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Research Article

A Study of the Impact of Municipal Solid Waste on Some Soil Physicochemical Properties: The Case of the Landfill of Ain-El-Hammam Municipality, Algeria

Saïda Mouhoun-Chouaki,[1] Arezki Derridj,[1] Djaber Tazdaït,[2] and Rym Salah-Tazdaït[2]

[1]*Laboratoire de Production, Protection et Amélioration des Végétaux, Mouloud Mammeri University of Tizi-Ouzou, P.O. Box 17 RP 15000 Hasnaoua, Tizi-Ouzou, Algeria*
[2]*Department of Biochemistry and Microbiology, Mouloud Mammeri University of Tizi-Ouzou, P.O. Box 17 RP 15000 Hasnaoua, Tizi-Ouzou, Algeria*

Correspondence should be addressed to Rym Salah-Tazdaït; rym.tazdait@ummto.dz

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Discharging of untreated municipal solid wastes (MSWs) onto land is very widespread in developing countries. The compounds contained in MSW cause a harmful effect to human and environment. Hence, an assessment of the extent of their local impact is of great interest to figure out the pollution they cause. Therefore, this study aimed at evaluating the effects of discharge of solid wastes on soil quality within the landfill of Ain-El-Hammam municipality (Algeria). To achieve this, different soil physicochemical parameters were considered: granulometry, electrical conductivity, pH, organic matter content, and heavy metal concentration. The results indicated the influence of the MSW on the physicochemical characteristics of the soil by enhancing the organic matter content of soil (4.53%) and increasing heavy metal content (Cu, Zn, Cd, Pb, Ni, and Cr), which is a clear indication of the level of pollution they are generating.

1. Introduction

The municipal solid wastes (MSWs) are undesirable materials mainly consisting of household wastes and so are called household garbage. They also include similar waste to MSW which refers to wastes of the industrial companies, crafts, trades, hotels, schools, public services, and hospitals and municipal services such as road wastes, parks and gardens' maintenance, and other recreational areas that present physicochemical features or equivalent to toxicity of household garbage [1].

The exponential growth of the world population, the urbanization, the socioeconomic development, and the improvement of living standards have trained phenomenal augmentation of the municipal solid wastes' production in the whole world [2]. Their quantity has increased over the years in the developing countries, and their management faces many difficulties from the technical and economical sides as from the methodological and organizational sides. Facing this reality, open landfills (dumps) have become the only available way for their elimination [3].

The landfill is still worldwide and very common. It has been the principal method of the municipal solid wastes' elimination in the recent decades because it is the simplest practice and the most economical of this type of wastes' storage in a lot of countries, particularly in the developing countries [4].

Unfortunately, these open landfills cause serious sanitary risks by the lodging of different stray animals and the proliferation of insect vectors of a lot of diseases. They also present nuisance and considerable environmental impacts by the production of both leachate and biogas [5].

The leachate conveys an important pollution load essentially formed of heavy metals, organic matter, and important community of pathogenic bacteria: by leaching and infiltration through the ground, it begets an organic, bacteriological, and heavy metal pollution of soils, surface water, and ground water (phreatic zone) [6].

The organic fraction's biodegradation of MSW begets biogas emissions which cause the atmospheric pollution by contributing to the greenhouse effect and global warming, particularly the methane and hydrogen that are highly flammable, and if they are not collected and valorised in a renewable energy form, they will be led to a potential risk of fire or explosion [7].

Algeria has adopted the law no 01–19 from December 12th, 2001, on management, on control, and on the wastes' elimination and put in place a national program of the municipal wastes' management whose objectives are inter alia, landfills eradication, and the application of the technical burying that remains the most privileged method because of the absence of the incineration and the composting processes [8].

Despite the construction of many different technical burying centres since 2002, it still exists in Algeria multitudes of functional landfills implanted anywhere, without any impact study and their effects on the ground are not very well-known.

