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Assessment and characterization of the physicochemical parameters of Moroccan leachate during the confinement period (coronavirus).

A.Ourhedja[(a)]*, Y. Miyah[(b)], M. N. Bargach[(a)], F. Zerrouq[(b)] and R. Tadili[(a)]

[(a)] *Department of Physics, Laboratory of Solar Energy and Environment, Faculty of Sciences, Mohammed V University in Rabat, P.B. 1014, Rabat - Morocco.*

[(b)] *Laboratory of Materials, Processes, Catalysis, and Environment, School of Technology, University Sidi Mohamed Ben Abdellah Fez - Morocco.*

** Corresponding author:*
asmae.ourhedja@um5r.ac.ma

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Abstract

This work was carried out to respond to a major environmental issue which is water pollution and its repercussions on receiving environments, in particular the problem of leachate in the city of Fez-Morocco. The leachates generated by many economically relevant industrial activities contain recalcitrant organic compounds that remain unchanged at the biological stage of the treatment plant, which could make it difficult to comply with the discharge standard limits currently in force. During this work, we evaluated the elements present in the leachate as well as a physicochemical characterization study such as the chemical oxygen demand (COD), the biochemical oxygen demand over 5 days (BOD5), the pH, the electrical conductivity, the total phosphorus, the ammonium, suspended matter, and heavy metals, before and during the period of coronavirus containment.

Keywords: *Controlled Landfills – Household waste – Leachate characterization – Water waste treatment – Confinement period.*

1. Introduction

Morocco has to face a continuous increase in the volume of its waste which has a direct impact on the health of residents and all environmental compartments (air, water, and soil) by the leachate and biogas generated, and therefore several projects have been established to enhance them and reduce their impact while reducing greenhouse gas emissions [1,2]. The waste that generates this odorless gas affluence also serves as organic fertilizers, advantageous substitutes for the usual chemical fertilizers [3]. The quality of the soil and that of the water tables is thus better preserved [4]. This gas exploitation is also an asset for the economic development of the territory concerned. Finally, the generated biogas can be injected into the gas distribution network, which increases the share of green energies in overall energy consumption. Landfill leachate is complex wastewater resulting from the percolation of rainwater through the waste but also from biological, physical, and chemical processes taking place within the landfill itself [5]. Their composition reveals in particular high values of conductivity, COD, BOD_5, anions, cations, ammonia, heavy metals, etc., and depends on many factors: composition of the waste, age of the discharge, weather conditions, etc. The leachates are produced when the content in humidity exceeds the maximum retention value, which is defined as the maximum value of liquid that a porous medium can retain without producing percolation. This process depends on several factors such as the climatic and hydrogeological factors of the site: (rains, snow, groundwater intrusion, etc.), waste quality (age, permeability, moisture content, and particle size), site operation and management (compaction, vegetation, irrigation, etc.) and the internal mechanisms (decomposition of organic compounds, the formation of biogas and heat) [6]. The composition of leachate is variable over time and space including inorganic, organic compounds, and microorganisms. Their composition is difficult to determine because the landfills constitute a complex reactor that evolves spontaneously. During the biological evolution of waste from a landfill over time, three types of leachate can be classified as Young leachate, Intermediate leachate, and Stabilized leachate [7-8]. Despite the diversity of household waste sent to landfill, the composition of the leachate follows some major constants because a large part of the waste consists of putrescible and biodegradable materials [9]. The aim of this work to study the influence of the coronavirus period on the overall physicochemical characterization of the leachate from the controlled landfill in the city of Fez in Morocco.

2. Materials and methods

2.1. Sampling site of the controlled public landfill of Fez

The controlled landfill in the city of Fez, located in the commune of Aïn Beida, at about 11 km northwest of the center of Fez, covers an area of 110 hectares (Figure 1), and currently receives more than 1000 tonnes of waste per day, with an operating life of 30 years (2004 to 2034). The landfill is managed by the ECOMED group specializing in solid waste management, more particularly in the field of treatment and recovery of solid waste for sustainable development. The good choice of this landfill site was based on certain particularities for the preservation of the environment and the protection of public health. The acceptability of the waste is evaluated by the technical service of the center (ECOMED group) according to various criteria: the requirements of the operating permit, the characteristics of the waste, its origin and its physico-chemical properties. The accepted waste is sent to the landfill and is then dumped and spread horizontally in compacted layers in storage bins. A branched network of pipes, installed in three layers with a pipe slope of 2 to 2.5%, is used for the drainage of large volumes of leachate and the collection of methane emissions

generated by the waste, characterized for the city of Fez. by a high humidity and a high rate of organic matter.

