DOI: 10.24996/ijs.2025.66.9.25

ISSN: 0067-2904

Distribution of Heavy metals, Polycyclic aromatic hydrocarbons, Micro-plastics particles, and their potential contamination of soil in a selected area in Baghdad City, Iraq

Ola Riyadh Abbas[1], Kamal B. Al-Paruany[2], Maysoon Hassan Mashjel[1]
[1]Department of Biology, College of Science for Women, University of Baghdad, Baghdad, Iraq.
[2]Environment, water and renewable Energy Center, Scientific Research Commission, Baghdad, Iraq.

Received: 8/7/2024 Accepted: 18/9/2024 Published: 30/9/2025

Abstract
In this study, the heavy metals, polycyclic aromatic hydrocarbons (PAHs), micro-plastics (MPs), and their potential soil contamination in a specific area in Baghdad City, Iraq were studied. During February and June 2024, soil samples were collected from six locations (Agricultural, plastic factory, Oil factory soil, Barren soil, residential, and Landfill soil) within Baghdad City. The total concentration of heavy metals of Pb, Cu, Zn, Mn,, Cd, and Fe in the soil samples ranges between 3.27and 26.4, 12.9 and 33.6, 24.7 and 114, 319 and 715, 0.37 and 2.19 and 603 and5142 mgkg^{-1} in the dry period, while it ranges between 3.07and 24.7, 12.10 and 31.51, 23.17 and 106.9, 299.2 and 690, 0.35and2.05 and565 and 4822 mgkg^{-1} in the wet period, respectively. The landfill soil (S6) recorded the highest values of heavy metals, which suggested that the storage of all the material caused the Accumulation of heavy metals, while the lowest average values were recorded by S5. On the other hand, the concentration of ΣPAH (S1,S2,S4 and S5) ranged from 0.2 to 0.8 mg/kg and from 0.21-0.82 mg/kg in dry and wet periods, respectively, While the Σ16PAHs in surface soil samples in S3 and S6 were more than the heavy pollution threshold (1.0 mg/kg) in both periods. It showed that a significant amount of PAHs were accumulated in the surface soils of this industrial complex. Oil Factory soil was significantly higher for all compounds, followed by landfill sites. The MPs mass varied between 2 to 20 particles kg^{-1} in the six samples, and the total average of MPs concentration of the sampling sites ranged from 28 to 60 particles per kg in the dry period. while The MPs mass varied between 2 to 19 particles kg^{-1} in the six samples, and the total average of MPs concentration of the sampling sites ranged from 39 to 62 particles per kg in the wet period. The results found that the selected site is polluted with MPs from high to low and the concentration of MPs in the wet period is higher than in the dry period, which may be related to low levels of human and industrial activities and the effect of Climate. The Contamination Factor (CF) values of heavy metals in the study area for two periods (dry and wet) were calculated, The results show that all site samples of the study area for two periods had low contamination in elements of pb, Cu, Mn, and Fe except S6 were medium contamination in Pb and Zn. While all the site samples had very high contamination in an element of Cd. Other indexes (Ecological risk index) were studied in the results of soil samples of the studied area (S1,S2,S3,S4,S5 and S6), showing that the elements Pb, Cu, Zn, and Mn, have low ecological risks Possible

*Email: Kamalalparuany@yahoo.com

and falls within the environmental risk level (40> Er). At the same time, Cd was recorded in all sites of the studied area a risk Potentially environmental and falls within the environmental risk level 329>Er≤ 160. Finally, The MPs, PAHs and heavy metals especially cadmium levels in some soils of Baghdad were contaminated. This information will help manage and restore the Iraqi soils to lessen potential contamination by using new techniques of treatment.

Keyword: Micro-plastic, PAHs. Heavy metals, Baghdad , Soil pollution , Ecological risk.

توزيع العناصر الثقيلة ، المركبات الأروماتية متعددة الحلقات و المايكرو بلاستك والتلوث المحتمل للتربة في مناطق مختارة من بغداد / العراق

علا رياض عباس[1] , كمال برزان البرواني[2*], ميسون حسن مشجل[1]

1 قسم البيولوجي ،كلية علوم البنات ، جامعة بغداد . بغداد . العراق.

2 مركز البيئة والمياه والطاقات المتجددة ،هيئة البحث العلمي ، بغداد ، العراق.

الخلاصة

تهدف الدراسة إلى تقييم المعادن الثقيلة والهيدروكربونات العطرية متعددة الحلقات والمواد البلاستيكية الدقيقة وتلويثها المحتمل للتربة في مناطق مميزة في مدينة بغداد، العراق. خلال شهري شباط وحزيران 2024، تم جمع عينات التربة من ستة مواقع (الزراعية، مصنع البلاستيك، تربة مصفى النفط، التربة القاحلة، السكنية، وتربة مكب النفايات) داخل مدينة بغداد. أظهرت النتائج أن قيم التوصيلية الكهربائية وكمية الاملاح الذائبة في عينات التربة تتراوح بين (9.20–3.01 ديسي ميتر) و (5.89–2.86 ملغم كغم −1) في فترة الجفاف على التوالي بينما تتراوح بين (8.66–2.83),(5.54–1.81) في الفترة الرطبة على التوالي. بينت النتائج ان كل من EC وTDS مرتفعة جداً في بعض عينات التربة، مما يشير إلى وجود مواد غير عضوية في العينات. تراوحت التراكيز الكلية للمعادن الثقيلة مثل الرصاص والنحاس والزنك والمنغنيز والكادميوم والحديد في عينات التربة بين (26.4–3.27)،(33.6–12.9)،(114–24.7)،(715–319)، (2.19–0.37) و(5142–603) ملجم كغم$^{-1}$ في فترة الجفاف، بينما يتراوح بين (24.7–3.07)، (31.51–12.10)، (106.9–23.17)، (690–299.2)، (0.35–) 2.05) و (4822–565) ملغم كغم$^{-1}$ في الفترة الرطبة على التوالي. سجلت تربة مكب النفايات (S6) أعلى قيم للمعادن الثقيلة مما يشير إلى أن تخزين جميع المواد تسبب في تراكم المعادن الثقيلة في حين سجلت أقل متوسط القيم لـ S5. من ناحية أخرى، تراوح مجموع تركيز المركبات الاروماتية من 0.2 إلى 0.8 ملجم كجم $^{-1}$ ومن 0.21–0.82 ملجم كجم$^{-1}$ في فترة الجفاف والرطب على التوالي بينما كان مجموع المركبات الاروماتية في عينات التربة السطحية في S6 وS3. كانت أكثر من عتبة التلوث الشديد (1.0 مجم كجم −1) في كلتا الفترتين الزمنيتين. بسبب تراكم كمية من المركبات الهيدروكربونات العطرية متعددة الحلقات في التربة السطحية. وسجلت تربة مصانع الزيوت أعلى التراكيز ولجميع المركبات، تليها مواقع دفن النفايات. تراوحت كتلة المواد البلاستيكية بين 2 إلى 20 جسيمًا كجم$^{-1}$ في العينات الست، وتراوح المتوسط الإجمالي لتركيز MPs في مواقع أخذ العينات من 28 إلى 60 قطعة لكل كجم في فترة الجفاف. بينما تراوحت كتلة العناصر النقطية ما بين 2 إلى 19 قطعة كجم$^{-1}$ في العينات الست، وتراوح متوسط إجمالي تركيز العناصر النقطية في مواقع أخذ العينات من 39 إلى 62 قطعة