Consequently, in this study, the landfill's ground of the municipality of Ain-El-Hammam has been chosen as a model to evaluate the municipal solid wastes' impact on certain physicochemical properties of the landfill's ground.

2. Materials and Methods

2.1. Area of the Study Site. The study was conducted in the municipality of Ain-El-Hammam (A.E.H.), in Kabylia, Algeria. The municipality is located 45 km southeast of the capital city of Tizi-Ouzou province and 150 km east of the Algerian capital city (Algiers). In 2008, A.E.H. had 20401 inhabitants and covered a total area of 38.55 square kilometres.

The site is the municipal landfill of A.E.H. (N 36°36′03.7″, E 4°16′28.2″). The site resulted from the administrative apportionment of 1985, and it is located in Ait-Sidi-Ahmed village, which is 7 km distant from the capital city of A.E.H. and covers a total area of about 8 ha, which increases constantly due to the regular input of waste.

2.2. Climatic Characteristic Determination of A.E.H.

2.2.1. Ombrothermic Diagram of Bagnouls and Gaussen. Ombrothermic diagram of Bagnouls and Gaussen was used to describe the length and the intensity of the dry season by determining the intersection (grey area) of the average rainfall (R) and temperature (T) curves [9]. This diagram outlines that a month is considered biologically dry when its total rainfall is less than or equal to two times its average temperature ($R \leq 2T$) [10].

2.2.2. Emberger's Pluviothermic Quotient. Emberger's pluviothermic quotient (Φ) (equation (1)) is specific to the Mediterranean climate and is usually the most used in the north of Africa [11]. This quotient was developed for Morrocan vegetation and resulted in identifying different bioclimatic stages [12]:

$$\Phi = \frac{1000 \times R}{((T + t) \times (T - t))/2}, \quad (1)$$

where R is the total annual rainfall (mm), T is the mean maximum temperature of the warmest month in Kelvin degrees, and t is the mean minimum temperature of the coldest month in Kelvin degrees.

2.3. Sampling of Municipal Solid Waste. The estimation of the physical composition of the municipal solid waste under study was carried out using the method proposed by the Direction of Environment of the province of Tizi-Ouzou. The principle of the method is to make 100 kg of waste samples at the time of discharging by introducing the samples into black garbage bags and weighing them using a roman balance. The samples were then manually sorted, and each component was identified, separated, and weighted.

2.4. Landfill Soil Sampling. Sampling is the most critical step in the collection of the spacial distribution data of soil properties [9]. In this study, the random-stratified sampling method was applied because the landfill soil is rough, which generates a variability in the deposition of waste along the landfill. In this type of sampling, samples are collected in random-chosen places in a homogenous area [13]. To achieve this, the landfill area under study was subdivided into homogenous strata according to an altitudinal gradient of 100 m. In brief, the upper 5 cm soil surface layer containing debris was removed, and three random samples of the soil from each stratum were then taken from 25 cm below the ground surface (Figure 1). The samples were put into plastic bags, labelled, and transported to the laboratory where they were dried at room temperature, cleared of debris, and sifted through a 2 mm mesh screen.

2.5. Physicochemical Analysis of the Landfill Soil

2.5.1. Granulometric Analysis. The granulometric analysis aimed at pinning down the mineral composition of soil (clay, silt, and sand). The analysis was carried out on soil samples with a particle size less than 2 mm according to the international method using Robinson's pipette [14]. In brief, organic matter was destroyed by oxidation with hydrogen peroxide (6% (w/v)) and dispersed. Clays and fine silts were withdrawn, and the sand fraction was recovered after successive washing. The proportion of each granulometric component was then calculated. Besides, the soil texture was determined using the classical textural triangle.

2.5.2. Electrical Conductivity and pH Measurement. The electrical conductivity (EC) (expressed in $\mu S \cdot cm^{-1}$) of the soil was monitored according to Mathieu and Pieltain [15] using a conductivity meter (Inolab®, Germany) and a ratio of 1 : 5 (w/v).

