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Monitoring of the Fluctuation of the Pollutant Load of Leachate Rejected in Environment. Study in the Northeast of Algeria

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Abstract

In order to model the environmental impact of leachate produced at the engineered landfill center (ELC) of Bouguerguer, Guelma located in the north east of Algeria. A physico-chemical characterization during 2020, was carried out in order to estimate this impact. For this purpose fourteen parameters have been studied which are, In vivo: pH, conductivity, Salinity. In vitro: Organic element contents (BOD_5, COD); Heavy metal contents (Fe, Zn, Pb, Cd and Cr); The contents of nutrient elements (Nitrate, Nitrite, Ammonium and Suspended matter). The results obtained show that the leachates studied, have the following characteristics: A basic pH of 8,85 , Suspended matter a fairly large load with 5397,92 mg/L. The organic load interpreted by a COD that reaches an average 1603, 75 mg O_2/L and a BOD_5 that reaches an average of 778,54 mg O2/L, which strongly justifies the presence of organic pollution. The mineral pollution is also present, translated by a high electrical conductivity which reaches an average value of 33,38 mS/cm, Nitrates and nitrites average 15,68 and 17,93 mg/l respectively. The leachates are also characterized by a high content of Fr, Zn, Pb, Cd and Cr with an average of (42,70 ; 10,44 ; 8,27 ; 4,37 and 5,97 mg/l) respectively. Noting that the results obtained constitute the first characterization of leachates in this landfill and thus provide a database for future research.

Keywords: leachate; household waste; heavy metals; pollution.

Introduction

The last few decades have seen a resurgence in environmental issues, especially with the arrival of the coronavirus pandemic, which has called into question the effectiveness of the urban solid waste management system (Mohamed et al., 2021). The relentless urbanization and population growth, the production of municipal solid waste (MSW), human health risk; the environmental impact, the technologies linked to the treatment, recycling and recovery of waste, etc. are all still being discussed (Folino et al., 2024), (Ghosh et al.,2023), (Gunarathne et al., 2023) (Mesbahi-Salhi et al., 2023). The landfilling of sorted or unsorted household waste and technical landfill is the most widespread waste disposal practice in developing countries (Parvin & Tareq, 2021) (Alam et al., 2020). One of the main environmental concerns arising from landfilling is leachate, which is considered a serious menace in waste disposal areas. Indeed, the leachate issue is crucial in the waste management process, as monitoring not only takes place during landfill operation, but can last for several decades after landfill closure, leachate quality continues to be observed (Podlasek et al., 2023),(Somani etal., 2019). However, the decomposition of waste gives rise to leachates and biogas, which are the main problems associated with the disposal of non-recoverable waste, as they are generated by the degradation of the residual organic fraction of household waste (Folino et al., 2024). Landfill leachate is generally considered to be toxic, posing a potential threat to human health, the environment and ecosystems (Baderna et al., 2019) (Ghosh et al., 2023). These landfill leachates are generated by the infiltration of rainwater which mixes with water produced by the biodegradation of waste and water inherent in the waste, which includes a large quantity of dissolved organic matter (DOM), salts minerals, heavy metals ions and other organic compounds as well as pathogenic micro-organisms (Gu et al., 2022), (Liu et al., 2015). Discharge of raw leachate without adequate treatment can affect environmental health by contaminating soils, surface water and even groundwater, and consequently will threaten human health (Kitambala & Phuku, 2018),(Abdel-Shafy et al., 2023). Heavy metals are among the main toxic components of landfill leachates, as they are non-biodegradable, capable of deteriorating the quality of surface water and groundwater, and are toxic even to biological systems (Gautam et al., 2014) (Verma & Dwivedi, 2013), (Parvin & Tareq, 2021), where they can interact with organic contaminants and alter their fate, behaviour, stability and bioavailability (Yang et al., 2019). At the organism level, they are persistent, bioaccumulative, endocrine disrupting and carcinogenic (Kibria, 2010) . On the other hand, DOM, which also makes up a large proportion of leachates, has the capacity to combine with heavy metals and eliminate them, and therefore plays a major role in the bioavailability of these metals in ecosystems (Rikta et al., 2018).

Several studies that have focused on landfill leachate characterization met on the following conventional parameters including pH, ammonia (NH_4+), conductivity, mineral salts, chemical oxygen demand (COD), total organic carbon (TOC), biochemical oxygen demand (BOD), suspended matter and heavy metal concentrations. The ratios of BOD_5/COD and COD/TOC are typical indicators for the biodegradability of organic compounds and the oxidized state of organic carbon. Therefore, the quality of landfill leachate is affected directly by several factors, such as the waste type, landfill age, operational conditions, climate and hydrogeology (Dabaghian et al., 2018).