لكل كجم في الفترة الرطبة. توصلت النتائج إلى أن الموقع المختار ملوث بالملوثات العضوية الثابتة من الأعلى إلى الأقل وأن تركيز الملوثات العضوية الثابتة في الفترة الرطبة أكثر منه في فترة الجفاف، الأمر الذي قد يكون مرتبطًا بانخفاض مستويات الأنشطة البشرية والصناعية وتأثير المناخ. تم حساب قيم CF للمعادن الثقيلة في منطقة الدراسة لفترتين (الجافة والرطبة)، وأظهرت النتائج أن جميع العينات الموقعية لمنطقة الدراسة للفترتين منخفضة التلوث بعناصر الرصاص والنحاس والمنجنيز والحديد باستثناء المحطة S6 متوسطة التلوث بالرصاص والزنك. بينما كانت جميع عينات الموقع تحتوي على نسبة عالية جداً من التلوث بعنصر الكادميوم. مؤشر آخر (مؤشر المخاطر البيئية) تم دراسة نتائج عينات التربة لمنطقة الدراسة (S1,S2,S3,S4,S5 وS6) تبين أن عناصر الرصاص والنحاس والزنك والمنغنيز لها مخاطر بيئية منخفضة وممكنة. يقع ضمن مستوى المخاطر البيئية (Er< 40). بينما سجل الكادميوم في جميع مواقع منطقة الدراسة خطراً بيئياً محتملاً ويقع ضمن مستوى الخطر البيئي 329(160≥Er<).وأخيراً، من الواضح أن مستويات البلاستك الدقيقة والـ PAHs والمعادن الثقيلة وخاصة مستويات الكادميوم في بعض التربة مدينة بغداد كانت مرتفعة. في هذه الدراسة جميع المعلومات ستسهم في إدارة واستعادة التربة العراقية لتقليل التلوث المحتمل وباستخدام تقنيات المعالجة الجديدة.

1.Introduction

According to ontology, soil is a loose mineral or organic substance composed of three phases: solid, liquid, and gaseous. It is created by weathering processes, including interactions between the lithosphere, atmosphere, hydrosphere, and biosphere.[1]. Healthy soils are essential to all life. For everything from agriculture to water purification to human health, soil is a vital resource. Food production is a vital advantage of good soil. We may also get clean water and air from healthy soils. [2].The primary problem facing all living things on earth today is environmental pollution. It may also be described as an unfavourable alteration to the physical, chemical, and biological properties of the air, water, and soil. To address and lessen it, organized and coordinated measures are required. In addition to its impact on other living things, It modifies the environment's natural equilibrium and all its components, both living and non-living, [3]. Recently, there have been three types of soil Pollution. Agriculture soil pollution by use of pesticides and insecticides, industrial discharges of chemicals from mining and manufacturing and solid waste soil pollution. The term "heavy metal contamination" describes the excessive, largely human-caused accumulation of hazardous heavy metals in the soil. Some important elements that are poisonous to living things are found in soil as heavy metals, including lead (Pb), chromium (Cr), arsenic (As), mercury (Hg), and cadmium (Cd). They also include additional heavy metals including zinc (Zn), copper (Cu), nickel (Ni), stannum (Sn), vanadium (V), and others that have varying degrees of biological toxicity [4;5].

The accumulation of heavy metals in the soil can adversely affect the environment and human health. The inability to degrade them and their accumulation in human tissues negatively impact health, leading to metabolic disorders, blood-related diseases, and brain damage [6].

A family of organic compounds known as polycyclic aromatic hydrocarbons (PAHs) comprises two or more fused benzene rings. Natural sources include forest fires, from volcanic eruptions. and truck emissions. Hazardous waste sites can be a concentrated source of PAHs on a local scale. [7]. Phenalene, anthracene, and naphthalene are typical PAH examples. Numerous cancer types have been related to exposure to polycyclic aromatic hydrocarbons. Additionally, these chemical substances might lead to cardiovascular disorders in people. [8]. They may have a variety of harmful effects on both people and animals. These organic molecules are mostly released into the atmosphere, where they depositional accumulate in the soil due to their transportation across varying distances. [9;10].

MPs are a pollutant of increasing concern and although they have been widely detected in aquatic environments, Recently, research has focused on recent advances in analytical methods, pollution characteristics, and environmental impacts of Microplastics in soil; despite the presence of MPs in soil, There are no established techniques available for the quantification. The accumulation of plastic debris in the world's oceans and the various environmental issues caused by waste plastic and soil environment [11].The accumulation of residual MPs in field soil can cause negative impacts on crop production because they degrade soil structure, change the physicochemical characteristics of soil, change microbial activity, decrease seed germination, hinder the germination process of roots; and affect greenhouse gas emissions [12]. Microplastics can also interact with soil fauna, affecting their health and soil functions. "Earthworms, for example, make their burrows differently when Microplastics are present in the soil, affecting the earthworm's fitness and the soil condition [13].

Iraq's soils differ significantly from one another due to several soil-forming elements. The morphological, physical, chemical, and mineralogical variations between northern and southern Iraq indicate a general decline in the degree of soil development in those regions. Most soils found in Iraq are secondary in origin, meaning that the components were moved from their original location of weathering and accumulated elsewhere.

In Iraq, most works are done for specific purposes (salinity, soil texture, nutrient levels PAHs, Heavy metals ..etc.). In Iraq evaluating or assessing soil properties and their health effects were studied [14;15;16;17;18;19;20;21;22;23;24;25;26;27]. Finally, the interactions between soil science and human health come from many academic disciplines, including chemistry, geology, geography, anthropology, biology, agronomy, sociology, public health and medicine. As a result, achieving a clear overview of how soil contamination affects our health requires interdisciplinary teams. The current study aims to assess and identify soil pollutants from human activities in specific areas of Baghdad City. It also seeks to estimate the concentrations of heavy metals, Micro-plastic and PAHs in the soil and their health effects.

1.1 Site Description

The research area includes portions of the Iraqi Baghdad Governorates (Figure 1). The coordinates of the study region are 33˚14'-33˚25' N and 44˚31'-44˚17' E. The Tigris River flows from north to south, dividing the city into two sections: Karkh, and Risafa. Baghdad's climate is arid to semi-arid, with dry hot summers and cold winters. The average annual rainfall is around 151.8 mm. The geographical locations of the soil samples are shown in Table 1.