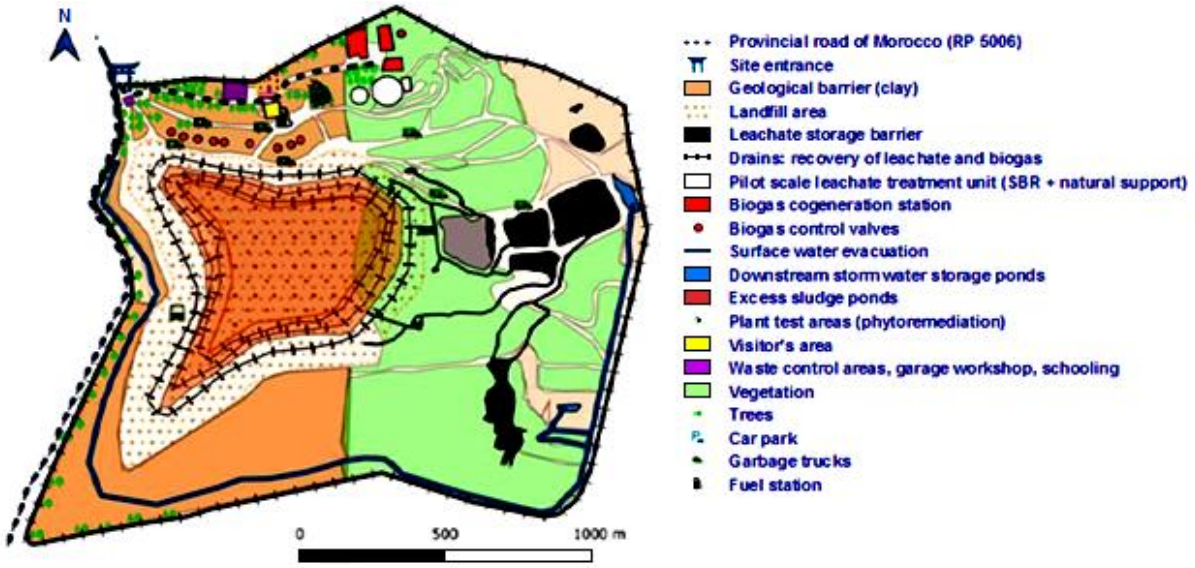

Figure 1 : Location of the different entities of the controlled public landfill in Fez.

Despite the advantages of the controlled landfill in Fez in terms of environmental preservation (stopping the dumping of waste in the Sebou River, collection and treatment of leachate, collection and treatment of biogas, collection and evacuation of rainwater, etc.), some health problems are encountered on this site:
- The prevailing wind (Chergui) which blows towards the city can give off nauseating odors which reach the center of the city of Fez and could affect public health;
- The large quantity of waste received by the landfill produces enormous quantities of leachate of about 25 m^3 per day which are currently pumped to the four storage basins of the landfill.

2.2. Main techniques for characterizing the leachate in the city of Fez

In the experimental study, the samples were stored in a refrigerator at a temperature below 4 °C and sent to the Biotechnology laboratory at the Faculty of Sciences of Dhar El Mahraz within 24 hours. The parameters which were analyzed are the pH (WTW, pH 522 with the combined electrode), the electrical conductivity (HACH multiparameter, model 44600), the turbidity (WTW Laboratory Turbidimeter 550 in Analytical Devices), the chemical oxygen demand COD (Lovibond MD 100 Vario COD kit), and the heavy metals ICP (Shimadzu AA660 model). All the experimental analyzes were carried out following the AFNOR standard [10-11].

3. Results and discussion

The following experimental results were collected over a period of fifteen months (from June 2019 to August 2020) spread over five quarters, the last two-quarters of which correspond to the period of confinement (quarantine) following the spread of the COVID 19 pandemic. In other words, trimester T_1 is from June 2019 to August 2019, T_2 is from September 2019 to November 2019, T_3 is from December 2019 to February 2020, T_4 is from March 2020 to May 2020, and T_5 is from June 2020 to August 2020.