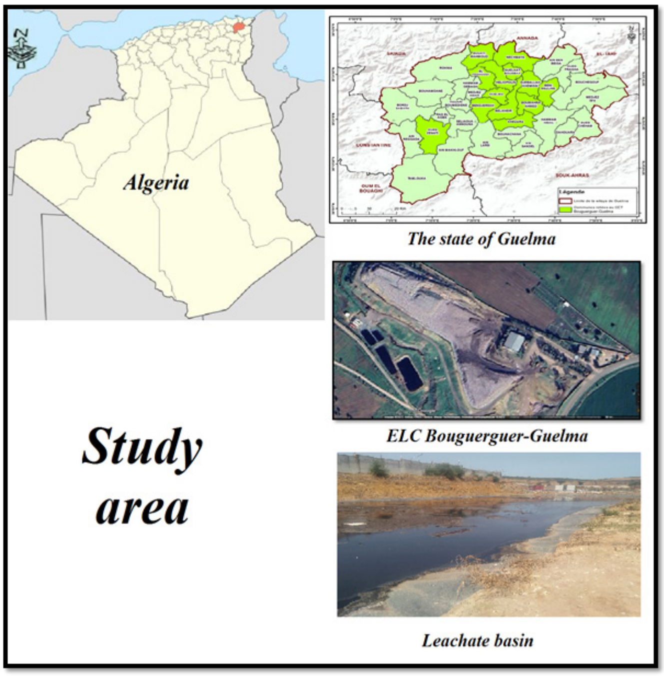
Over the last decade, the contribution of leachates to the pollution and contamination of water bodies and soils in the vicinity of landfill sites has been reported in several locations around the world. In this way, and in view of the issues relating to human and environmental health, the primary objective of the present study is to characterize the leachates from an existing landfill in the northeastern Algerian region of Guelma. The main method used to characterize leachates is to determine the concentrations of the parameters measured in the leachates, and then compare them with the standards adopted in environmental regulations. Indeed, it is almost essential to carry out detailed systematic examinations of the characteristics of leachates, especially in terms of heavy metals and organic pollutants in landfill sites. To this end, the quality of the leachates was monitored over a twelve-month period (January-December 2000), using a monthly sampling frequency (12 samples were taken). It should be noted that the results obtained represent the first characterization carried out at this landfill (ELC, Bouguerguer-Guelma). This study may therefore help local waste management authorities to understand the seriousness of the pollution caused by leachates, and to take appropriate preventive measures against soil, surface water and groundwater contamination.

Materials and Methods

Study Area

The study was carried out in the state of Guelma (Northeast of Algeria) that is one of the largest countries in Africa and the Arab (worldmeter, 2015). Climate is highly variable throughout the country; with predominant of Mediterranean climate, with dry, hot summers and mild, wet winters. For the temperature, there are two main periods: a cool period around 10,3°C (from November to April) and a dry one about 27,2°C (from May to October) while the average rainfall is around 800 mm. Note that, these climatic factors have a crucial function in the process of waste biodegradation.

The city of Guelma is located in the northeast of the country (Figure. 1). It covers a land area of 3686,84 km^2 with a population of 594,079 inhabitants (estimated in 2009) distributed differently throughout 34 municipalities. The engineered landfill center (ELC) of Guelma is located in Bouguerguer (36°29’12.2”N 7°28’19.6”E), around 5 km north-east of the chief town of Guelma (Table.1). Since January 2012, the center has been operating with two cells: one has already been filled and the second almost full (Mesbahi-Salhi et al., 2023).



ELC: Engineering Landfill Center.

Figure 1: Geographical location of the ELC Bouguerguer, Guelma, Algeria.

ELC	Region	State	Municipality	longitude	latitude
Bouguerguer	East	Guelma	Heliopolis	7°47’13,4”W	36°48’67,9”N

Table 1: GPS coordinates of the study area.

Technical characteristics of the ELC, Bouguerguer, Guelma

The engineered landfill center in the wilaya of Guelma was built on a surface area of 12,5 hectares. It includes: two leachate basins and two cells with a capacity of 195 10 3.Indeed, the site is getting full early and its capacity is largely exceeded, and even the practice of successive heightening is reaching its limit, especially, with the coronavirus pandemic, where there has been a remarkable increase in the amount of waste coming in (Mohamed et al., 2021). This has implied the installation of a third cellar to accommodate the growing flow of waste (in construction).

