% by volume of the population consisting of particles of smaller size.

\*\* $D[3,2] = \sum n_i d_i^3 / \sum d_i^2$  is defined as the diameter of a sphere having the same volume / surface area ratio (Sauter mean diameter) where  $n_i$  is the number of particles of average diameter  $d_i$ .

According to Table 2, the RTS fraction reveals a class of large particles larger than 100 µm. This could be explained by a non-sphericity of the grains which have different or even cylindrical geometric shapes. The SEM analysis makes it possible to evaluate this characteristic. Parameter D [3,2] provides important information on the solid / liquid interface. The smaller the D [3,2], the larger the inter-facial area available for exchanges [9]. This promotes rapid retention and adsorption of pollutants on the filter substrate. Similarly, the higher the specific surface area of the material, the stronger the tendency to agglomerate[10]. The chemical composition measured by EDX (FIG. 3) makes it possible to deduce that the sample RTS is rich in Fe with a mass percentage which exceeds 50% characterizing the iron oxides. The sand contains calcium, silicon and titanium with a mass ratio of 12.6; 11.4 and 9.82 respectively. Other elements Al, Mg, Na, K and Cl are present at relatively lower percentages (<4%). These elements do not seem to be homogeneously distributed in each grain. The IR spectrum of the STB sand is illustrated in FIG. 4. The presence of a wide band at about 3438 cm<sup>-1</sup> and an absorption at 1637 cm<sup>-1</sup> are noted. This band is attributed to the O-H elongation and angular deformation of the physisorbed molecular water on metallic elements (M = Fe, Ti, Si, etc.) in the form of M-OH at the grain surface[11][12]. A very intense absorption band at 466 cm<sup>-1</sup> is attributed to the mode of deformation and vibration of the Si-O bond. The fine and intense bands observed between 420 and 560 cm<sup>-1</sup> are attributed to the Si-O deformation bands characteristic of the silica oxides very abundant on the surface of the RTS grains. This observation is in perfect agreement with the EDX and X-ray fluorescence analyses. Very low absorptions around 2393 cm<sup>-1</sup> can be attributed to the presence of organic matter (CH elongation) probably due to contamination during the operation. pelletizing [13].



**Figure 4:** Infrared Spectrum of RTS

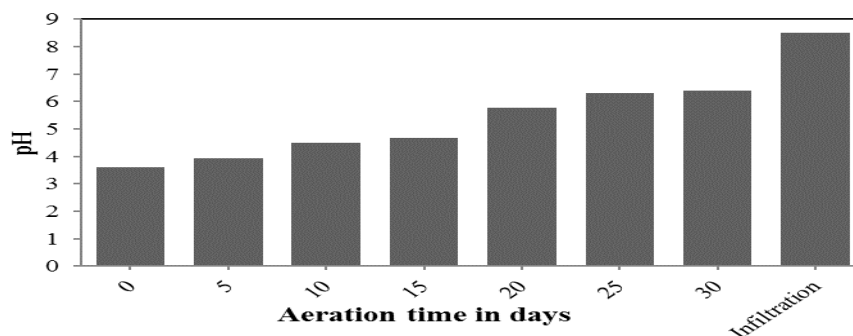
**Table 3:** Chemical analysis of the RTS used for the mineralogical quantification (in mass%)

Oxyde	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	SiO <sub>2</sub>	ZrO <sub>2</sub>	CaO	Al <sub>2</sub> O <sub>3</sub>	MgO	MnO <sub>2</sub>	Na <sub>2</sub> O	SO <sub>3</sub>	K <sub>2</sub> O
RTS	73,1	11,4	4,99	1,83	2,76	1,03	0,457	0,386	0,229	0,181	0,154

The analysis of the results in Table 3 shows that the fraction of the RTS consists mainly of two mineral phases: hematite and rutile. Nevertheless, it is important to note that the titaniferous sand explored in this study contains a considerably higher Fe<sub>2</sub>O<sub>3</sub> content (over 70% for RTS), as has also been demonstrated by EDX analysis, than that found in the siliceous sands frequently used in water purification [14]. The other oxides represent only a small portion of the mineral fraction (<5%). The specific surface area  $S_{\text{BET}}$  and the mesoporous volume of the sandy material RTS are 0.884 m<sup>2</sup> / g and 0.006 cm<sup>3</sup> / g.