3.1. Evolution of COD and BOD_5 in raw leachate over time

The biological evolution in terms of COD and BOD_5 concentrations of the raw leachate from the controlled landfill of Fez is carried out as a function of time (Figure 2). The observed values of the average concentrations show that in quarter T_2, the average concentrations of COD and BOD_5 in the raw leachate were 18 275 mgO_2/l and 7 620 mgO_2/l, respectively, while in 2020, these concentrations increase and reach respectively 52 852 mgO_2/l for COD and 24 766 mgO_2/l for BOD_5.

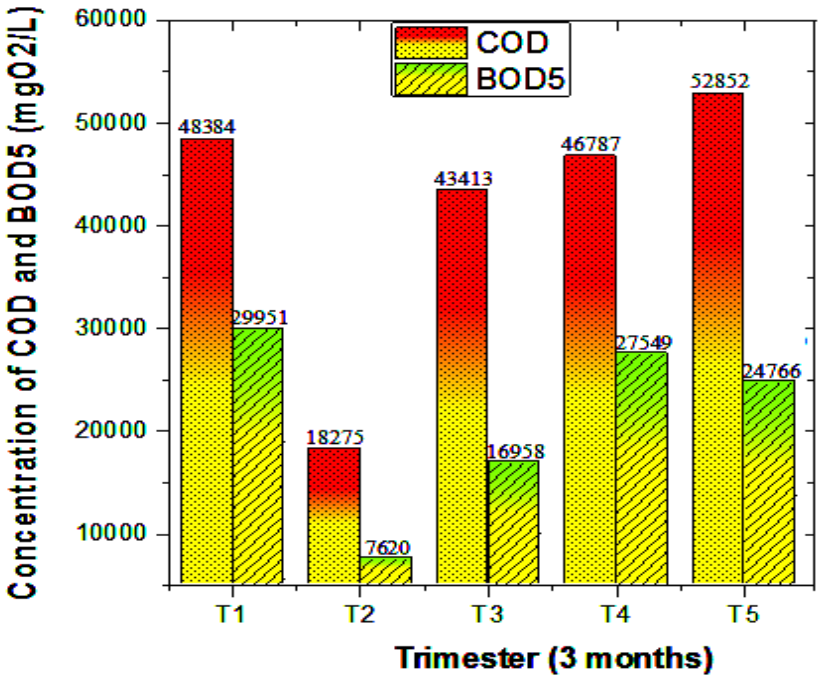

Figure 2. Quarterly analysis of the leachate COD and BOD_5 of the city of Fez.

Table 1. Evolution avec le temps des concentrations COD, DBO_5 and the ratio COD/DBO_5 for the raw leachate from the controlled landfill of Fez

Trimester	**COD (mgO_2/l)**	**DBO_5 (mgO_2/l)**	**COD/DBO_5**
T_1 : June - July - August (2019)	48 384	29 951	1.616
T_2 : September - October - November (2019)	18 275	7 620	2.398
T_3 : December (2019) – January – February (2020)	43 413	16 958	2.558
T_4 : March – April - May (2020)	46 787	27 549	1.698
T_5 : June - July - August (2020)	52 852	24 766	2.132

By referring to the prescriptions indicated in the literature, a high COD value (typically greater than 20 000 mgO_2/l) indicates a high organic load, associated either with young leachates in the acetogenesis phase, or with accidental pollution (intake toxic waste). While a low COD value, (typically less than 2 000 mgO_2/l) is characteristic of stabilized leachate, associated with the strictly anaerobic methanogenesis phase [12]. The study of the COD/BOD_5 ratio is a good indicator of the biodegradability of an effluent. A value of this ratio

close to 1.0 corresponds to very good biodegradability, while a value greater than 4.0 indicates that the effluent is very difficult to biodegrade. The analysis of the values of this ratio for the raw leachate from the controlled landfill of Fez (see Table 1), shows that for the five quarters, the COD/BOD_5 ratio is less than 4.0, which indicates a significant biodegradability of a young leachate, probably rich in products coming mainly from agrifood industries and urban wastewater.

3.2. Evolution of the leachate pH over time

Figure 3 represents the variation in the pH of the leachate collected at the Fez landfill over several quarters. The results show that the leachate is a slightly acidic medium since the pH is below 7.0, and remains almost constant throughout the study period. We can therefore consider that the pH is an insignificant physico-chemical parameter during this period.