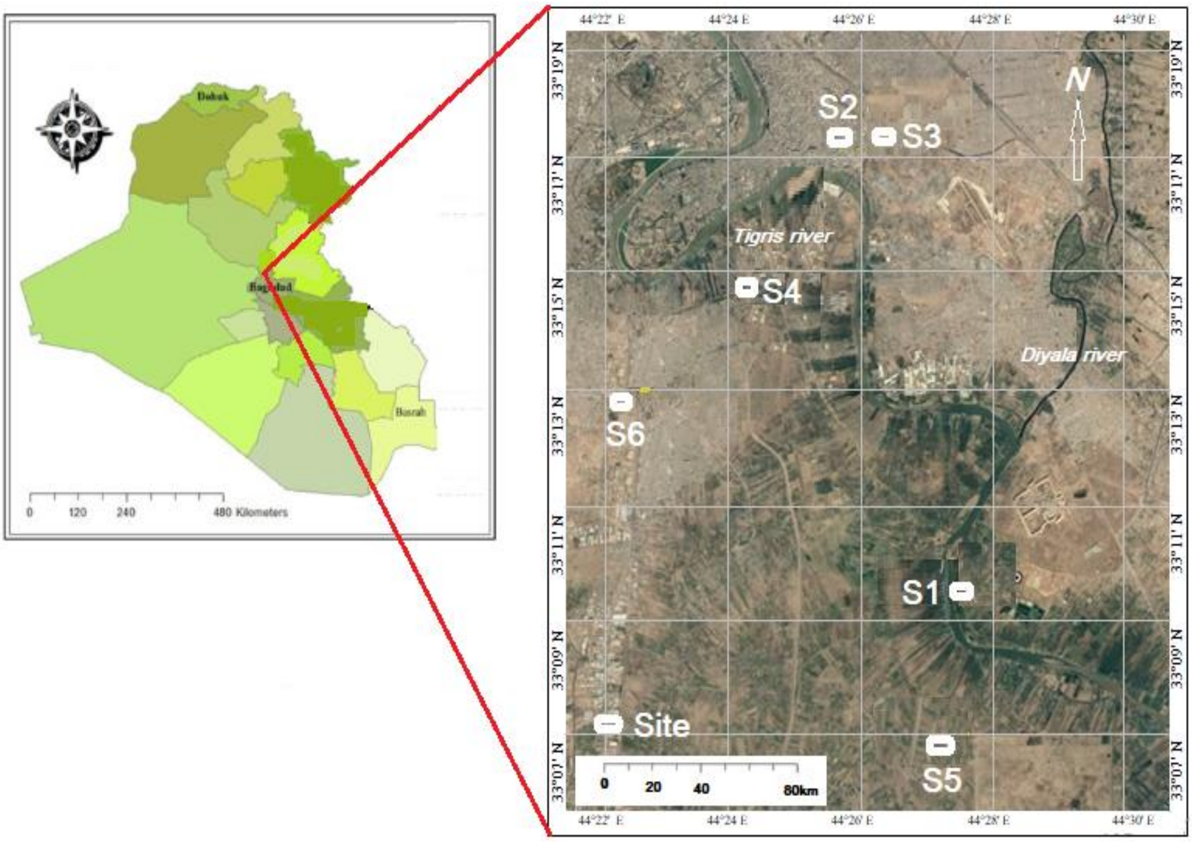

Figure 1: Map of the study area and sample location.

Table 1: The name, type and geographical location of the studied samples

Sites	Symbol	E	N
Agriculture soil	S1	44° 28' 49"	33° 10' 45"
Plastic factory soil	S2	44° 27' 10"	33° 17' 47"
Oil Factory soil	S3	44° 27' 11"	33° 17' 58"
Residential area	S4	44° 24' 41"	33° 15' 28"
Barren soil	S5	44° 29' 01"	33° 08' 10"
Landfill soil	S6	44° 22' 31"	33° 13' 38"

2. Materials and Methods

1.Sampling

During February and June 2024, soil samples were collected from six locations (agricultural, commercial, industrial, residential, and roadside) within Baghdad City. All soil samples were collected from the surface at a depth between 0 and 30cm by hand auger, then reserved in labeled plastic bags. a 0.5 x 0.5 m^2 region, Microplastic samples were gathered from both the shallow layer (0-3 cm) and deep layer (3-6 cm) of the soil. After removing large debris, the samples were stored in plastic bags and then sent to a laboratory for further analysis.

2.Extraction

The samples were disintegrated using a porcelain pestle and mortar, air-dried in the lab, homogenized, and sieved using a 2-mm polyethylene sieve to eliminate big debris, stones, and pebbles. After that, these samples were kept for additional examination in pristine selfsealing plastic bags. In the laboratory of soil and water at Agriculture University and in the chemical laboratory of Scientific Research Commission. the PAHs from soil samples were extracted, Following the US Environmental Protection Agency's (USEPA) 3550C method [28], the soil samples (1g) were combined with 2 g of Na_2 SO_4 anhydride and acetone (a 1:1, v:v) solvent; the sample vessel was then moved to an ultrasonic bath for 15 minutes extraction; this extraction process was repeated three times. The extract was cleaned up using an alumina/silica gel column.

In the process of MPs measurement, particles were separated from the host soil matrix by floating them out using salt solutions of predetermined densities. The inexpensive and easy way to extract low-density polymers from soils using distilled water [29]. In the past, soil Microplastics were extracted using saturated NaCl solutions with a density of 1.18 g cm^3. Nevertheless, it was anticipated that this approach would not separate numerous high-density plastics [30]. This entails increasing the number of extractions and ultrasonic treatments, extending the flotation period, and continuing to extract using saturated NaCl solutions. Seven out of the nine common types of MPs spiked in soils—PP, PE, polyamide (PA), polycarbonate (PC), acrylonitrile butadiene styrene (ABS), polymethyl methacrylate (PMMA), and PS particles were successfully extracted from the soil using $CaCl_2$ solutions. According to Van Devriese et al. (2015) [31], using $ZnCl_2$ or NaI might help attain the ideal solution density of 1.6-1.8 g cm^3.

3. Analytical Techniques

A. Heavy metal determinations were done by Atomic Absorption Spectrometry (AAS 6300, Shimadzu, Japan).

B. Gas chromatography (GC) devices with critical operation were used to estimate the PAHs concentration in soil samples of the study area.

C. FTIR spectroscopy uses state of the art analytical method in MPs research, because it enables the precise identification of polymer types, their abundance, shape, and size.

d. Other Methods and devices were used to estimate and measure the physical-chemical properties of soil samples as follow in Table2.

Table 2: Methods and devices were used to estimate and measure the physical chemical properties of soil samples.

Variables	Method and Devices	Refer.
pH	pH-meter	Page et al, 1982 [32]
EC and TDS	EC-meter	Page et al, 1982[32]
Sand, Silt and Clay	Hydrometer	Black et al.,1965[33]
Na and K	Flame photometer	Page et al, 1982[32]
Ca and Mg	Titration with EDTA-Na_2	Richard,1954[34]
SO_4	Uv-Spectrophotometer	Black et al.,1965[33]
Cl	Titration with $AgNO_3$	Black et al.,1965[33]
CO_3 and HCO_3	Titration with sulfuric acid	Richard,1954[34]
T Nitrogen	Kjeldahl method	Page ,1982[32]
T phosphor	Uv-Spectrophotometer 880nm	Black et al.,1965[33]
O.M	Wet digestion	Jones,2001[35]
Heavy metals	Atomic absorption spectrometer after digestion	Jones,2001[35]

4. Assessment of the risk of Heavy metals , PAHs and MPs in Health and Environment **.**
The degree of pollution and the extent of soil enrichment with heavy metals under study were evaluated based on indicators of Pollution as following:
A. Contamination Factor (CF)
It is one of the most important parameters used to determine the extent of pollution and is known as the pollution index. For the single element that determines the level of soil contamination, this factor is calculated and classified according to equation 1. Mekky etal., (2019) [36] Table3 .

$$\boldsymbol{CF} = \boldsymbol{Csample} / \boldsymbol{Cbackgroun} \qquad \text{----------1}$$

where: CF: contamination factor, C = concentration of the heavy element in the soil, background C = normal concentration of the element in the crust.

Table 3: Contamination factor level depends on Mekky etal.,(2019).

Contamination Factor	Contamination level
1>CF	Low Contamination
1≤ CF <3	Medium contamination
3≤ CF < 6	High contamination
6<CF	Very high contamination

B. Ecological Risk Index (Er)
The environmental risk index is one of the most important indicators used in a variety of research fields Scientific studies such as biological toxicology, chemistry, ecology, and environment)., Chen et al.,2020[37] developed an indicator that is calculated and classified according to equation .

$$\mathbf{Er=Tr*CF} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\mathbf{2}$$

Whereas
CF: Contamination factor, Tr: is the toxic hazard factor for the elements according to [38] Table4.
(As=10, Cd=30, Cr=2, Cu=5, Pb=5, Mn=1, Zn=1, Ni=1)

Table 4: Classification of the Ecological risk according to [38].