### 3.3. pH evolution

The raw young leachate has a very acidic pH (pH = 3.6). The monitoring of this parameter during the treatment of this leachate gave the results of fig 5. It shows a progressive increase of the pH as the aeration time goes by. This increase may be due to the degradation of the organic charge by the microorganisms in the form of organic anions. The excess cations were then equilibrated with bicarbonate ions, formed from the CO<sub>2</sub> released by the work of microorganisms and brought by aeration. RTS infiltration of aerated leachate for 30 days resulted in an increase in pH to a slightly alkaline value. This increase can be attributed to the alkaline pH of the sand. In fact, this natural basicity can come mainly from alkaline aluminosilicates [15] and corresponds to the release of ions of a basic nature in leachates [16][17]. Infiltration increased the pH from 6.4 to 8.5 (the norm is 6.5 to 8.5)

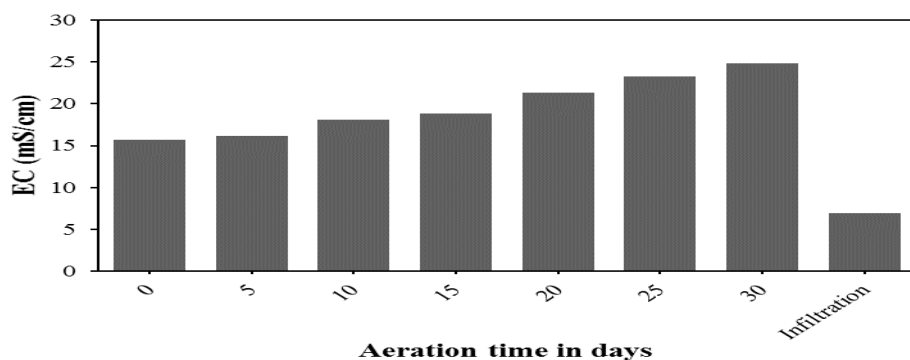


**Figure 5:** Evolution of the pH of young leachate treated by aeration and infiltration on sand



### 3.4. Evolution of electrical conductivity (EC)

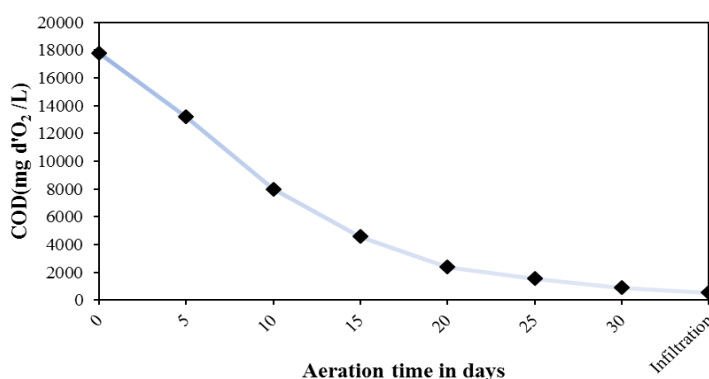
During the aeration, the evolution of the conductivity has known a significant increase (figure 6), due to the increase in the ionic charge and the different reactions taking place in the leachate. Conductivity decreased following the RTS infiltration due to mineral complexation in RTS and to the chemical exchanges between leachate and the filtering material (precipitation and adsorption) [18]



**Figure 6:** Evolution of the electrical conductivity of the young leachate treated by aeration and infiltration on RTS

### 3.5. Evolution of the COD

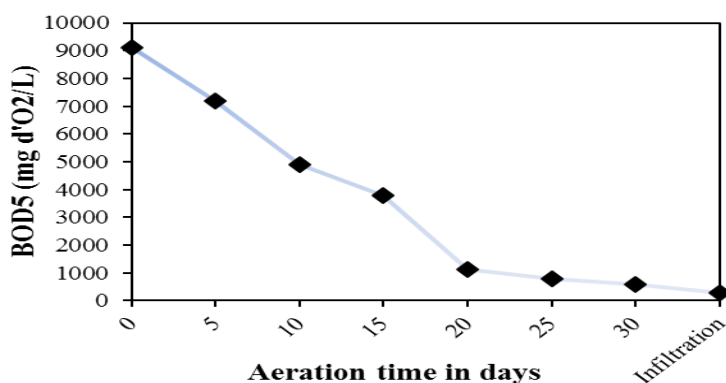
Figure 7 shows the evolution of the chemical oxygen demand (COD) of the leachate during treatment. The findings show that the process of combining aeration with sand infiltration contributes to a 97% COD reduction. After a month of aeration of the leachate, its COD reached the value of 1100 mg of O<sub>2</sub> / L. Infiltration-percolation on RTS leachate further decreased its COD (540 mg O<sub>2</sub> / L). This value is lower than the limit value of direct discharge fixed at 600 mg O<sub>2</sub> / L [19]. The rate of removal of COD by combining these two techniques shows a significant retention of oxidizable materials. On the other hand, it can be explained by the important adsorption properties of the finer minerals of the sand, which is consistent with the characterization of titaniferous sand.