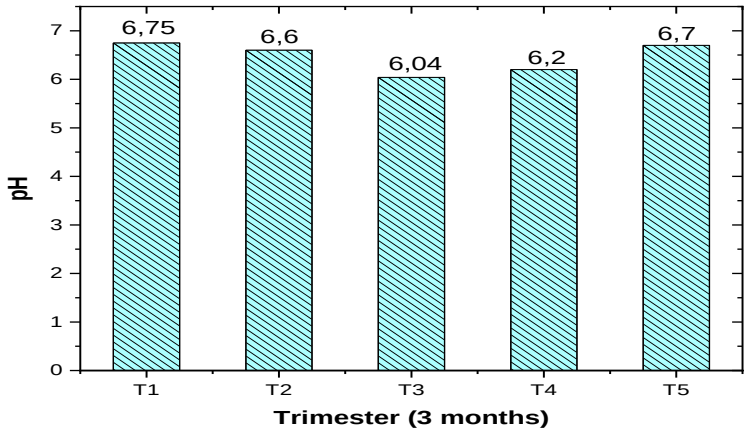

Figure 3. Quarterly analysis of the leachate pH of the city of Fez.

3.3. Evolution of the conductivity of the leachate over time

Figure 4 shows that the average concentration of undissolved solid substances, contained in suspension in the raw leachate, undergoes a significant increase during the last two quarters. More intense domestic activities carried out at home by the populations during this period of beginning of confinement (T_4 and T_5) seem to be at the origin of the production of waste rich in poorly dissolved substances (products of house paints, cleaning, materials construction, etc.).

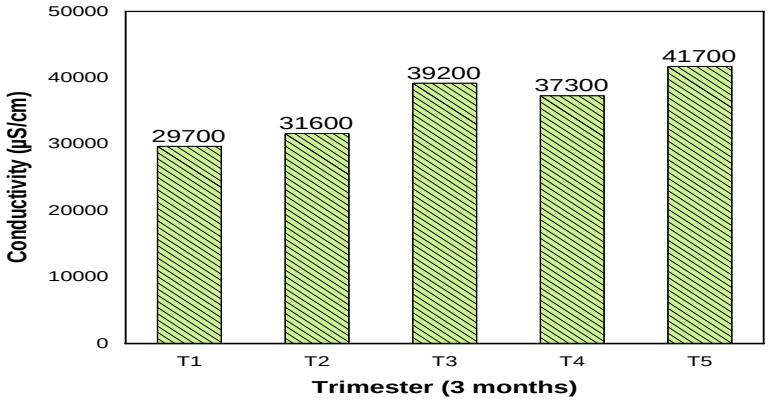

Figure 4. Quarterly analysis of the leachate conductivity of the city of Fez.

3.4. Evolution of the suspended solids (SS) in leachate over time

Figure 5 shows that the average concentration of undissolved solid substances, contained in suspension in the raw leachate, undergoes a significant increase during the last two quarters. More intense domestic activities carried out at home by the populations during this period of the start of confinement (T_4 and T_5) seem to be at the origin of the production of waste rich in slightly dissolved substances (house paint products, cleaning, laundry products, construction materials and debris, etc.).

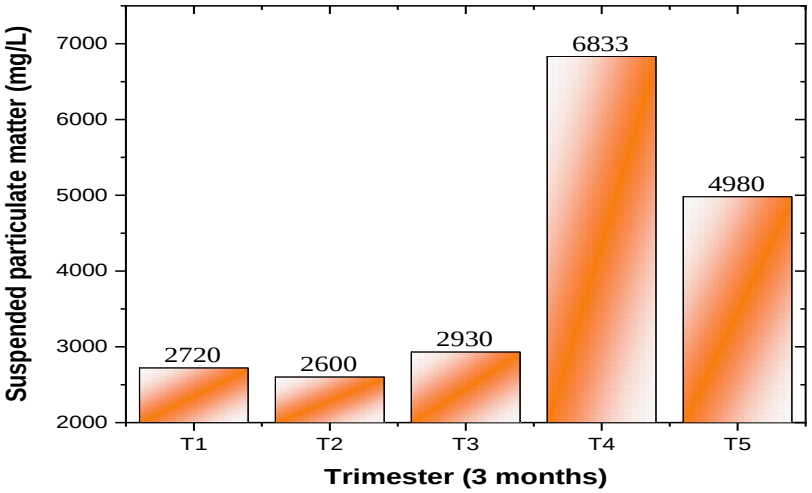

Figure 5. Quarterly analysis of suspended leachate from the city of Fez.