The Sampling Campaign

In order to carry out this study, a monthly sampling campaign was carried out throughout the year 2020 from January to December. At the level of the ELC of Bouguerguer, Guelma. Sampling was carried out using a 500 mL bottle with its end (Rodier et al.,1996). The samples were taken in 1L polyethylene bottles, previously washed with nitric acid and then with distilled water. In the field, before filling the bottles, they were washed with the sample to be taken. The bottles were filled to the brim and then the cap was screwed on to avoid any gas exchange with the atmosphere. The leachate samples were kept in a cooler during transport to the laboratory, which is located 42 km from the study site (+4°C), and were analyzed within 24 hours.

Analysis Methods

The sample was extracted from the basin of leachate. All analytical methods used in this work are listed in (Table.2). The recorded data were analyzed with Microsoft Office Excel 2013. A literature search seems crucial in order to compare the results found with those previously performed, especially as they concern common parameters.

Results

Physico-chemical Characterization

The sampling of these leachates (raw) was committed from the same point of the basin n°1, although the examination of the results of the physico-chemical characterization (Table.2), shows a marked complexity and variation of the leachates studied. This variation not only varies considerably over time (within the site itself) but also in space (from one site to another). The variation depends on several factors such as landfill operation, climatic conditions and mainly the nature of the waste and the age of the landfill (Al Ashoor, 2016).

	Parameters	unit	Average	Standard deviation	Methods
In situ	PH en 25°C		8,85	0,486	NF T 90 - 008
	Conductivity en 20°C	(mS/cm)	31,38	12,965	NF T 90 - 031
	Salinity en 20°C	(g/L)	18,94	8,478	NF T 90 - 031
In vitro	Nitrite (NO_2-)	(mg/L)	17,93	15,282	DIN EN 26777-D10
	Nitrate NO_3-	(mg/l)	18,98	14,233	DIN EN 26777-D10
	Ammonia (NH_4+)	(mg/L)	122,42	194,468	DIN 38406-E5
	COD	(mg O_2/L)	1603,75	1462,754	DIN ISO 15705 :2002
	BOD_5	(mg O_2/L)	778,54	819,049	DIN EN 1899-1-H51
	Suspended matter (SM)	(mg/L)	5397,92	4336,374	Centrifugal method.
	Lead (Pb)	(mg/L)	5,64	4,498	Dithizone method.
	Cadmium (Cd)	(mg/L)	4,37	2,984	Dithizone method.
	Chromium (Cr)	(mg/L)	8,10	4, 605	DIN EN ISO 7393 G4-2
	Zinc (Zn)	(mg/L)	10,44	6,790	APHA 3500-Zn F
	Iron (Fe)	(mg/L)	42,70	36,287	Dithizone method.

Table 2: Results of the physico-chemical characterization of the leachate, ELC Bouguerguer-Guelma.

Content of in situ Parameters

The results of the physico-chemical characterization of the leachate in (Table. 2) show:

pH of the leachate varies between 7,88 and 9,36 with an average of 8,85 (± 0,486), knowing that this value falls within the reference limit between (< 3,7 and 8,9 >).The hydrogen potential (pH) for our site is slightly above alkaline neutrality. Similar results were also found by, Smaoui et al. in Tunisia (Smaoui & Bouzid, 2019).

EC (electrical conductivity), the monthly monitoring of leachate electrical conductivity shows values ranging from 9,49 to 44,5 mS/cm with an annual average of 31,38 (± 12,965) mS/cm. High values were recorded in summer with EC = 42, 2 ; 44, 5 and 43, 9 mS/cm for the months: June, July and August successively. However, it was during the winter season that low conductivities were obtained (9, 49 mS/cm in December and 12, 57 mS/cm in January 2020).

Salinity, The leachate has a high salinity (at 20°) ranging from 5, 12 to 27,7 g/L with an average of 18,94 ±8,478 g/L.

Content of in vitro parameters

Organic content on COD, BOD_5, SM

COD or Chemical Oxygen Demand refers primarily to the amount of oxygen consumed by chemically oxidisable materials in water. COD represents the majority of the organic compounds and oxidisable mineral salts contained in the sample (Kouassi et al., 2014). The recorded values ranged from

675 to 5900 mg/O_2/L. The average content is 1,603 (±1462, 754) mg/O_2/L (Table.2, Figure.2). This content is more than 5 times higher than the reference value which is limited to (COD = 300 mg/O_2/L).