Ecological Risk Index	Er
Low potential environmental risk	40>Er
Medium potential environmental risk	80>Er≤40
High potential environmental hazard	160>Er≤80
Potential environmental hazard	320>Er≤160

3. Results and Discussion
The results of physical, chemical, PAHs, and heavy metals for six samples of soil in Baghdad for two periods are shown in Tables 5 and 6.

Table 5: The results of PAHs, Heavy metals and MPs for six samples of soil in Baghdad in the dry period,2024.

Sites	unit	S1	S2	S3	S4	S5	S6
pH	-	7.70	7.14	8.04	7.61	7.32	6.98
EC	dSm^{-1}	4.30	6.06	7.32	6.85	3.01	9.20
TDS	$mg\ L^{-1}$	2.86	3.88	4.72	4.36	1.92	5.89
sand	$(gm\ kg^{-1})$	183	237	253	217	185	194
clay	$(gm\ kg^{-1})$	412	336	376	396	410	430
silt	$(gm\ kg^{-1})$	405	427	371	387	405	376
Na	mgkg-1	916	1182	1351	1072	807	1511
K	mgkg-1	1120	1445	1652	1310	987	1848
Ca	mgkg-1	1648	2126	2431	1928	1452	2719
Mg	mgkg-1	557	719	822	652	491	919
Cl	mgkg-1	3499	4514	5161	4094	3083	5773
SO_4	mgkg-1	2184	2817	3221	2555	1924	3604
HCO_3	mgkg-1	1759	2269	2595	2058	1550	2902
CO_3	mgkg-1	439	566	648	514	387	724
Total p	mgkg-1	1362	1757	2009	1594	1200	2247
Total N	mgkg-1	1040	507	808	129	460	1169
O.M	gm kg-1	1.29	0.291	0.409	0.525	0.714	1.78
Total pb	mgkg-1	5.25	11.4	9.16	4.83	3.27	26.4
Total Cu	mgkg-1	14.2	21.9	24.16	18.7	12.9	33.6
Total Zn	mgkg-1	24.7	50.1	71.4	35.9	18.9	114
Total Mn	mgkg-1	390	585	609	417	319	715
Total Cd	mgkg-1	0.516	1.94	1.78	0.815	0.372	2.19
Total Fe	mgkg-1	3047	1681	2300	603	2802	5142

Table 6: The results of PAHs, Heavy metals and Micro-plastic for six samples of soil in Baghdad in wet period,2024.

sits	unit	S1	S2	S3	S4	S5	S6
pH	-	7.24	6.72	7.56	7.16	6.89	6.57
EC	dSm^{-1}	4.05	5.70	6.89	6.44	2.83	8.66
TDS	$mg\ L^{-1}$	2.69	3.65	4.44	4.10	1.81	5.54
sand	$(gm\ kg^{-1})$	179	230	249	219	191	198
clay	$(gm\ kg^{-1})$	414	340	379	394	407	427
silt	$(gm\ kg^{-1})$	407	430	372	387	402	375
Na	mgkg-1	859	1108	1267	1005	756	1417
K	mgkg-1	1050	1355	1549	1229	925	1733
Ca	mgkg-1	1545	1993	2279	1808	1361	2550
Mg	mgkg-1	522	673	770	611	460	862
Cl	mgkg-1	3281	4233	4840	3839	2891	5414
SO_4	mgkg-1	2048	2642	3021	2396	1804	3379
HCO_3	mgkg-1	1649	2128	2433	1930	1453	2722
CO_3	mgkg-1	411	531	607	481	362	679
Total p	mgkg-1	1277	1647	1884	1494	1125	2107
Total N	mgkg-1	975	475	757	120	431	1096
O.M	gm kg-1	1.21	0.27	0.38	0.49	0.67	1.67
Total pb	mgkg-1	4.92	10	8.59	4.53	3.07	24.76
Total Cu	mgkg-1	13.32	20	22.66	17.5	12.10	31.51
Total Zn	mgkg-1	23.17	46	66.97	33.67	17.73	106
Total Mn	mgkg-1	365	548	571	391	299	670
Total Cd	mg kg-1	0.48	1.82	1.67	0.76	0.35	2.05
Total Fe	mg kg-1	2857	1576	2157	565	2628	4822

The values of pH in the soil samples range between 6.98 and 8.04 in the dry period, while they range between 6.72 and 7.52 in the wet period, Indicating the soil's exceptional buffering ability. The highest pH value (8.04) is observed in the landfill area during the fall season. This can be attributed to the accumulation of waste in the study area . The values of EC and TDS in the soil samples range between 3.01 and9.20 dSm^{-1}, 2.86 and5.89 mg L^{-1} in the dry period, respectively, while it ranges between 2.83 and8.66 dSm^{-1} ,1.81 and 5.54 mg L^{-1} in the wet period, respectively as shown in Figure 2and 3. Both the EC and TDS are quite high in S6, suggesting the presence of organic matter in the sample locations. The decreased electrical conductivity values are attributed to the elevated moisture levels during this period.

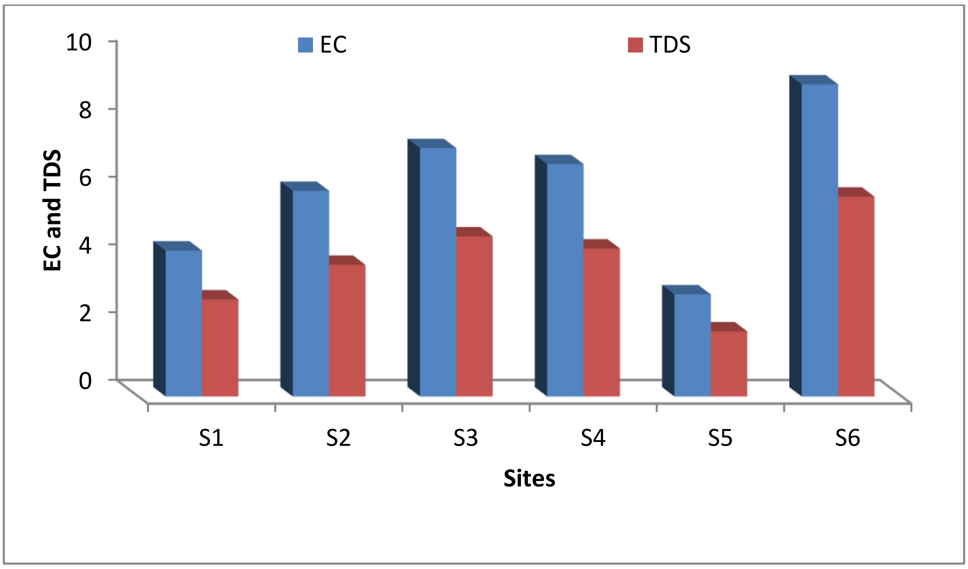

Figure 2: Distribution of EC and TDS values in the soil samples of the studied area during the dry period.