3.5. Variation in total phosphorus in leachate over time

Figure 6 indicates that there has been a substantial increase in the total phosphorus concentration of the raw leachate over the past three quarters. This increase could be explained by a massive use by households during this period of confinement of laundry products (soap and detergent) containing Polyphosphates, a large-scale spreading in the city by the authorities of cleaning and disinfectant products containing the phosphoric acid, wind erosion of agricultural soils rich in fertilizers surrounding leachate ponds, etc.

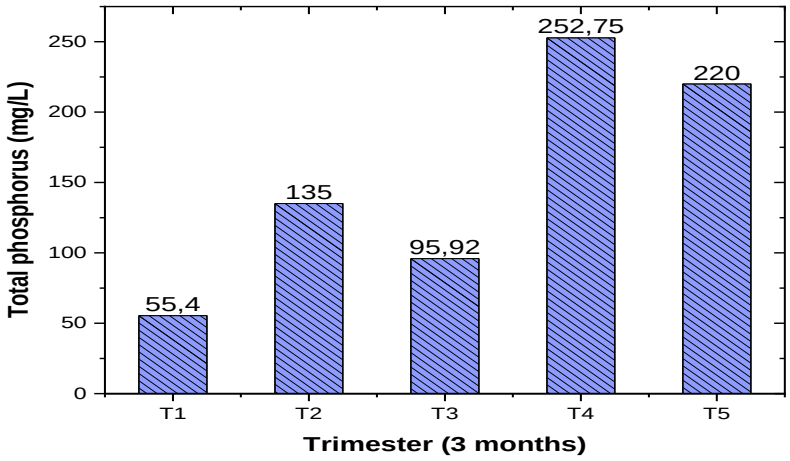

Figure 6. Quarterly analysis of the leachate total phosphorus of the city of Fez.

3.6. Variation in leachate ammonium over time

Figure 7 reveals that over the last three trimesters there has been a sharp increase in the average ammonium content of the raw leachate. An increase during the quarantine of organic discharges of agricultural, domestic or industrial origin by the inhabitants of the city of Fez and its region seems to be at the origin of this sharp increase in the average ammonium content of the raw leachate.

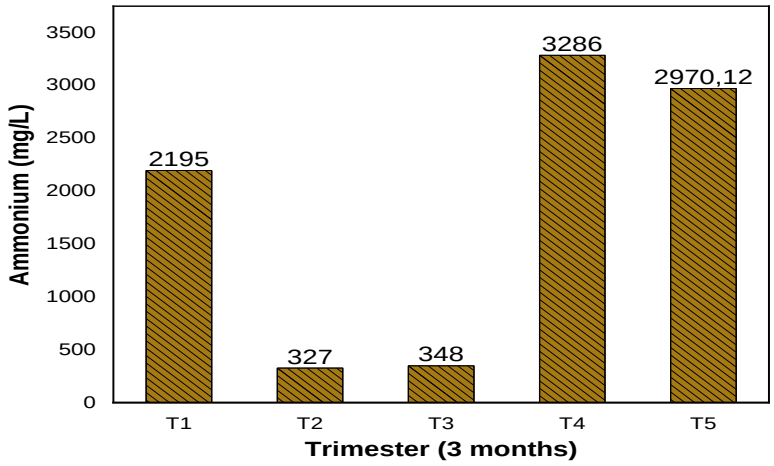

Figure 7. Quarterly analysis of the leachate ammonium of the city of Fez.