BOD_5 or Biochemical oxygen demand for five days is one of many indicators of organic pollution/water quality. It mainly expresses the level of biodegradability of an effluent (Makhoukh et al., 2011). The results (Table.2, Figure.2) show a BOD_5 varies between 127, 5 and 2840 mg/O_2/L. The average value is approximately 778, 54 mg/O_2/L. This value is more than 7 times higher than the reference value (BOD_5 = 100 mg/O_2/L).

The organic fractions (BOD_5/COD) provide information on the biodegradability of organic particles. This report also provides information on the nature of the biochemical transformations occurring within the landfill and the relative age of the leachate studied (Belle, 2008).

Thus, according to Mohd the BOD_5 / COD ratio (Mohd-Salleh et al., 2020) :

> 0, 5 for young leachates.

< 0, 1 for stabilized leachates.

< 0,1 to 0,5> for intermediate leachates.

COD / BOD_5 content and ratio of leachate

COD =1603,75 (mg O_2/L)

BOD5 =778,54 (mg O_2/L)

$$x = \frac{1603{,}75}{778.54} = 0{,}48$$

In our case, the average of the different BOD_5 / COD ratios gives the value of 0,48 that justifies that the leachates studied are intermediate leachates or of average biodegradability; this means that the organic molecules contained in the leachates have not yet reached the final stage of their breakdown.

SM (suspended matter) the results show high SM (Suspended matter) levels in the leachate ranging from 310 to 14000 mg/L, with an average of 5397,92 mg/L (Table.2, Figure.2). The highest concentrations are marked during the wet season and it related to the low dissolved oxygen concentration.

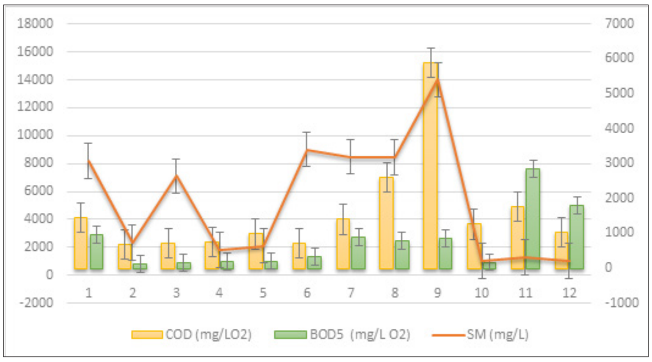


Figure 2: Monthly fluctuation in COD, BOD_5, SM) during 2020.

Heavy metal content (Fr, Zn, Pb, Cd and Cr)

The illustration (Figure.3) shows the monthly fluctuation of the heavy metals in the leachates studied (from the landfill of Bouguerguer-Guelma) namely: Cd, Cr, Zn, Fe and Pd, during the year 2020, and which consequently record the following averages (4,37 ; 8,27 ; 10,44 ; 42,70 and 5,97) mg/l respectively. It varies from 1,3 to 108,4 mg/L. Iron appears to be the most abundant element, with levels ranging from 3,62 to 108,4 mg/L, with an average level of 42,70 (±36,29) mg/L. Zinc (Zn) comes second with records very high values, ranging from 3 to 27,5 mg/L, with an average of 10,44 ±6,8 mg/L. The toxic metals have relatively high levels:

Plumb (Pb) = 5, 64 (±4,498) mg/L.

Cadmium (Cd) = 4, 37 (±2,984) mg/L.

Chromium (Cr) = 8, 10 (±4,605) mg/L.