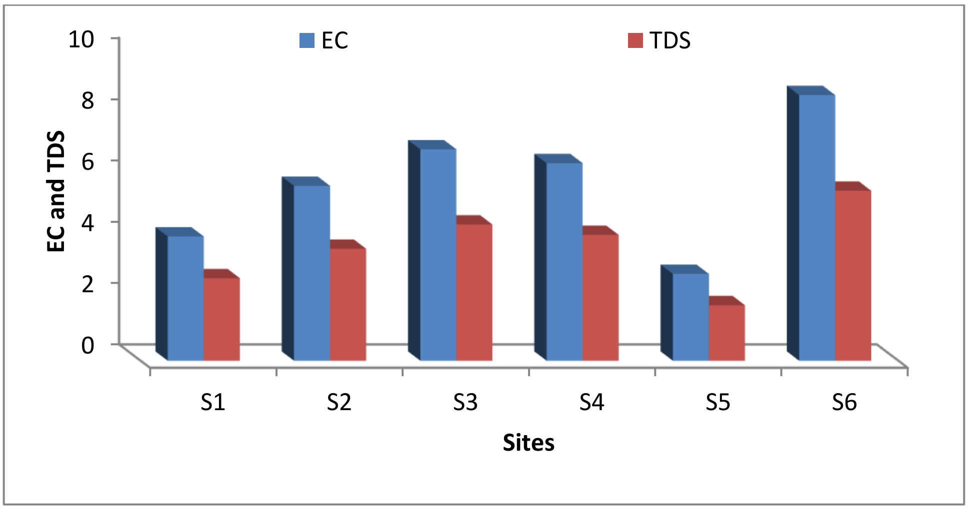

Figure 3: Distribution of EC and TDS values in the soil samples of the studied area during the wet period.

According to Figures 4 and 5, this kind of soil is loamy sand. A grain size study showed that sand ranged from 336 to 430 milligrams per kilogram of soil, silt from 371 to 405 milligrams per kilogram of soil, and clay from 183 to253 milligrams per kilogram of soil in the dry period. A grain size study showed that sand ranged from 179 to 249 milligrams per kilogram of soil, silt from 372 to 430 milligrams per kilogram of soil, and clay from 430 to 427 milligrams per kilogram of soil in the wet period.

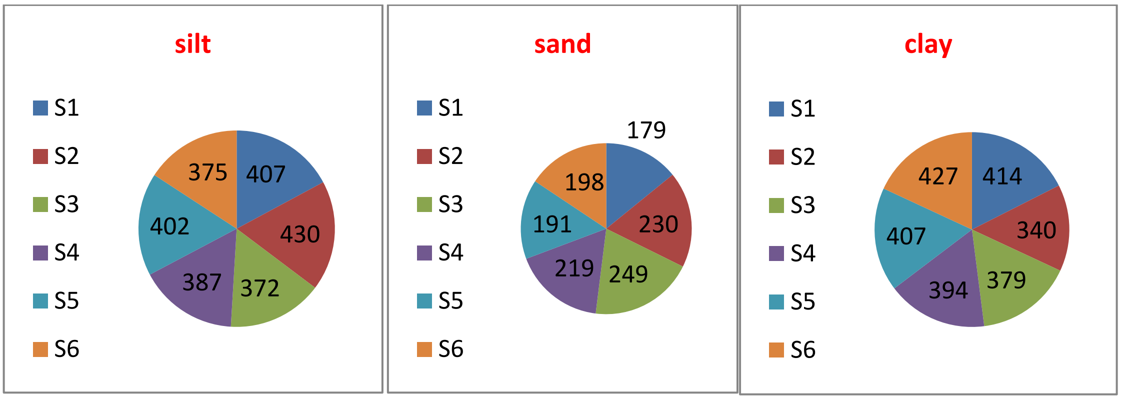

Figure 4: Distribution of sand, silt and clay in the studied area during the wet period

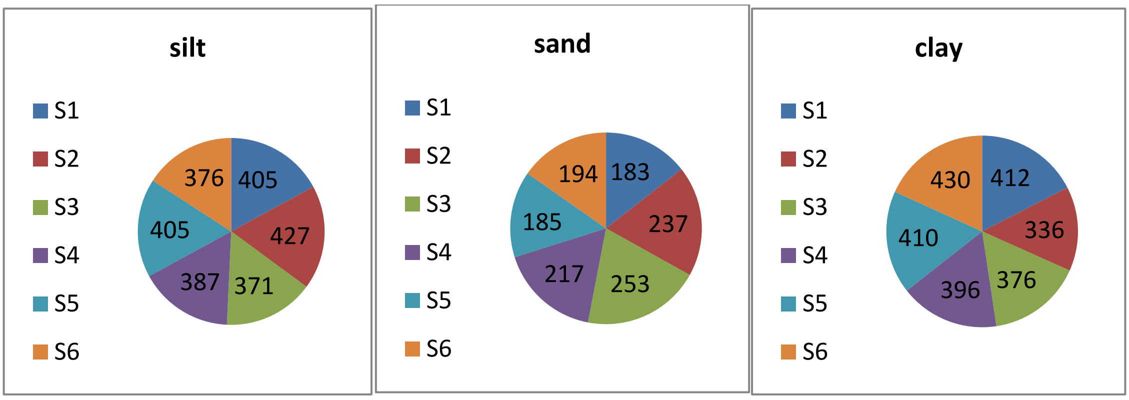

Figure 5: Distribution of sand, silt and clay in the studied area during dry period.

The concentration of cations Na, K, Ca and Mg in the soil samples range between 916 and1511, 1120 and1848, 1452 and2719 and 491 and919 mg L^{-1} in the dry period, respectively while in the soil samples range between 859 and1417, 925 and1733, 1361and2250 and 460 and862 mg L^{-1} in the wet period, respectively as shown in tables 3and 4. The concentration of anions SO_4, Cl, CO_3 and HCO_3 in the soil samples range between 1924 and 3604, 3083 and5773, 439 and724 and 1550 and2902 mg L^{-1} in the dry period, respectively while in the soil samples ranges between 1804 and3379, 2891and 5414, 362 and 679 and 1453 and2722 mg L^{-1} in the wet period, respectively as shown in Tables 3and 4. There is a high variation in anions and cations concentration of the studied samples due to the differences in the nature of the soil, water content and chemical process.

The total Nitrogen (N), phosphorous (P) and O.M in the soil samples of the studied area were 129 and1169, 1200 and 2247 and 0.291 and 1.78, respectively, in the dry period, while in the soil samples of the studied area was 431 and 1096, 1125 and 2107 and 0.29 and1.67 respectively in the wet period. The differences in the values of M.O are due to the variation in soil structure and activity of soil organisms.

The total concentration of heavy metals of Pb, Cu, Zn, Mn, Cd and Fe in the soil samples ranges between 3.27 and26.4, 12.9 and33.6, 24.7 and114, 319 and715, 0.37and2.19 and 603 and5142, respectively in the dry period, while it ranges between 3.07 and24.7, 12.10 and31.51,23.17 and106.9, 299.2 and 690, 0.35 and 2.05 and 565 and 4822 respectively in the wet period, The landfill soil (S6) recorded the highest values of heavy metals, this suggested that the storage all the material caused Accumulation of heavy metals, while the lowest averages values recorded by S5.

The concentration of PAHs in the soil samples in the studied area for two periods (dry and wet) is shown in Table 7.

Table 7: concentration of Σ16PAHs in the soil samples in the studied area for two periods (dry and wet ,2024).