3.7. Variation of heavy metals in the leachate over time

Table 2. Raw leachate heavy metals concentrations for each quarter

		Concentration (mg/l)						
Elements		**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**Average**	**Limit values**
Aluminum	**Al**	35.5	2.008	3.001	2.3	5.1	9.582	10.0
Arsenic	**As**	0.153	0.085	0.092	0.25	0.09	0.134	0.1
Baryum	**Ba**	0.647	0.366	0.425	0.527	0.72	0.537	1.0
Cadmium	**Cd**	0.009	0.004	< 0.01	< 0.01	< 0.01	< 0.009	0.25
Copper	**Cu**	0.316	0.05	5.06	1.26	0.28	1.393	2.0
Total Chromium	**Cr**	1.98	1.232	1.52	3.1	3.2	2.206	2.0
Iron	**Fe**	119	51.09	95.31	77.7	61.88	80.996	5.0
Lead	**Pb**	0.093	0.057	< 0.01	< 0.01	< 0.01	< 0.036	1.0
Manganese	**Mn**	8.65	6.49	15.68	4.13	14.48	9.886	2.0
Mercury	**Hg**	0.00346	0.002	0.003	0.006	0.0075	0.004	0.05
Nickel	**Ni**	0.71	0.489	2.31	2.21	0.66	1.276	5.0
Selenium	**Se**	< 0.010	0.006	0.08	0.016	0.015	< 0.025	0.1
Silver	**Ag**	< 0.0067	< 0.005	< 0.005	< 0.005	< 0.003	< 0.005	0.1
Zinc	**Zn**	6.0	0.63	8.59	2.59	1.91	3.944	5.0

Table 2 below reveals that, on the one hand, the concentration of each heavy metal in the raw leachate of the Fez-Morocco landfill varies from one quarter to another, and on the other hand, the average concentrations of heavy metals in the leachate remained, in the majority of cases, below the limit values [13]. The average concentrations of two heavy metals, which are iron and manganese, present however, an exception because their values are very high, compared to the authorized standard limit values. This could be attributed to the fact that despite limited industrial activity during this period, significant oxidation of these two materials would have been responsible for these unusually high concentrations.

3.8. Comparative study between different leachate

Table 3. Raw leachates bibliographic characterization

Leachate Origin	**Chemical Oxygen Demand (mg/l)**	**Biochemical Oxygen Demand (mg/l)**	**pH**	**Suspended Solids (mg/l)**	**Conductivity (µS/cm)**	**Period**	**Reference**
Fez, Morroco	18275-52852	7620-29951	6.2-6.75	2600-6833	29700-41700	2019-2020	This study
Alexandria, Egypt	12850-16350	9620-11700	7-7.8	24954-30482	35260-42857	-	[15]
Staoueli's landfill (Algiers), Algeria	10500	5500	7.10	7370	8700	-	[16]
Curitiba, Brazil	3162	916	7.9-8.1	-	32230	March 2016	[17]
	3892	1400	7.9-8.1	-	47130	January 2017	
	3078	1400	8-8.1	148	26130	June 2017	
	4829	1300	8-8.2	660	43605	September 2018	
	9569	7500	7.9-8	642	18123	January 2018	
	7673	2500	8.2-8.4	820	35160	May 2018	
Fez, Morocco	95700	42000	6.26	60060	22500	-	[14]
Ulu Maasop, Malaysia	7624	614	7.76	-	23000	Sep-Oct 2017	[18]
Kampung Keru, Malaysia	5082	610	8.59	-	13570		
Jbel Chakir (Tunis),Tunisia	7830-28190	2841	7.2-7.9	-	32200-67200	-	[19]
Nam Son (Hanoi),Vietnam	6325	-	8	-	10500	-	[20]
Riyadh, Saudi Arabia	13900-22350	-	5.49-6.32	2280-8919	42500-58900	Feb-May 2008	[21]

Landfill leachate characteristics from each in recent years in different corners of the world from the African continent (Morocco, Algeria, Tunisia, Egypt) to the Asian continent (Malaysia, Vietnam, and Saudi Arabia) and Brazil are listed in Table 4. The characterization of the leachate from the landfills that we have cited in Table 2 was carried out long before the containment following the pandemic, a period during which industrial activity was restricted. For example, a study by El Mrabet et al. (2020), was carried out on landfill leachate that was characterized long before December 9, 2019, the date they submitted their scientific article, and therefore we can see the difference with that in our work in terms of COD, BOD_5, pH, suspended solids and electrical conductivity which are much better and still much closer to the norm [14].

4. Conclusion

The results show great variability in the composition of the leachate. This variability essentially depends on the biological and physicochemical evolution of these effluents over time. For this reason, the limit values in Table 1 represent the variations of the various parameters. The COD value (138.76 mg O_2/L) reveals a relatively high organic load. These leachates are characterized by a very high conductivity (35.9 mS/cm) and a relatively basic pH. Thus, these effluents are loaded with dissolved salts and the concentrations of certain heavy metals are relatively higher than the Moroccan discharge standards.

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