The pH of a 1 : 2.5 fine soil to water solution was estimated using a calibrated pH meter (Inolab®, Germany).

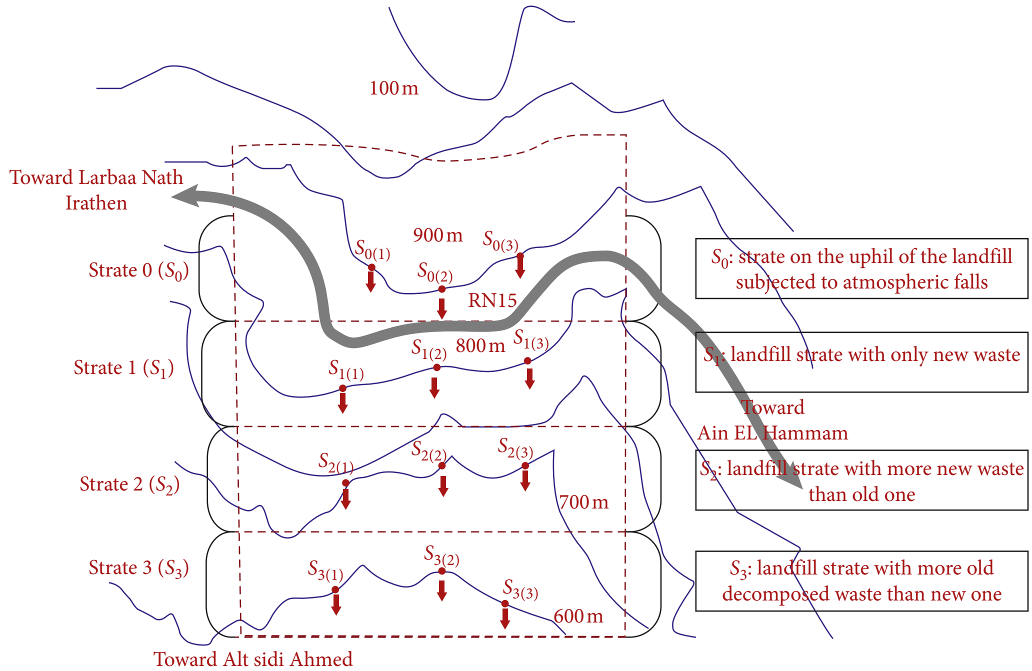

Figure 1: Random stratified sampling in the A.E.H. landfill soil (scale: 1/1000).

2.5.3. Total Limestone Determination. The total limestone was determined by the volumetric method, which measures the amount of soil calcium carbonates ($CaCO_3$) after chlorhydric acid (HCl) attack.

The excess chlorhydric acid was titrated with sodium hydroxide (NaOH) solution in the presence of phenolphtaleine until purplish red colour appeared.

2.5.4. Organic Carbon and Organic Matter Determination. Organic carbon (C) determination was carried out by chromic acid oxidation [16]. In brief, the soil sample was oxidized by potassium bichromate solution in the concentrated sulfuric medium. The excess potassium bichromate was titrated with Mohr's salt solution.

The percent organic matter (M_0) was deduced from the percentage of organic carbon using a specific M_0 to C factor.

2.5.5. Heavy Metal Determination. Determination of heavy metals in soil was carried out by the atomic absorption spectrometry flame (AASF) method. The AASF instrument used was ZEEnit 700 (Analytik Jena, Germany). The procedure followed was that of the Research and Development Centre of Sonatrach (Algeria). Before being analysed, the soil sample was subjected to the following heavy metals extraction procedure: the dried soil sample was ground and then sifted through a 250 μm mesh screen. One gram $\pm$ 0.5 mg of the sifted soil was introduced into the 50 mL Teflon bomb to which chlorhydric acid (7.5 mL), nitric acid (2.5 mL), and fluorhydric acid (6 mL) were added. The bomb was sealed and was left to rest all night at room temperature. The bomb was then introduced into a heat block (Equilabo®, France), heated for 10 min at 250°C and at 180°C for 2 h, and allowed to cool at room temperature. The solution was then transferred into a polyethylene tube, and the final volume was adjusted to 250 mL with deionized water. On the contrary, the control experiment (blank) was performed under the same conditions but without soil sample addition. The levels of six heavy metals (expressed as μg per g of the sample) were measured using the following wavelengths: Cu, 324.7 nm; Zn, 213.9 nm; Cd, 228.8 nm; Pb, 217.0 nm; Ni, 232.0 nm; and Cr, 357.9 nm. Calibration curves for the six heavy metals tested were constructed using standard solutions of 1000 ppm of each element (HORIBA Jobin Yvon®, France).

