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Synthesis of leachate from the Al Hoceima controlled landfill and characterization (Morocco , North of Africa)

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Abstract

The leachate contains various types of organic and inorganic matter which can pollute aquatic environments if they are not properly treated. The choice and the efficiency of treatment techniques depend on the characteristics of the leachate, these characteristics change from one region to another and according to time and seasons. The objective of this study is to prepare a synthetic leachate based on the characteristics of a real leachate (the case of the Al Hoceima controlled landfill), in order to carry out tests of treatability of this synthetic leachate by controlling the different analysis parameters, in order to be able to choose the suitable treatment technique for the type of leachate to be treated. In our case for the leachate from the controlled landfill of Al Hoceima city the characteristics are very variable; COD varies from 12365 to 33600 mg(O_2)/L, ammonium varies between 1921 and 4060 mg/L, chloride from 4660 up to 7196 mg/L. In fact, this solution was made from organic ($CH3CO_2H$, CH_3CO_2Na) and inorganic compounds ($MgSO_4$, $CaCl_2$, $Ca(OH)_2$, NH_4Cl, KOH, MgCl2), the various analyzes of this solution gave values comparable to the real solution.

Keywords: *Synthetic Leachat, Landfill leachate, Physico-chemical characteristics.*

1. Introduction

In Morocco, the production of solid waste is constantly increasing, following population growth and the intensification of economic activity [1-2]. Several programs in Morocco consist of the establishment of controlled landfills and the rehabilitation of uncontrolled landfills. The controlled landfill is the ultimate link in any waste treatment sector, whether of domestic or industrial origin. It is the place of elimination or storage of the final residues of the refuse treatment chains, if they are well elaborated, and in many situations, it is still the only form of waste treatment [3]. One of the impacts of landfilling is the production of liquid effluents rich in organic, mineral and metallic matter called leachate. [4-7]. The leachate designates any filtering liquid by percolation through the waste landfilled or contained therein, by being bacteriologically and chemically charged with dissolved and suspended organic and / or mineral substances [8-10], leachate characteristics vary from region to region and seasonally [11]. It must be treated before discharging into the natural environment to avoid environmental and / or health impacts and to meet the requirements of discharge standards [12,13], on the other hand, the continuous production of leachate constitutes a persistent threat to local waters, both surface and deep. The choice of leachate treatment is based on the characteristics of the leachate [14,15], each treatment process has advantages and limits, so before going on to treatment, it is necessary to characterize the leachate to choose the suitable process [16,31]. The present study firstly assesses the variation in the characteristics of the leachate from the controlled landfill of Al Hoceima city, and then selects the parameters important for treatment. The objective of this study is to prepare a synthetic leachate based on the characteristics of the real leachate from the Al Hoceima controlled landfill, since no prior study has been conducted and performed on the preparation of this type of leachate. Also to perform treatability tests of this leachate by modifying and controlling the analysis parameters, in particular the COD.

2. Materials and methods

2.1. Location and characteristics of the Al Hoceima city controlled landfill

The controlled landfill of Al Hoceima is located 6 km southeast of the city and approximately 3.5 km northeast of Izafzafene and covers an area of 34 Ha, with Lambert coordinates: X=510000 m and Y=633000 m. It has been in service since 2008, and receives 80 t.day-1 (140000 inhabitants) of waste from many urban and rural communities: Al Hoceima, Imzouren, Beni Bouayach, Ait Youssef Ouali, Izmouren and Ait Kamra [31] (Fig. 1).

Figure 1. Geographic location of Al Hoceima city controlled landfill

The landfill is located in the Rif area which has a great Mediterranean climatological diversity since there are sub-climates ranging from semi-arid to humid, dry and hot in summer, and rainy and cool in winter. The rainfall is

characterized by an irregularity which manifests itself in the amount and intensity of the rains. The landfill site extends over the interface of the Tisirene aquifer and the Predorsalian aquifer, and formed by the domain of secondary and tertiary flyschs. It is bounded to the south and east by the watershed with the Rhis wadi. The site shows an absence of groundwater, we note on the site the presence of a temporary pond supplied by runoff collected by a track. In this pond, the water can stay for several months, which attests to the impermeability of the substratum [31].