Sites	**Dry period** mg/kg	**Wet period** mg/kg
S1	0.8	0.82
S2	0.7	0.71
S3	77	81
S4	0.21	0.22
S5	0.2	0.21
S6	34	36

It is noteworthy to mention that, Σ16PAHs in surface soil samples in S3 and S6 throughout both periods were greater than the heavy pollution standard (1.0 mg/kg). It showed that a significant quantity of PAHs was stored in the surface soils of this industrial complex and landfill. the concentration of, Σ16PAHs (S1, S2, S4, and S5) predominating in the surface layer and ranging from 0.21-0.82 mg/kg throughout the wet and dry periods, respectively. Figure 6. Landfill sites were the next most abundant source of soil for all chemicals, behind oil factories. The results noted that Naphthalene is more abundant, followed by Fluorene, Chrysene, Benzo [a] Anthracene and Dibenzo [a and h] Anthracene in oil soil (S3) in both periods. Fluorene is commonly followed by Naphthalene, Benzo [a] Anthracene, Chrysene and Dibenzo [a and h] Anthracene. based on Maliszewska-Kordybach (1996)[39], divided the PAHs pollution in soils into four groups. (Table 8).

Table 8: Classification of PAHs pollution of soil according to [39].

Σ16PAHs soil concentration	**Type of pollution**
bellow 0.2 mg/kg	No pollution
0.2-0.6 mg/kg	light pollution
0.6-1 mg/kg	moderate pollution
over 1 mg/kg	heavy pollution

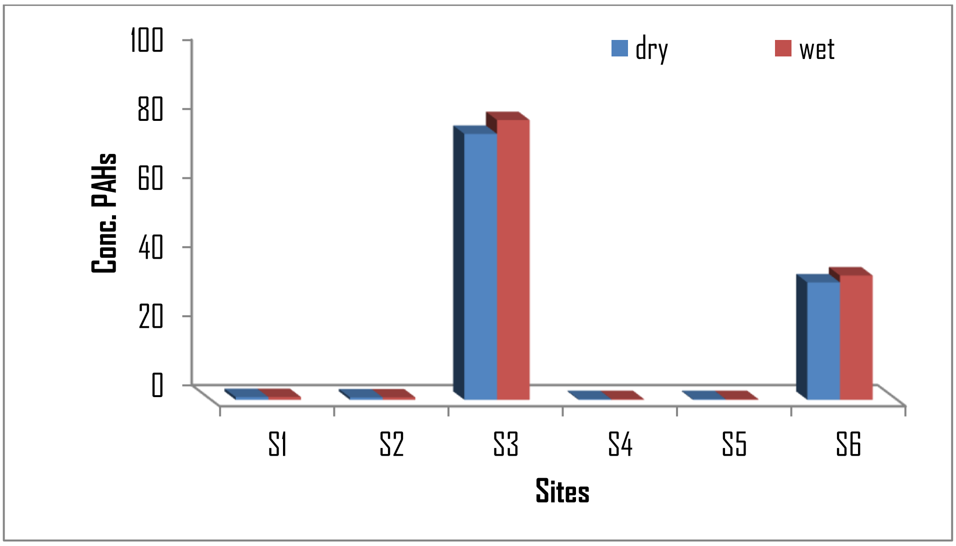

Figure 6: Total PAHs concentration in the soil samples of the studied area.

The site of the Oil soil (S3) had the highest concentration of PAHs (77 μg / kg) in the dry period, while the differences were evident between the other sites. The Barren soil recorded the lowest total hydrocarbons of 0.2 μg / kg,. Aoeed et al.,2021[40], In a previous study at

Karkuik City in Iraq showed that the highest total concentration of 16 polycyclic aromatic hydrocarbons was 609.77 µg / kg.
For the sources of PAHs, it is observed that, by application of weight equations according to molecular weight. Depends on Ant/(Ant+Phe). The results showed that the source of the compounds in oil soil in both periods was a petro-genic source while noting that burning fossil fuels and burning plants are the main sources of PAHs in the Landfill soil samples. The result of micro-plastic concentration of six sites in the study area for two periods is shown in Table 9.

Table 9: concentration of MPs in the soil samples in the studied area for two periods (dry and wet ,2024).

Sites	Type and concentration (Particle/kg) in dry period		Total particle %	Sites	Type and concentration particle/kg) in wet period		Total particle %
S1	circular	10	28	S1	circular	12	39
	parts	6			parts	5	
	Fibers	6			Fibers	9	
	Film	3			Film	8	
	Large pieces	3			Large pieces	5	
S2	circular	17	60	S2	circular	13	62
	parts	15			parts	19	
	Fibers	15			Fibers	13	
	Film	5			Film	8	
	Large pieces	8			Large pieces	10	
S3	circular	13	35	S3	circular	11	60
	parts	8			parts	19	
	Fibers	8			Fibers	10	
	Film	4			Film	14	
	Large pieces	2			Large pieces	2	
S4	circular	20	58	S4	circular	14	59
	parts	13			parts	13	
	Fibers	13			Fibers	13	
	Film	8			Film	15	
	Large pieces	6			Large pieces	8	
S5	circular	15	43	S5	circular	13	61
	parts	9			parts	12	
	Fibers	10			Fibers	15	
	Film	5			Film	12	
	Large pieces	4			Large pieces	9	
S6	circular	16	45	S6	circular	13	53
	parts	10			parts	11	
	Fibers	11			Fibers	11	
	Film	4			Film	12	
	Large pieces	4			Large pieces	6	

The number and shape of Microplastic in six samples of soil in Baghdad City at two periods (dry and wet) is shown in Table 7. In general, The MPs mass varied between 2 to 20 particles kg^{-1} in the six samples, and the total average of MPs concentration of the sampling sites ranged from 28 to 60 particles per kg in the dry period. The MPs mass varied between 2 to 19 particles kg^{-1} in the six samples, and the total average of MPs concentration of the sampling sites ranged from 39 to 62 particles per kg in the wet period. The results found that the selected site is polluted with MPs from high to low and the concentration of MPs in the wet period is higher than in the dry period, figure 7. which may be related to low levels of human and Industrial activities and the effect of Climate. MPs concentrations in selected soil samples were higher than reported in other sites, indicating crucially impacted by anthropogenic activities from the plastic factory in the Al-Zafrania region.

Based on our results, the physical properties were varied between circular, parts, Fibers, Film and Large pieces which are smaller than 5mm. When comparing the concentrations of Microplastics between the stations, it was noted that station 2 has the highest concentration, possibly due to the geographical location near the plastic factory. The highest and smallest widths of microplastics in site 2 ranged between 2 mm to 19 mm in both periods, while the different widths of MPs were found in the other sites. The highest and smallest widths of microplastics in site 2 ranged between 0.4 mm and 4.8 mm, while the different widths of MPs were found in the other sites. Plastic part was the highest (average 27%) among the Microplastics shapes in site 2, followed by circular shape (average 24.6%), Fibers (average 22.95%), Large pieces (average 14.7%) and Film (average 10.6%). Figure 7, Moreover, Microplastics may interact with soil fauna, impacting both their well-being and the functions of the soil. For example, when Microplastics are present in the soil, earthworms construct their burrows in a different way that impacts both the soil's quality and the earthworms' fitness. Because MPs may be adsorbed onto root hairs and alter root development, MP stress in plants directly affects the roots of the plant. On the other hand, MP stress in leaves probably results in oxidative stress, which lowers photosynthesis and leaf development [41].