2.6. Data Analysis. The significance of the difference between the soil physicochemical variables and the different strata of A.E.H. landfill was checked by analysis of variance (ANOVA) with one factor (stratum in the case of this study) using StatBox 6.4 software (STATBOX, France). The null hypothesis (H_0) assumes no relationship between the physicochemical variables under study and the landfill strata, while the alternative hypothesis (H_1) states the opposite. The two hypotheses were tested at the 0.05 level of significance.

3. Results and Discussion

3.1. Climate Study Results. The Bagnouls and Gaussen's ombrothermic diagram for the 1998 to 2007 period (Figure 2) clearly indicated that the A.E.H. region is characterized by a dry summer period of nearly three months, which started from the early of the last week of June through the end of September, while the rest of the year corresponds with a wet period, which spreads out over almost nine months.

According to the Emberger's climagram of A.E.H. shown in Figure 3, the Emberger's pluviothermic quotient (Φ) value

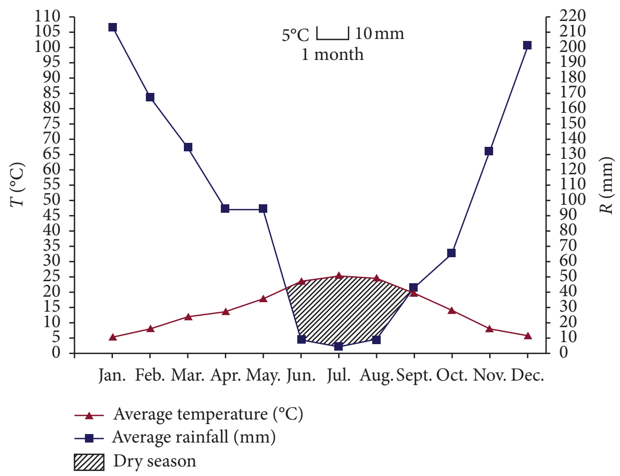

Figure 2: Ombrothermic diagram of Bagnouls and Gaussen of A.E.H. between 1998 and 2007.

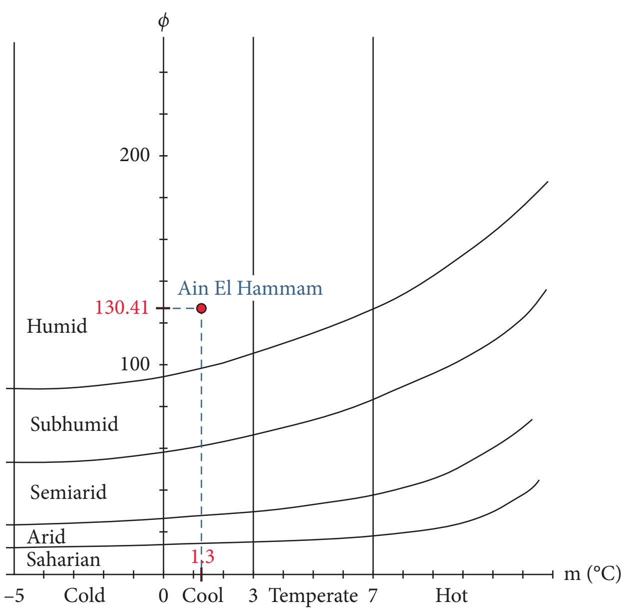

Figure 3: Emberger's climagram of the study area (A.E.H.).