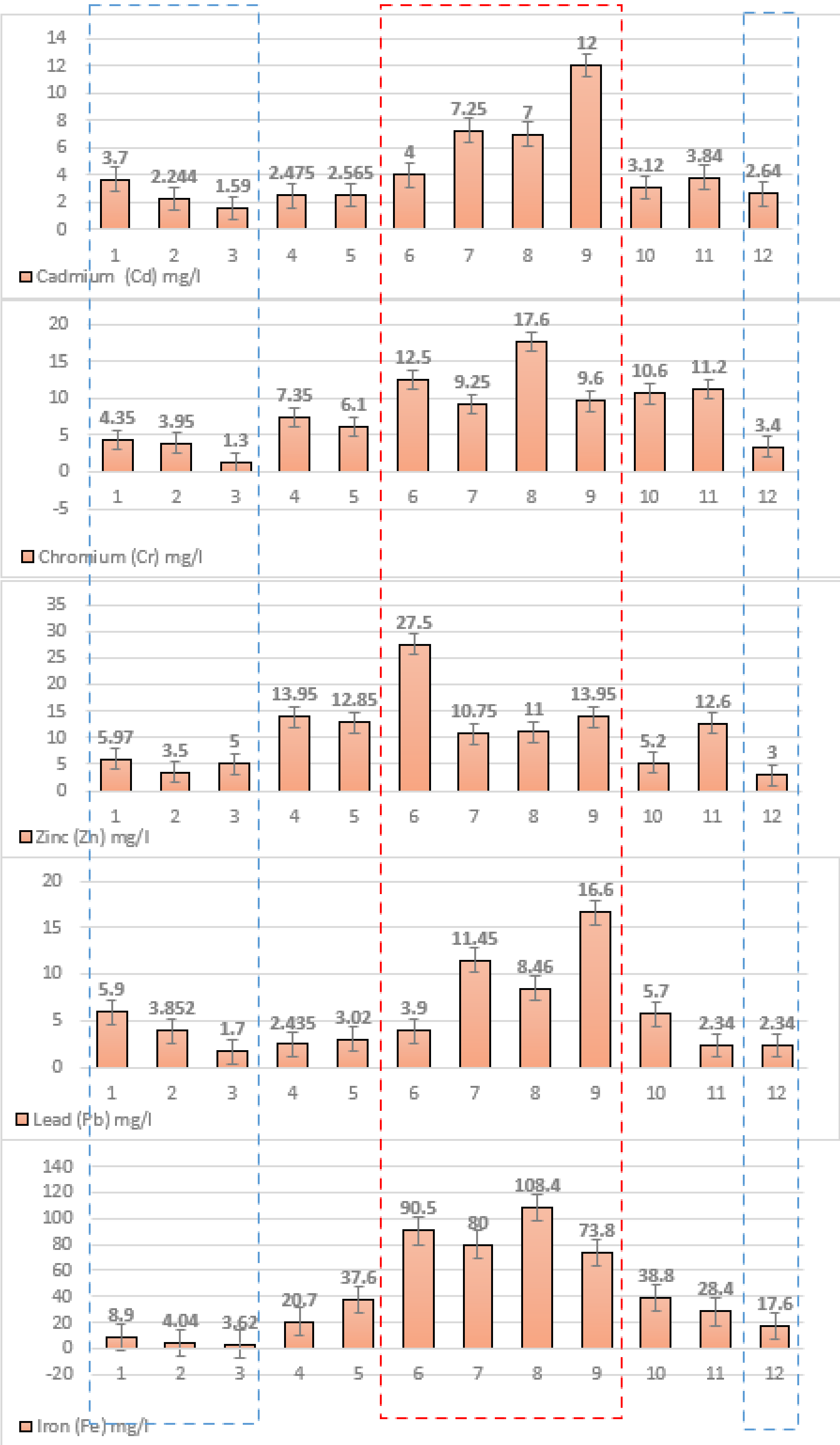


Figure 3: Monthly fluctuation in heavy metals during the year 2020.

Content of NO_2-, NO_3-, NH_4 +

Nitrates (NO_3-) The levels recorded range from 4, 46 to 57,12 mg/L with an average level of 18,98 (± 14,233) mg/L (Table.2, Figure.4). The recorded value is below the maximum concentration allowed by the WHO (1980), which is 50 mg/L. The reference limit values are between 2 and 845 mg/L.

Nitrite (NO_2-) content of the leachate is low and ranges from 5,90 and 55,5 mg/L, with an average of 17,93 (± 15,282) mg/L; these low levels are due to the low values of dissolved oxygen and redox potential in the leachate (Table.2, Figure.4).

Ammonia (NH_4+) is one of the rings of the nitrogen cycle in its primitive state. It is a water-soluble gas (Mejraoua & Zine, 2017).The results show a wide range of values from 7, 2 to 572 mg/L, with a mean value of 122,42 mg/L (Table.2, Figure.4).

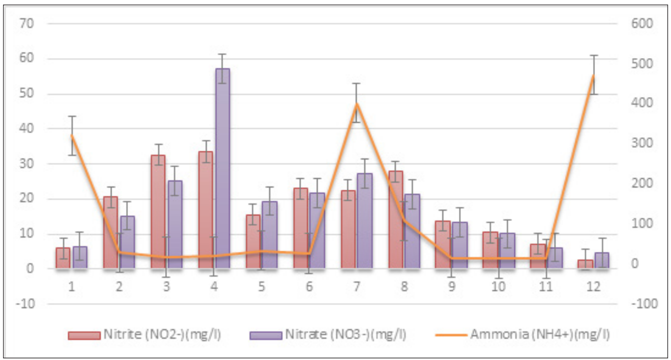


Figure 4: Monthly fluctuation of (NO_2-, NO_3-, NH_4+) during 2020.