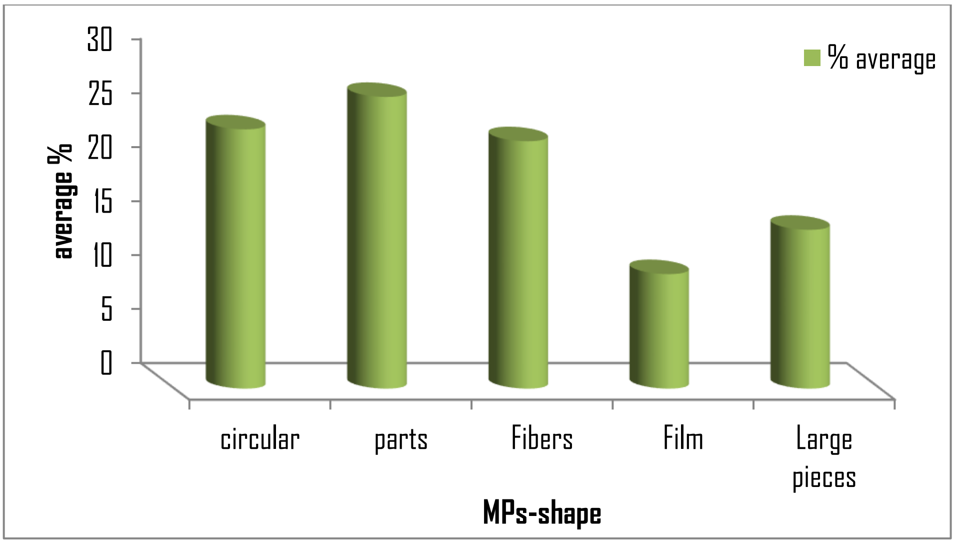

Figure 7: Average % of MPs shape in six sites of the studied area.

This study pointed out the occurrence and distribution patterns of Microplastics in some areas of Baghdad. In addition, the results suggested that the soil was polluted by microplastics. We recommended to identify the type of MPs in the other area of Baghdad such as polyethylene (PE), polyethylene terephthalate (PET) and nylon.

Assessment of the risk of Heavy metals , PAHs and MPs in Health and Environment .

Contamination Factor (CF)

The results of CF values of heavy metals in the study area for two periods (dry and wet) are compared with Mekky etal.,(2019)[36] classification, where all site samples of the study area for two periods are low contamination in the element Pb, Cu, Mn and Fe except S6 were medium contamination in Pb and Zn. While all the sites samples were Very high contamination in element of Cd, as shown in Tables 10 and 11.

Table 10: The results of CF of Heavy metals in the study area in the dry period.

CF Fe	CF Cd	CF Mn	CF Zn	CF Cu	CF pb	Sites
0.07773	5.16	0.522088	0.352857	0.258182	0.35	S1
0.042883	19.4	0.783133	0.715714	0.398182	0.76	S2
0.058673	17.8	0.815261	1.02	0.439273	0.610667	S3
0.015383	8.15	0.558233	0.512857	0.34	0.322	S5
0.07148	3.72	0.427041	0.27	0.234545	0.218	S5
0.131173	21.9	0.957162	1.628571	0.610909	1.76	S6

Table 11: The results of CF of Heavy metals in the study area in the wet period.

CF Fe	CF Cd	CF Mn	CF Zn	CF Cu	CF pb	Sites
0.072883	4.8	0.488621	0.331	0.242182	0.328	S1
0.040204	18.2	0.733601	0.657143	0.363636	0.666667	S2
0.055026	16.7	0.764391	0.956714	0.412	0.572667	S3
0.014413	7.6	0.523427	0.481	0.318182	0.302	S5
0.067041	3.5	0.400268	0.253286	0.22	0.204667	S5
0.12301	20.5	0.896921	1.514286	0.572909	1.650667	S6

Ecological Risk Index (Er)

The Ecological Risk index was classified by Kormoker , (2019)[38] into four categories based on the Er values, (Tables 12 and 13). Based on this classification the Ecological Risk index in the studied area for two periods of study area. The results of the Ecological risk index in the soil samples of studied area (S1,S2,S3,S4,S5 and S6). The results show that the elements lead, copper, zinc, and manganese, have low ecological risks possible and falls within the environmental risk level (>40 Er). While cadmium was recorded in all sites of the studied area a risk potentially environmental and falls within the environmental risk level 329(>Er≤ 160). In general the impact of PAHs , Heavy metals and MPs in the soil is an indirect effect, in general high values in wet period **compared** to the dry period due to effect of climate conditions and human activities.

Table 12: The results of Er of heavy metals in the study area in the dry period.

Er Cd	Er Mn	Er Zn	Er Cu	Er pb	Sites
154.8	0.522088	0.352857	1.29091	1.75	S1
582	0.783133	0.715714	1.99091	3.8	S2
534	0.815261	1.02	2.196365	3.053335	S3
244.5	0.558233	0.512857	1.7	1.61	S5
111.6	0.427041	0.27	1.172725	1.09	S5
657	0.957162	1.628571	3.054545	8.8	S6

Table 13: The results of Er of Heavy metals in the study area in wet period.

Er Cd	Er Mn	Er Zn	Er Cu	Er pb	Sites
144	0.488621	0.331	1.21091	1.64	S1
546	0.733601	0.657143	1.81818	3.333335	S2
501	0.764391	0.956714	2.06	2.863335	S3
228	0.523427	0.481	1.59091	1.51	S5
105	0.400268	0.253286	1.1	1.023335	S5
615	0.896921	1.514286	2.864545	8.253335	S6

4.Conclusions

In conclusion, the study pointed out the distribution patterns (special and temporal) of Heavy metals, PAHs, and MPs in some areas of Baghdad city.The findings indicated that some soil in the investigated region was contaminated with heavy metals,PAHs, and MPs. The Cd concentration as heavy metals was the highest element in most selected sites. Depends on Ant/(Ant+Phe). The results showed that the source of the compounds in oil soil in both periods was a petro-genic while noting that burning fossil fuels and burning plants are the main sources of PAHs in the Landfill soil samples. The highest and smallest widths of Microplastics in site 4 ranged between 0.4 mm and 4.8 mm, while the different widths of MPs were found in the other sites. plastic shapes were the highest (average 27.77%) among the MPs shapes in site2, followed by the circular shape. Our study drives us to continue completing similar environmental investigations to find the occurrence of micro plastics in Iraqi soil in other places. The results of CF show that all site samples of the study area two periods had low contamination in elements of Pb, Cu, Mn, and Fe except S6 which had medium contamination in Pb and Zn. while all the site samples had very high contamination in Cd concentration.

5. References

[1] D.Cahyyana, A simple definition of soil .soil security.volum.16. September, 100146**.** 2024**.**

[2] C.Gardi, M. Angelini, M. Barceló, S. Comerma, J. Cruz Gaistardo, C. Encina Rojas, A., Jones, Atlas de suelos de América Latina y el Caribe, Comisión Europea - Oficina de Publicaciones de la Unión Europea, L-2995 Luxembourg, 176 pp.2014.

[3] V.Kumar, A. Sharma, G. Dhunna, A. Chwla, A Tabulated Review on Distribution of Heavy Metals in Various Plants. Environ Sci Pollut Res. 24(3), pp. 2210-2260.2017.

[4] Y.Sanayei, N. Ismail and S.M Talebi, Determination of heavy metals in Zayandeh Rood river, Isfahan-Iran. World Applied Sciences Journal,Vol. 6, No9, pp. 1209-1214.2009.

[5] U.S. EPA, Clean Water Act, sec. 503, vol. 58, no. 32. (U.S. Environmental Protection Agency Washington, D.C.).1993.

[6] A.S, Al-Hayani, The Status of Some Heavy Metals in the Danfili River Basin, Unpublished Ph.D. Thesis, College of Agriculture and Forestry, University of Mosul, Iraq, 1-230 P.2-2018.

[7] S.Pike, Polycyclic Aromatic Hydrocarbons, in: Sullivan J.B. & Krieger G.R. (Eds), Hazardous Materials Toxixology: Cli nical Priciples of Environmental Medicine, Williams & Wilkins, Baltimore, MD, pp 1151-1154, 1992.