(130.41), the average of minimum temperatures of the coldest month value (m) (1.3°C), and the municipality of A.E.H. can be classified in the humid bioclimatic stage with fresh variant.

3.2. Physical Composition of Household and Equivalent Waste in A.E.H. Municipality. The results of the manual sorting of the household and equivalent waste collected at the landfill of A.E.H. are presented in Figure 4.

It should be noted that organic matters are predominant in the collected waste with an average percentage of around 69.39%. This could be explained by the way of life and food habits of the Algerian population that privileges the consumption of vegetables and fruits. High rates of textiles

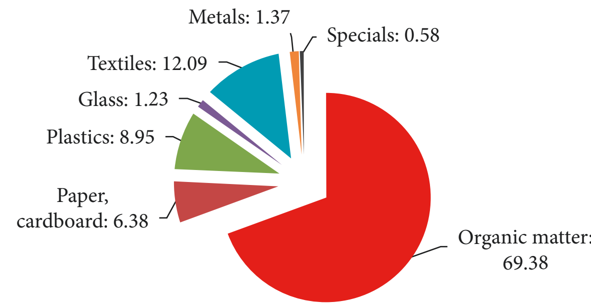

Figure 4: Average physical composition of household and equivalent solid waste in A.E.H. municipality (2010-2011).

(12.09%) could be explained by the increase in textile wet weight in humid cool climate in Ain-El-Hammam.

The percentages of paper and carton, on the one hand, and plastics, on the other hand, neared 6.38% and 8.95%, respectively, which mostly consisted of various packages generated by households, shops, and craft industries.

Specials wastes showed very low percentage (0.58) probably due to the small amounts of dangerous products used by households in Ain-El-Hammam.

Table 1 gives a comparison between the physical characterization data on the household and equivalent waste collected by this study and other data collected from other landfills of some countries of different continents.

The results from the Table 1 revealed that the percentage of organic matters collected from the four African countries selected exceeded 60% and reached in this study almost 70%, while the values observed for the Asian countries did not exceed 52%. This latter value is the maximum and was obtained in Akaider landfill (Jordan), while the minimum value (43.5%) corresponded to the Iskandar landfill site in Malaysia.

The landfills in the three North American countries (Canada, USA, and Mexico) and in Australia exhibited the lowest percent organic matter values, namely, 30% (Canada), 18.6% (USA), 30.2% (Mexico), and 25% (Australia), while those in South American countries showed clear fluctuations between them ranging from 34% (Argentina) to 75% (Caribbean).

Besides, the percentages values of the recyclable waste (paper, cardboard, plastics, glass, textiles, and metals) fluctuated very sharply in the range of 0.3% to 32% in all the countries of the six continents under comparison. Paper and cardboard contents were found to be the highest in the landfills in North America (32% in USA), Europe (15% in Spain), and Australia (9.4% in Sydney), while plastic waste exhibited the highest percentages with 16%, 20%, and 22.2% recorded in South America (Brazil), Africa (Nigeria), and Asia (Malaysia), respectively.

On the contrary, as shown in the same table, the special waste contents are not available for some countries such as Argentina, Spain, or China, but they are very low or even nil for some others, with a value of 0.6% in this study, and a maximum value of 0.7% was reported in Nepal.

These findings could undoubtedly be explained by the differences between the countries of the six continents under comparison in terms of their culture, civilization, feeding

Table 1: Comparison of the physical composition values of the household and equivalent waste collected from some countries of different continents.