2.2. Characteristics of the Al Hoceima landfill leachate

The characteristics of leachate differ from one region to others and from one landfill to another, they depend on the nature of the waste, method of exploitation, the age of the waste, and also from one season to the other. The characterization of the leachate is done by physico-chemical analyzes of several parameters; Table 1 presents the characteristics of the leachate from the controlled landfill of Al Hoceima [31]. These leachates are characterized by a COD which varies between 12365 and 33600 mg/L, which means that it is a young leachate [17], we also note the presence of several important parameters such as chloride which reaches values up to 7196 mg/L, ammonium which varies between 1921 and 4060 mg/L and an average of 1298.5 mg/L of nitrates.

Table 1. ***Characteristics of the Al Hoceima controlled landfill leachate***

Parameters	**Min.**	**Max.**	**Average**	**Unit**
Temperature	11.5	30.5	21.1	°C
pH	7.2	8.6	7.9	pH
Conductivity	20000	37700	32933.3	µs/cm
COD	12365	33600	19435.5	mg (O_2)/L
BOD_5	2881	22501	9802.2	mg (O_2)/L
Ammonium	1921	4060	3184.5	mg/L
Nitrite	-	-	383	mg/L
Chloride	4660	7196	5691.5	mg/L
Nitrate	-	-	1298.5	mg/L
Orthophosphate	-	-	143	mg/L

2.3. Physicochemical Analysis

A sample of the synthetic leachate is taken and diluted according to the range of analysis to be performed. Several parameters are analyzed to get an idea about the characteristics of this leachate. Table 2 summarizes the different parameters analyzed, method and technique used in this study.

Table 2. ***Methods and techniques used for the characterization of synthetic leachate***

Parameters	**Units**	**Method and technique**
pH		Electrometric measurement (Hach HQ40d Dual-Input Multiparameter)
COD	$mg.L^{-1}$	HANNA HI 839800 COD Reactor AFNOR NFT 90-101 norm
		OxiTop BOD Measuring System
Conductivity	$\mu s.cm^{-1}$	Electrical Conductivity (Hach HQ40d Dual-Input Multiparameter)
NO_2^-; PO_4^{3-}; NO_3^-; NH_4^+	$mg.L^{-1}$	Molecular Absorption Spectrometry
Cl^-	$mg.L^{-1}$	Determination by mercuric nitrate (Mohr method)

3. Results and Discussion

3.1. Synthetic leachate

Synthetic leachate is a leachate produced experimentally in the laboratory by mixing several chemicals in order to have a solution which has the same characteristics of a real leachate. In our case, we took the Al Hoceima city controlled landfill leachate as a reference, based on the composition of synthetic leachate used in a study by Guyonnet et al. [18,31].

3.2. Composition of synthetic leachate

The synthetic leachate used for the experiments is a fluid synthesized in the laboratory to represent the same physicochemical characteristics of the real leachate from the Al Hoceima controlled landfill. The synthetic leachate used in this study is prepared in the laboratory based on the concentrations of the compounds used in the study by Guyonnet et al. [18], according to the difference between Moroccan and European leachate, a synthetic leachate concentrated twice more than the Guyonnet's study was prepared. The table 3 below shows the concentrations of the compounds used for the preparation of synthetic leachate. After preparing the synthetic leachate, and because the COD is a significant parameter for the treatment of leachate [19,20], COD analyzes were carried out to check the solution prepared [31], the following table 3 shows the 1st composition of the synthetic leachate.

Table 3. ***The components of the first composition of the synthetic leachate***

Components	**Concentration**
Magnesium chloride ($MgCl_2$)	1.92 $g.L^{-1}$
Potassium hydroxide (KOH)	1.92 $g.L^{-1}$
Ammonium chloride (NH_4Cl)	5.20 $g.L^{-1}$
Acetic acid (CH_3CO_2H)	3.50 $mL.L^{-1}$
Sodium acetate (CH_3CO_2Na)	4.93 $g.L^{-1}$
Calcium hydroxide ($Ca(OH)_2$)	1.04 $g.L^{-1}$
Calcium chloride ($CaCl_2$)	4.22 $g.L^{-1}$
Magnesium sulfate ($MgSO_4$)	1.20 $g.L^{-1}$

3.3. Preparation and physico-chemical analyzes of the synthetic leachate of Al Hoceima

Four samples were prepared to carry out COD analyzes of the first synthetic leachate composition, the average value is 8880 mg/L, the Al Hoceima city controlled landfill leachate is characterized by a COD of 19435.5 mg/L, then the COD value in the prepared synthetic leachate should be increased. Before proceeding to the adjustment of COD; nitrites, nitrates and phosphate were added since they do not exist in the first composition of the synthetic leachate.