The different types of leachate

There are three types of leachate: young leachate from newly commissioned landfills, rich in easily biodegradable organic molecules and volatile fatty acids. Intermediate leachates and stabilized leachates from old landfills that contain an accumulation of complex and non-volatile molecules such as humic and fulvic substances (Sillet et al., 2001). The main physico-chemical characteristics of these different categories of leachate is show in the table (Table.3).

	Young leachate	Intermediate leachate	Stabilised leachate
Age of the landfill	< 5 years	5 à 10 years	> 10 years
PH	< 6,5	6,5 à 7,5	> 7,5
COD (g L^{-1})	> 20	3 à 15	< 2
BOD5/COD (Biodegradability)	> 0,5 Good	0,1 à 0,5 Fairly low	< 0,1 Very low
Volatile Fatty Acids (%)	> 70	5 à 30	< 5
Metals (g L^{-1})	2	<2	<2

Table 3: Classification of leachate (Baig et al., 1999).

According to the illustrated contents (Table.3), characterizing the different types of leachate. In addition, with a BOD_5/COD ratio = 0, 48. Leachate studied can be considered as intermediate leachate; The COD with a maximum of 5900 mg L^{-1}, the concentration is between 3000 and 15000 mg L^{-1}; this confirms our judgment. However, the pH tends towards alkalinity with a value of 8,85 (± 0,486) which characterizes stabilized leachates, Also, the age of the landfill (9 years) and the concentrations of heavy metals analyzed (>2 in most cases) confirm that the leachates of the ELC of Bouguerguer are almost at the beginning of the stabilization phase.

Discussion

Leachate from engineering landfill center (Type II) is a pollutant with high levels of heavy metals, ammoniacal nitrogen (NH_4+), organic load (COD, BOD_5) and suspended matter (SM), as well as phenolic and fulvic substances. The main source of leachate pollution is the composition of household waste: detergents, pesticides, solvents and medicines, as well as rainwater and run-off, etc. This characterization studies fourteen parameters on a monthly basis monitored throughout the year 2020, i.e. 168 results obtained. This observation allowed us to say that the majority of leachate constituents studied present significant concentrations. However, they fall within the range of concentrations found in references (Baig et al., 1999),(E. Grisey, 2013). Through this analysis, a number of salient points characterising the evolution of leachates can be drawn, which are detailed:

Evolution of substances produced by the landfill

Ammonium (NH_4+)

This chemical element is the main long-term reducing agent in landfill leachate and is one of the main pollutants (Christensen et al., 2001). NH_4+ concentrations found in various landfills vary from a few dozen to several thousand (10-13000 mg/l), (Rafizul & Alamgir, 2012). In fact, The behavior of NH_4+ over time varies greatly from one site to another (Ehrig, 1989). In our case, this fluctuation is very marked, and is very heterogeneous, fluctuating between (13, 4 to 472 mg/l), with two prominent peaks, at the height of summer and at the height of winter. However, approximately nine years after the creation of the first leachate source cell, the concentrations of NH_4+ reached the (122, 42 ± 194, 47 mg/l). While one study reported levels of 500 - 1500 mg/l, after a period of up to eight years (Chu et al., 1994). The low levels recorded can therefore be explained by the absence of a final cover over the whole of the first landfill, which favored the percolation of meteoric water into the waste mass (leaching). Leaching increases further if the reservoir is subject to significant annual rainfall, exceeding an average of 1,600 mm/year. However, the authors agree that: the NH_4+ is the main pollutant in leachates, apart from organic matter (Kulikowska & Klimiuk, 2008). Consequently, the arrival of the methanogenic phase is within the first eight years of existence of the landfill. (Robinson & J.R., 1993). Other authors report that it costs ten years of deposit (Ehrig & Scheelhaase, 1993). This diversity depends on the composition of the waste and the operating method used.

Suspended matter (SM)

The highest levels were recorded during the wet season and are linked to the low concentration of dissolved oxygen. Concentrations of SM far exceed those set by the Algerian standard (30 mg/l), executive decree nº 06-141 (AND, 2020). It can be said that the leachates collected are polluted, and this is a feature common to all household waste landfills (Christensen et al., 2001).

The anions NO_2-, NO_3-

NO_3- form the terminal stage of nitrogen oxidation. In addition, they are the most highly oxidized form of nitrogen present in water (Mejraoua & Zine, 2017). Low concentrations of nitrate and nitrite were observed, due to the contribution of ammoniacal nitrogen or NTK. Nitrates form the terminal stage in the oxidation of nitrogen, and represent the highest oxidation state of nitrogen in water. These low levels are due to the low levels of dissolved oxygen in the leachate.