Countries (landfills)		Waste type							
		Organic matter	Paper and cardboard	Plastics	Glass	Textiles	Metals	Specials*	References
Africa	Algeria (A.E.H.)	69.4	6.4	9.0	1.2	12.1	1.4	0.6	Present study
	Morocco (Marrakech)	70.0	14.3	7.1	1.5	4.8	1.0	—	[17]
	Nigeria (Amassoma)	61.3	5.4	20.0	—	4.9	—	—	[18]
	Tanzania (Kinondoni)	64.6	10.7	9.7	1.4	—	1.4	—	[19]
Asia	Jordan (Akaider)	52.0	13.0	17.0	3.0	—	1.0	0.5	[20]
	Malaysia (Iskandar)	43.5	20.9	22.2	3.5	7.7	1.5	—	[21]
	Nepal (Tulsipur)	46.0	6.0	10.0	7.0	1.0	2.2	0.7	[22]
	China (Beijing)	46.6	11.1	12.7	1.6	2.5	0.3	—	[23]
Europe	Spain (Castellón)	57.0	15.0	10.0	7.0	4.0	4.0	—	[24]
	Portugal (Porto)	44.3	7.4	11.0	4.3	5.7	2.2	0.1	[25]
	Lithuania (Kaunas)	61.2	4.7	8.8	13.5	1.7	—	—	[26]
North America	Canada (Ontario)	30.0	32.0	10.0	6.0	—	3.0	—	[27]
	USA (Illinois)	18.6	21.5	11.0	4.4	5.8	4.4	0.0	[28]
	Mexico (Ensenada)	30.2	10.4	15.3	—	8.9	—	—	[29]
South America	Argentina (Buenos Aires)	34.0	10.0	12.0	1.0	—	2.0	—	[30]
	Brazil (Belo Horizonte)	52.0	10.0	16.0	—	2.0	2.0	—	[31]
	Caribbean (Haiti)	75.0	5.0	7.0	2.0	—	3.0	—	[32]
	Australia (Sydney)	25.0	9.4	6.8	0.6	4.1	5.5	—	[33]

*Paints, batteries, thermometers, neon tubes, bulbs, dyes, phytosanitary products, expired drugs, and radiographic foils.

habits, mode of life, socioeconomic level, and demographic effectives and demographic levels.

3.3. Results of Physicochemical Analysis of the Landfill Soil

3.3.1. Granulometric Analysis. The results of the granulometric analysis are indicated in Table 2, in which information on the soil texture was inherent to each stratum, whose depth of 25 cm was deduced using the soil texture triangle reported by Mathieu and Pieltain [17].

The data obtained clearly indicated that all the analysed soil samples showed a very high percentage of clay exceeding 40%. The lowest clay percentage (43.28%) was recorded in stratum 3, while the highest value was obtained for stratum 0 with 69.44%. This high level of clay could be explained by the nature of A.E.H. parent rock, which is basically slaty-micaceous with several meters thick (P.D.A.U., 2005). It should be noted that slaty-micaceous are mainly derived from areas with clay-rich sedimentary rocks [18]. Besides, the percentages of clay (58.71%, 48.03%, and 43.28%) and silt (14.87%, 6.21%, and 4.33%) in strata 1, 2, and 3, respectively, are lower than those observed in stratum 0 (69.44% and 28.03% for clay and silt, respectively). This could be due to soil washing by the rainfall of the area under study, which is characterized by a humid climate with fresh variant (Emberger's climagram) and almost 9 months wet period (Bagnouls and Gaussen's ombrothermic diagram). Indeed, in humid climate areas, the rainfall dissolves some of the soil mineral components, induces chemical reactions, washes the soil, makes its upper part impoverished in certain compounds, and drives the fine particles towards the lower strata [19]. Besides, the uneven slope of the landfill land could contribute to the increase of this phenomenon.

Table 2: Granulometric analysis of the landfill soil of A.E.H.

Strata*	Granulometry			Textures
	% clay	% silt	% sand	
Stratum 0	69.44 ± 0.30	28.02 ± 0.17	2.55 ± 0.07	Clayey
Stratum 1	58.71 ± 0.28	14.87 ± 0.06	26.41 ± 0.32	Clayey
Stratum 2	48.03 ± 0.50	6.21 ± 0.23	45.76 ± 0.69	Clayey-sandy
Stratum 3	43.28 ± 0.16	4.33 ± 0.02	52.39 ± 0.18	Clayey-sandy

*The depth of each stratum is 25 cm.