For the increase in COD, different amounts of glucose were added to several samples of the 2nd composition of the synthetic leachate, and COD analyzes were carried out for each sample. The following table 4 presents the concentrations of the chemical components used for the preparation of the 2nd composition of the synthetic leachate.

For the COD analyzes after the addition of glucose, 4 samples of the leachate (2nd composition) of 100 mL were prepared and 0.28 g of glucose was added to the first sample, 0.2 g to the second sample, 0.3 g in the third and 0.45 g in the fourth. Then the COD analyzes were carried out for each sample. After carrying out the COD analyzes for each sample, a COD of 14400 mg/L was found for the 2.8 g/L glucose sample, 11320 mg/L for the 2 g/L glucose sample, 19200 mg/L for 3 g/L of glucose, and a COD of 30132 mg/L for the sample of 4.5 g/L of glucose. Since the real

leachate from the Al Hoceima city controlled landfill is characterized by a COD of 19435.5 mg/L (average value), then the second sample was chosen with 3 g/L of glucose and which has a COD of 19200 mg/L, the table 4 below shows the composition of the final synthetic leachate which is adjusted to the characteristic of the Al Hoceima city controlled landfill real leachate

Table 4. ***Final composition of Al Hoceima controlled landfill synthetic leachate***

Components	**Concentration**
Magnesium chloride ($MgCl_2$)	1.92 $g.L^{-1}$
Potassium hydroxide (KOH)	1.92 $g.L^{-1}$
Ammonium chloride (NH_4Cl)	5.20 $g.L^{-1}$
Acetic acid (CH_3CO_2H)	3.50 $mL.L^{-1}$
Sodium acetate (CH_3CO_2Na)	4.93 $g.L^{-1}$
Calcium hydroxide ($Ca(OH)_2$)	1.04 $g.L^{-1}$
Calcium chloride ($CaCl_2$)	4.22 $g.L^{-1}$
Magnesium sulfate ($MgSO_4$)	1.20 $g.L^{-1}$
Potassium dihydrogen phosphate (KH_2PO_4)	0.10 $g.L^{-1}$
Potassium nitrate (KNO_3)	2.12 $g.L^{-1}$
Sodium nitrate ($NaNO_2$)	0.58 $g.L^{-1}$
Glucose ($C_6H_{12}O_6$)	3.00 $g.L^{-1}$

3.4. Comparison of synthetic leachate and real leachate

After preparing the last composition of the synthetic leachate, physico-chemical analyzes were carried out to characterize this synthetic leachate and make a comparison with the real leachate from the controlled landfill of Al Hoceima city. Analyzes of COD, chloride, ammonium, nitrites, nitrates and phosphorus were carried out, the results of the analyzes were close to those of the real leachate from the controlled landfill of Al Hoceima [31], table 5 presents the characteristics of the synthetic leachate.

Table 5. ***Characteristics of the synthetic leachate of the Al Hoceima controlled landfill***

Parameters	**Averagr**	**Units**
Temperature	27	°C
pH	8.5	pH
Conductivity	13000	µs/cm
COD	19200	mg (O_2)/L
BOD_5	4000	mg (O_2)/L
Ammonium	2159	mg/L
Nitrite	535.7	mg/L
Chloride	7400	mg/L
Nitrate	1330	mg/L
Orthophosphate	425	mg/L

The preparation of the synthetic leachate in this study was adapted to the average values of each parameter of the real leachate, as shown in Fig. 2, to be more representative of the behavior vis-a-vis the real leachate.