NO_2- comes mainly either from the reduction of nitrate (NO_3-) or from incomplete oxidation of ammonium ions (Rodier et al., 1996). The results therefore mean that nitrogen oxidation has not reached the end of nitrification, and nitrogen degradation is not yet complete. Nitrate then becomes the dominant species driving nitrification due to high infiltration of oxygenated meteoric water (Basberg et al., 1998), favored by the arrival of heavy rainfall on the site.

Heavy metals (Fe, Cr, Zn, Pb and Cd)

The high concentrations of the five heavy metals in the leachates studied mean that they are considerably present in the waste, while only a small fraction of the TMEs (<0,02 to 1%) deposited in the landfill is leached out. (Kjeldsen et al., 2002). From this, we can deduce that the quantity of metals in the waste bins. In our case, leachates from the Bouguerguer-Guelma landfill, the most abundant element is iron, with an average content of 42,70 mg/l, followed by zinc (Zn) with an average content of 10,44 mg/l, chromium (Cr) with 8,27 mg/l, lead (Pb) with 5,97 mg/l and cadmium (Cd) with 4,37 mg/l. With the exception of iron, which is insensitive to alkaline pH levels, and although these concentrations exceed the permitted discharge standards, they remain less stringent than the large quantities of waste that are the source of these metals. What's remarkable is that the summer period has the highest concentrations, and appears to be the most critical It extends from June to September; when the following levels are recorded: Cadmium (Cd), (12,50; 09,25; 17,60 and 09,60) mg/l. Chromium (Cr), (04,00; 07,25; 07,00 and 12,00) mg/l. Zinc (Zn), (27,50; 10,25; 11,00 and 13,95) mg/l. Iron (Fe) with (90,50; 80,00; 108,4 and 73,80) mg/l and Lead (Pd) with the following concentrations: (03,90; 11,45; 08,46 and 16,60) mg/l.

The lowest concentrations are recorded during the winter period, from December to March, when the following levels are recorded respectively: Cadmium (Cd), (02.64; 03.60; 02.24 and 01.59) mg/l. Chromium (Cr),(03.40; 04.35; 03.95 and 01.30) mg/l. Zinc (Zn), (03.00; 05.97; 03.50 and 05.00) mg/l. Iron (Fe) (17.60; 08.90; 04.04 and 03.62) mg/l. Lead (Pd), (02.34; 05.90; 03.85 and 01.70) mg/l. A very significant difference between the two periods was recorded during this characterization, between the periods (summer and winter) two other transitory periods (Figure.3), with intermediate concentrations, of two months each, the first includes the month of April and May, the second almost at the end of the year, the month of October and November.

The existence of these toxic micropollutants is essentially due to their presence in the materials and objects contained in household waste (metal cans, plastics, various electrical accumulators, ceramics, etc.). When deposited in the bins, they slowly dissolve and are released, which are then transported with the precipitation water to form leachates (Chu et al., 2019). Added to this are the phenomena of precipitation and sorption. In addition, the dissolubility of heavy metals is directly affected by the pH of the medium, where it is favored by an acid pH and diminishes with an alkaline pH (Bilgili et al., 2007). However, fluctuations in concentrations over the short term (a few months) are due to the variable infiltration of rainwater (leaching).Several studies carried out on the characterization of leachates have confirmed the presence of certain mineral micropollutants (Mokhtaria et al., 2007), (Toklo et al., 2015), (Sanga et al.,2023).

COD, BOD_5

Over the twelve months monitored, COD values show a range from 675 mg O_2/l to 5900 mg O_2/l, (the peak) in September, with an average concentration of 1603 mg O_2/l. (Table.2, Figure.2). These results reflect a very high organic load. They are comparable to those reported by (Mokhtaria et al., 2007), (Kouassi et al., 2014) in Algeria. Other studies such as : (Toklo et al., 2015), (Ngnikam et al., 2012) record lower levels than ours; this large difference could be, according to (Kouassi et al., 2014) et (Al Ashoor, 2016), the result of several factors: the age of the landfill, the quantity and nature of the waste and its degree of decomposition, and the landfill conditions. Climatic factors such as rainfall, air humidity and temperature also play an important role. In fact, according to (Christensen, 2001), these different factors are the main cause of the variability in pollutant loads. It is important to note that COD decreases between the months of February and June. This decrease occurs during the wet season, and can be attributed to a combination of reduced organic contaminants and increased biodegradation. In order to increase in the summer period on a regular basis, and this is continuing. In addition, a steady decrease in COD is expected as organic matter degrades, and due to this biodegradable nature, the organic compound decreases faster than the inorganic compound (Gherbi, 2022), (Chian & DeWalle, 1976), especially as the age of the landfill increases.