3.4. Physicochemical Analysis of the Landfill Soil. Table 3 depicts the results of the physicochemical analysis of the landfill soil of A.E.H.

The obtained pH values for each stratum were compared to those of the soil assessment standards according to Baize [14].

On the basis of this comparison, it is shown that the pH of the four strata is neutral ranging between 6.95 and 7.4. The lowest pH value (6.95) was observed in the stratum (S_3) which is rich in MSW as indicated in Figure 1.

On the contrary, the results of Tables 2 and 3 clearly indicated that the analysed strata are rich in clay and organic matter. Similar results were reported by Oluyemi et al. [42] who found high organic matter content in Nigerian landfill soil, which was also characterized by a neutral pH and clayey texture.

With respect to soil EC measurements, the latter were compared to the standard soil salinity [14].

The EC values recorded for the four strata under study were all less than $4\,\mu S{\cdot}cm^{-1}$ indicating their nonsaline character, which is confirmed by their pH values (neutral) and their climate characteristic (humid), since saline soils are mainly encountered under arid or semiarid climates [43]. The highest

Table 3: Physicochemical analysis of the landfill soil of A.E.H. compared with previous studies.

Study site (Landfill)	Strata	pH	EC (μS·cm^{-1})	Total limestone (%)	Organic matter (%)	Heavy metals (mg·kg^{-1})						Reference
						Cd	Pb	Ni	Zn	Cr	Cu	
Algeria (Ain-El-Hammam)	0	7.4	2.0	4.8	1.7	0.5	7.3	20.0	43.0	76.0	18.8	Current study
	1	7.3	2.1	4.7	1.6	1.2	55.5	40.7	88.8	94.2	76.3	
	2	7.2	2.3	4.6	3.4	1.5	58.4	41.6	91.0	96.6	78.7	
	3	7.0	2.8	4.4	4.5	1.6	60.4	42.2	92.8	98.9	80.1	
Czech Republic (Pilsen)	—	—	—	—	—	0.2	5.4	44.1	42.0	86.7	51.2	[34]
Ghana (Accra)	—	—	—	—	—	0.9	59.2	5.1	297.1	17.9	27.0	[35]
Tunisia (Tunis)	—	—	—	—	—	1.1	55.2	28.6	92.1	32.4	48.2	[36]
Italy (Malagrotta)	—	—	—	—	—	0.1	53.6	10.3	25.6	16.8	6.3	[37]
Poland (Lubna)	—	—	—	—	—	0.3	21.0	2.1	11.0	4.5	2.7	[38]
Spain (Getafe-Madrid)	—	—	—	—	—	—	16.9	6.4	73.9	1.5	13.5	[39]
Morocco (Ahfir-Saidia)	—	—	—	—	—	—	61.8	47.2	68.1	51.5	—	[40]
Nigeria (Port Harcourt)	—	—	—	—	—	1.3	12.4	—	84.2	—	46.2	[41]

EC value (2.84 μS·cm^{-1}) recorded in the lowest stratum (S_3) of the landfill could be explained by the input of various salts and minerals by the MSW and by organic matter decomposition that occurs in this waste [19].

The measurements of total limestone were compared to the limestone standard values reported by Baize [14].

The average limestone contents recorded for the soils of the four strata were less than 5%, which is indicative of their light calcareous character. This could also explain their neutral character. According to Ghorbel-Abid and Trabelsi-Ayadi [23], the more the soil is calcareous, the more it is alkaline. Besides, the humid climate of the region under study favours the soluble salts washed by percolation of rainwaters.

The clay percentage of 40% observed in the landfill soil under study implies that the limestone content is low because based on the threshold of 40%, the clay content is inversely related to limestone content.

With respect to organic matters (OM) measurements, the latter were used to designate the landfill soil according to the standards reported by Soltner [24].