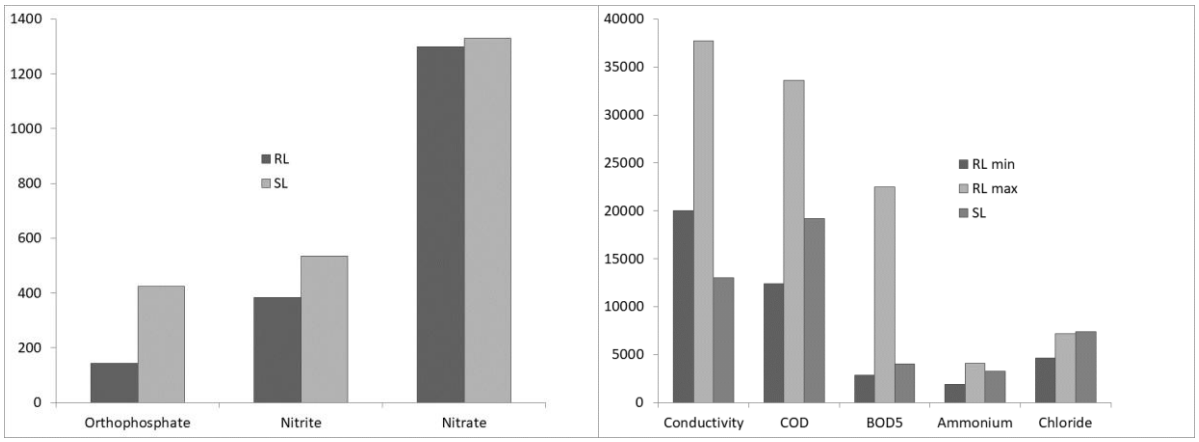

Figure 2. Comparison of the characteristics of the synthetic and real leachate of the Al Hoceima city controlled landfill.

The hydrogen potential (pH) is slightly alkaline; this basic character has been found by other studies [5]. The pH values obtained in the leachate could be linked to the low concentration of volatile organic compounds. As the landfill ages, the leachate becomes depleted in volatile organic compounds. This will then cause the pH to rise to 7 or more [21]. Nitrites (NO_2^-) and nitrates (NO_3^-) are found naturally in soil, water and plants, but generally in small quantities, they enter the nitrogen cycle, they are the result of nitrification of the ammonium ion (NH_4^+) [22]. The most common sources of nitrate in water are: i) chemical fertilizers used to improve crop growth; ii) waste from barns and storage sites manure; iii) soils containing nitrogen compounds from organic matter in decomposition. The registered content is of 1330 mg/L order, a value largely beyond the maximal concentration allowed by the World Health Organization which is of 50 mg/L. Nitrites come either from a reduction of nitrates, or from an incomplete oxidation of ammonium ions [23,24]. The NO_2^- contents of the synthetic leachate are high with an average of 535 mg/L. These high contents are due to the high values of dissolved oxygen and of the redox potential in the leachate. Orthophosphates react quickly with negatively charged chlorides to form amorphous precipitates. The results indicate that the average value of synthetic leachate orthophosphates is 425 mg/L, which is well above rejection standards. COD represents the amount of oxygen consumed by chemically oxidizable materials in water. The average content is 19200 mg(O_2)/L, the high value of the observed COD indicates that a very high organic load present in the leachate and on the other hand, shows that the liquid effluents are in the reducing conditions. The values obtained at the level of the pollutant load expressed by the COD, are higher than those 138.76 mg (O_2)/L for the Azemmour landfill, and 4808 mg(O_2)/L for Meknes landfill,[25] comparable to that reported by Benyoucef et al. [26] which is 25700 mg(O_2)/L for Kasba Tadla landfill, and lower than those for Oujda landfill 46000 mg(O_2)/L [27], Fes landfill 53200 mg(O_2)/L, the controlled landfill of Agadir 72000 mg(O_2)/L [28,29]. This difference could be related to the age, nature and quantity of the waste as well as different climatic factors such as rainfall, air humidity and temperature. Indeed, according to Christensen et al. [30], these different factors are the basis of the variability of the pollutant loads.

4. Conclusion

The results of the preparation of a synthetic leachate; based on the characteristics of a real leachate (the case of the Al Hoceima city controlled landfill); were presented in this paper, in order to carry out treatability tests by controlling the analysis parameters. After preparing the synthetic leachate, several physico-chemicals analyzes were carried out in order to adjust its characteristics to those of the real leachate from the Al Hoceima landfill. The physico-chemical analyzes allowed us to characterize the synthetic leachate and to specify the modifications which can control the

monitoring parameters. The synthetic leachate prepared is characterized by a COD of 19200 mg(O_2)/L which can be increased up to 30000 mg(O_2)/L and more, BOD_5 of 4000 mg(O_2)/L, pH of 8.5, conductivity of 13,000 µS/cm, ammonium of 2159 mg/L, nitrites of 535.7 mg/L, nitrates of 1330 mg/L, phosphorus of 425 mg/L, chloride of 7400 mg/L, BOD_5/COD which can be varied as required . This possibility of varying the characteristics of the synthetic leachate will allow us to carry out several treatability tests in order to find the most suitable techniques for the leachate that we want to treat.

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