[8] J.A Ellenhorn and D.G Barceloux, Polycyclic Aroma tic Hydrocarbons, in: Ellenhorn M.J. & Barceloux D.G. (Eds): Medical Toxicology: Diagnosis and Treatment of Poisoning. Elsevier, New York, NY, pp 952-954, 1988.

[9] J.J Nam and G.O, Thomas F.M Jaward, PAHs in background soils from Western Europe: influence of atmospheric deposition and soil organic matter. Chemosphere. 70 (9), 1596, 2008.

[10] N.M. Tue ,G. Suzuki, K.Misaki, P. Vivt , Aryl hydrocarbon receptor mediated activities in road dust from a metropolitan area, Hanoi-Vietnam: contribution of polycyclic aromatic hydrocarbons (PAHs) and human risk assessment. Sci. Total Environ. 491, 246, 2014.

[11] M. Ateia, Micro plastic release precursors of chlorinated and brominated disinfection byproduct in water .Chemosphere.251.125452.2020.
[12] S.W. Kim, Micro plastic inhibit the movement of spring tail species Environment Int 126.699-706.2019.
[13] J.Wang, M. Huang, Q.Wang, Y. Sun, Micro plastics significantly alter the temporal turnover of soil microbial communities. Sci. Total Environ. 2020;726:1-8. https://doi.org/10.1016/j.scitotenv.2020.
[14] M.S. Hussain, and K.G. Shali, Environmental conditions and classification of soils in northern Iraq. Zanco. 4:97-110.1979.
[15] W.K. Al-Agidi, Pedology: Soil survey and classification. Mosul Univ. Press, Iraq ; 1986.
[16] A.S, Muhaimeed, Soil survey and classification. Mosul Univ. Press, Iraq.1994.
[17] M. Ruaa , A. Al-Sheraefy , A. K. Hussien , Y.Aahed, Spatial distribution of heavy metals in the soil of different areas at a left bank in Mosul City, Iraq: Part 2. Iraqi National Journal of Earth Science, Vol. 23, No. 1, 2023 (132 -153).2023.
[18] A.S. Muhaimeed, and I.J. Mohammad, Characteristics, formation, and classification of alluvial soils of Naft valley in Manadali area. Iraqi J. Soil Sci. 1:138-144.2001.
[19] A.S. Muhaimeed, A.S. Al-Shikihi, S.K. Esa, and M.A. Jamal, Comparison of some properties of some properties of soils on both sides of great Zab river in Aski-Kalk. Zanco. 4:75-88. 2000.
[20] N.Z. Salim, Classification of Serwan river Levee's Soils in Kurdistan Region- Iraq. Journal of University Garmian. Vol.4, No.4 (December, 2017).
[21] A.H. Mohammed, M.T. Yaqub1 , Abdulkarem A.M, Survey and characterization of water resources and soils around Wadi Rehana region in the western desert of Iraq. Caspian Journal of Environmental Sciences, Vol. 20 No. 2 pp. 265-274.2021.
[22] H.K. Hussein , J. Wadaa, GEOTECHNICAL STUDY OF BAGHDAD SOIL. Global Journal of Engineering Science and Research Management . 4(9): September, 2017.
[23] A.F. Mena and F M Abdulhussein, Assessment of the Contamination of Baghdad Soils with Lead Element. Iraqi Geological Journal. 55(1F), 166-177.2022.
[24] T.B. Muhannad, K. Ka. Al-Ahmady, A. N Hamdon, Spatio-Temporal Analysis of Heavy Metals Concentration in The Soil for A Selected Sites in Mosul City. Iraqi National Journal of Earth Science, Vol. 24, No. 1, (200-215).2024.
[25] H. A. Al-Azawii., Mu.R. Nashaat, M. N.Al-Azzawi, Determination of Polycyclic Aromatic Hydrocarbon(PAHs) in the Tigris River through Passing Baghdad Province. Iraqi Journal of Science, Vol 56,No.2B, pp: 1372-1384. 2015.
[26] M. S. Mohammed, E. J. Abdullah, Heavy Metals Pollution Assessment of the Soil in the Northern Site of East Baghdad Oil Field, Iraq. Iraqi Journal of Science, 2016, Vol. 57, No.1A, pp: 175-183. 2016.
[27] A. A. Chyad, A. M. Saeed, A. S. Alhendi, Determination of Heavy Metals in Irrigation Water, Soil, Paddy, and Produced Riceof Some Paddy Fields of Iraq. Iraqi Journal of Science, 2022, Vol. 63, No. 11, pp: 4637-4649. 2022.
[28] USEPA, US Environmental Protection Agency (USEPA). Method 3550C–Ultrasonic Extraction. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. 3, 1, 2007.
[29] S.Zhan, S.Ali, B.Muhamed,Contimanation in drinking water.Desalin water treat.181.221-227.2020.
[30] G.P Peng, Xu, B. Zhu, M. Bai, D. Li, Micro-plastics in freshwater river sediments in Shanghai, China: a case study of risk assessment in mega–cities Environ. Pollut., 234 (2018), pp. 448-456.2018.
[31] L.V. L. Devriese, F. Galgani, J. Robbens, C.R. Janssen, Microplastics in sediments: a review of techniques, occurrence and effects Mar. Environ. Res., ,2015, pp. 5-17.2015.
[32] A.L.,Page, R. H. Miller and D. R. Kenney. Method of soil analysis, part 2, 2ndAgron. Madison Wisconsin, U.S.A, 1982.
[33] C. A ,Black,; D. D. Evans; L. E. Ensminger; J. L. White and F.E. Clark.. Methods of soil analysis. part 1 pp. 545-566 American Society of Agronomy. Madison Wisconsin. USA, 1965 (eds).

[34] A, Richards. Diagnosis and improvement of saline and alkali soils. Agric. Handbook No. 60. USDA. Washington, USA 1954.

[35] j. Jones, Benton. Laboratory guide for conducting soil tests and plant analysis. CRC Press LLC, 2001.

[36] H.S. Mekky, A.El-Anwar, A. Salman, S. A., Elnazer, A. A., Abdel Wahab, W., & Asmoay, A. S, Evaluation of heavy metals pollution by using pollution indices in the soil of Assiut District, Egypt. Egyptian Journal of Chemistry, 62(9), 1673-1683.2019.

[37] J.Chen, H. Zhang, J. Li, W. Shi, The toxic factor of copper should be adjusted during the ecological risk assessment for soil bacterial community. Ecological Indicators, 111, 106072.2020.

[38] T. Kormoker, R.M. Proshad, R., & Islam, M. , Ecological risk assessment of heavy metals in sediment of the Louhajang River, Bangladesh. SF Journal of Environmental and Earth Science. https://scienceforecastoa. com.2019.

[39] B. Maliszewska, Polycyclic aromatic hydrocarbons in agricultural soils in Poland: Preliminary proposals for criteria to evaluate the level of soil contamination. Applied Geochemistry, 11: 121–127. 1996.

[40] Y. H. Aoeed , A.B Mohammed , and A.M. Hameed1, Concentration of some Polycyclic Aromatic Hydrocarbons in soil samples of Kirkuk province, Iraq. Earth and Environmental Science 877 (2021) 012023.2021.

[41] S.C Izah, S.E Bassey, & E.I Ohimain, Ecological risk assessment of heavy metals in cassava mill effluents contaminated soil in a rural community in the Niger Delta Region of Nigeria. Molecular Soil Biology, 9.2018.