According to these standards, the OM contents observed in S_0 (on the upside of the landfill) and S_1 (1.73 and 1.60%, respectively) are low. This could be due to the accented slope of S_0 strata (Figure 1), which seems to favour the flow of waste towards the bottom of the landfill under the effect of gravity. In Algeria, with the exception of forest soils, the OM contents in the northern soils of the country do not exceed 2%, while these contents are often less than 0.1% in Saharan soils [25].

Besides, the OM contents recorded for the lowest strata of the landfill (S_2 and S_3, 3.36 and 4.53%, respectively) exceed the threshold value of 2%. These high contents could be explained by the accumulation of the MSW, which is a source of big amounts of organic matters (69.38%) (Figure 4) resulting from the decomposition process and the composting of organic waste (animals and plants) [22].

Regarding heavy metal measurements in the landfill soil, the contents of the six heavy metals under consideration (Cd, Pb, Ni, Zn, Cr, and Cu) are less than the limit contents established by AFNOR NFU 44-041, which are 2, 100, 50, 300, 150, and 100 mg·kg^{-1} dry soil, for Cd, Pb, Ni, Zn, Cr, and Cu, respectively. However, this observation indicates that our landfill is considerably contaminated with heavy metals, which have measurable concentrations near recommended cut-off values.

Others published studies have reported the same observation in some other soils (Table 3). However, there is a great discrepancy in heavy metal concentrations found in the landfills of the different countries under comparison, which could be due to the differences in spatiotemporal characteristics between these landfills and in quantitative characteristics between the solid wastes they contain. For comparison, Cu was the highest (80.1 mg·kg^{-1}) among all metals in Algeria (current study), while Zn was the highest in Ghana, Tunisia, Spain, Morocco, and Nigeria, with 297.1, 92.1, 73.9, 68.1, and 84.2 mg·kg^{-1}, respectively, and the highest level of metals in Czech Republic was shown by Cr (86.7 mg·kg^{-1}). The highest metal concentration found in Italy and Poland was Pb (53.6 mg·kg^{-1} and 21 mg·kg^{-1}, respectively).

On the contrary, the estimated levels of all metals were found significantly different from stratum to stratum ($p < 0.05$), and the order was as follows: $S_0 < S_1 < S_2 < S_3$. This is due to household waste heap in the lower part of the landfill (S_2 and S_3). Indeed, the main sources of heavy metals in household waste are hazardous materials such as batteries, paints, and inks. [15]; however, the concentrations of heavy metals are lower in household waste than in industrial waste [44]. Also, the uneven slope and the wet climate of our landfill promote drainage and leaching of heavy metals by rainwater explaining the lower percentages.

The presence of heavy metals in stratum S_0 is due to its location, overlooking the National Road Number 15 (NR15), i.e., in front of the landfill. This exposes the stratum to atmospheric falls attributed to open-air burning of waste.

Quaghebeur et al. [45] reported that most heavy metals present in soils polluted by household waste can be eliminated by runoff, drain out, and infiltration.

4. Conclusion

For the present study, an attempt has been made in assessing the impact of Municipal Solid Waste (MSW) on some physicochemical properties of Ain-El-Hammam municipality landfill soil taken as a model. The results revealed that the pollution brought by the MSW caused significant changes in some of the physicochemical characteristics of the soil under study. Also, the rough slope as well as the humid climate of our station favours the drainage and the leaching of heavy metals by rainwater which explains their low percentage. They have entrained a high content in the ground's organic material (4.35%) and a content augmentation in heavy metals (Cu, Zn, Cd, Pb, Ni, and Cr) that represent quantifiable and considerable quantities close to threshold values recommended by showing a significant growth following this gradient: ($S_0 < S_1 < S_2 < S_3$) but not reaching the pollution threshold fixed by the standards AFNOR NFU 44-041. The findings obtained in this study should draw the attention of public officials on the necessity of keeping watch over wastes input, which will probably increase in the future due to growing population, and to start treating and recycling the wastes instead of discharging them into the environment.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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