The BOD_5 values obtained during the summer season are the highest, when the flow of biodegradable organic matter leaving the landfill is at its highest. This rise in organic load is associated with an increase in leachate temperature, which coincides with bacterial development and abundance, leading to a rapid decrease in oxygen levels. This co-evolution shows that leachate heating is the cause of an amplification of heterotrophic bacterial activity, which is the source of the increase in COD (Gherbi, 2022).

PH Influence

It is unfeasible to discuss the fluctuation of pollutant concentrations without discussing the pH of the environment, as this plays a key role in determining the distribution of most pollutants. Most leachate pH values are above 7.50 and range up to 9, fluctuating between neutrality and alkalinity over the entire period of monitoring of leachates from the Bouguerguer-Guelma landfill, similar results were also found by : (Smaoui & Bouzid, 2019) in Tunisia. The basin containing these leachates is connected to the former landfill, currently in post-operation phase, to prevent the release of heavy metals sensitive to pH variations (especially when they tend towards alkalinity) (Peng et al., 2021), (Bäverman, 1997). The influence of the pH of the medium is strongly marked by the dissolubility of heavy metals, where they are favored by an acid pH and diminish with an alkaline pH (Begum et al., 2018), (Bilgili et al., 2007). However, fluctuations in concentrations over the short term (a few months) are due to the variable infiltration of rainwater (leaching of varying intensity). Given the heterogeneity of landfill sites, waste degradation rates vary from one site to another, making it difficult to achieve quasi-identical values. However, pH does affect the environment directly, as it affects the decomposers, e.g.: Kalloum report that pH 7 favors the development of methanogenic bacteria (Kalloum et al., 2007).

Temperature Influence

The leachate characterization results presented (Table.2. Figures.2-4) illustrate a significant fluctuation, marked by inter-seasonal variation, with summer remaining the most critical season, showing that climatic factors play a predominant role in this variation. Therefore, as the Bouguerguer-Guelma landfill is an opencast landfill, and therefore sensitive to climatic variations. It would seem that during periods of low flow, bacterial heterotrophic activity conditions and modulates the physico-chemical landfill juice produced is highly charged with biodegradable organic matter, suggesting that intensification of bacterial activity plays a major role in obtaining such high leachate quality (Thonart et al., 2007). In winter, the leachate contains less organic matter due to the combined effect of increased precipitation and lower temperatures, which inhibit the development of decomposers. (Grisey et al., 2001). This decrease in COD therefore occurs during the wet period of the zone, and can be attributed to the combination of a reduction in organic contaminants and their increased biodegradation (Samiha, 2021),(Gabarró et al., 2012). In summer, concentrations increase steadily. It should be noted that several studies carried out on other landfills have shown the association between the increase in bacterial remineralizing activity following an increase in leachate temperature, in particular , (Khattabi et al., 2007), (Kim et al., 2006), (Howard et al., 1983).

Conclusion

The characterization of leachate and the examination of its components is an important tool in the planning and implementation of waste management strategies (Ajo et al., 2021). Follow this path and, in order to measure the pollutant load contained in the leachate and before modelling the impact of this leachate, a physico-chemical characterization of its composition would be necessary in order to examine the degree of pollution of the leachate of the landfill in question. Marked seasonal (month-to-month) changes in the levels of the components studied were observed throughout the sampling period (the year 2020 from January to December). Indeed, the results of characterization obtained showed that the leachates of the ELC Bouguerguer Guelma are highly loaded with pollutants, where all the average contents obtained largely exceed the norm. The high BOD_5 and COD values of 778,54 and 1603,75 mg/L respectively indicate significant organic pollution. As for mineral pollution, it is also present with NO_2-, NO_3- and NH_4+ contents that exceed the norm, and record respectively (17,93 ; 15,68 and 122,42 mg/L) and a high conductivity reaching 31,38 mS/cm. All the heavy metals analyzed (Cd, Pb, Fe, Cr and Zn) recorded very high levels that exceeded the Algerian standard. Our results confirm that the leachates in evidence have a polluted character. According to our annual monitoring results, heavy metal pollution increases in the dry season and decreases in the rainy season. Overall, our study highlights a major environmental problem and the basic data obtained could be used in future research to monitor the pollution generated or even to develop the current management system. While waiting for the leachate treatment plant (with the reverse osmosis technique) installed in the ELC Bouguerguer since 2019, to be put in operation, the leachates produced are polluting and remain a cause of environmental and scientific stress too.

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