**Figure 7:** Evolution of the COD of young leachate treated by aeration and infiltration on RTS

### 3.6. Evolution of BOD5

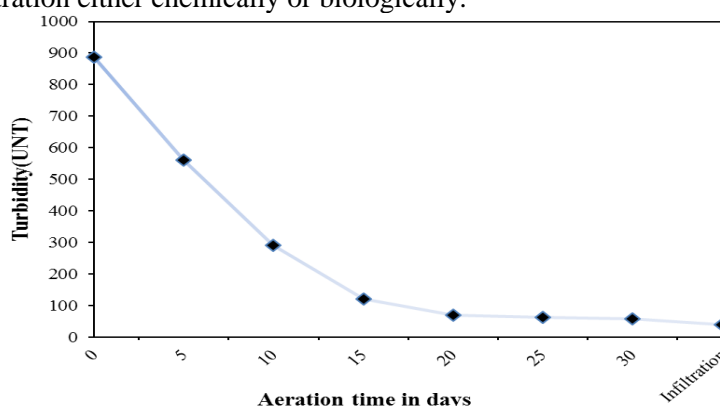
The BOD<sub>5</sub> concentration of the young leachate is 9100 mg of O<sub>2</sub> / L. Figure 8 shows a decrease in BOD<sub>5</sub> after the aeration-infiltration. After leachate treatment, the BOD<sub>5</sub> value is 280 mg of O<sub>2</sub> / L. This value is lower than the limit value of indirect discharge (500 mg O<sub>2</sub> / L). Both leachate treatment techniques resulted in a 97% reduction in BOD<sub>5</sub>. This reduction may be related to a better mineralization and oxidation of the organic matter of the leachate[20].



**Figure 8:** Evolution of the BOD5 of young leachate treated by aeration and infiltration on RTS

### 3.7. Evolution of turbidity

Turbidity takes various forms in leachate: mineral suspended solids, organic suspended solids and living suspended solids. The turbidity of the young leachate is of the order 886 UNT. Turbidity marked a very significant decrease during aeration and infiltration on RTS. After four weeks of aeration followed by infiltration-percolation on the titaniferous sand, turbidity recorded a 95.71% reduction (Figure 9). The turbidity of infiltrated leachate reached 38 UNT, which is less than the 250 UNT direct discharge limit [21]. This is due to the degradation of the suspended material by aeration and infiltration either chemically or biologically.



**Figure 9:** Evolution of turbidity of young leachate treated by aeration and infiltration on RTS

## 4. Conclusion

The results obtained in this study show that the organic load in the young leachate is relatively high 17800 mg of O<sub>2</sub> / L for COD, 9100 mg of O<sub>2</sub> / L for BOD5 and 886 UNT for turbidity. The treated leachate is highly biodegradable (the BOD5 / COD ratio is greater than 0.5). Aeration for one month further reduces the pollutant load with a minimal cost compared to other techniques. Similarly, the infiltration-percolation treatment is in favour of the treatment through aeration with regard to the composition of the pretreated leachates. The abatement of the analyzed pollutant is significantly effective: about 93.82% for COD, 93.73% for BOD5 and 93.45% for turbidity. The second treatment makes it possible to increase the retention rate in order to keep the concentrations of the pollutant in terms of COD, BOD5, the turbidity and the pH lower than the norms of direct rejection, the value of the BOD5 = 280 mg of O<sub>2</sub> / L (the direct discharge limit value DBO5 = 300 mg of O<sub>2</sub> / L) and the value of the COD after treatment is equal to 540 mg of O<sub>2</sub> / L (the indirect release limit value COD = 600 mg of O<sub>2</sub> / L). However, it decreased the conductivity. Based on these results, it would be possible to apply our combined system for an effective treatment of leachate from the Grand Agadir landfill on a large scale.



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