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Using the Direct Method in the Environmental Impact Assessment of Air Pollution in Iraq

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ABSTRACT

Dust storms represent the primary source of air pollution in Iraq, with a significant increase in the number of suspended particles in the atmosphere of Baghdad. Research conducted over the past three decades has revealed that the city of Baghdad is subject to approximately 20 dust storms per year. Human activities have been identified as a contributing factor to environmental degradation, particularly in densely populated cities such as Baghdad, which has a population exceeding eight million. The recent increase in industrial growth exacerbates the problem, leading to increased emissions and environmental degradation. In 2018, the highest monthly average of total suspended particles (TSP) was recorded in June, July, and August, with a value of 850 µg/m3. October, on the other hand, exhibited a significantly higher average of 1500 µg/m3. In 2019, the TSP reached its maximum level of 1024.5 µg/m^3 in June and subsequently decreased to its minimum monthly average of 70.2 µg/m^3 in January. These levels are elevated in comparison to international standards . To achieve a comprehensive understanding of the air quality in Baghdad, it is imperative to conduct meticulous measurements of total suspended particulate (TSP), heavy metals, and a diverse array of gases. This comprehensive analysis is expected to elucidate the city's air quality concerns and facilitate the development of efficacious solutions. Addressing these pollutants is imperative to enhance public health and the environment in one of Iraq's most densely populated regions.

Keywords: Environmental impact assessment, direct method, air pollution, dust storms, total suspended particles.

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Introduction

Pollution poses a significant threat to the environment and human health. It has existed since the advent of fire, but its severity increased with industrialization. Additionally, weather, and geographical factors have played a role in deteriorating air quality, which adversely impacts not only human health but also animals and plants. This research is part of an initiative to create an air quality management program in Baghdad. The aim of this study is to set national air quality standards and intermediate standards necessary for the air quality management system (AQMS) to monitor all key air pollutants that influence human health.

Data and Methods

The research aims to measure air pollutants and particulate matter from natural and human sources and compare them to environmental standards. The goal is to set up monitoring stations in Baghdad to track Total Suspended Particles (TSP) and other pollutants. It will also demonstrate direct ways to assess the environmental impact of these pollutants. The study is based on lab analysis of samples collected in 2018 and 2019 from Al-Kadhimiya District, which located in northwest Baghdad. It spans latitudes 33°19' to 33°35' and longitudes 44°19' to 44°23'. The district is bordered by the Tigris River to the east and northeast, Al-Tarmia District in Salah Al-Din Governorate to the north, Al-Anbar Governorate to the west, Abu Ghraib District to the southwest, and Al-Mansour District (part of Al-Karkh District) to the south, as shown in Map (1).

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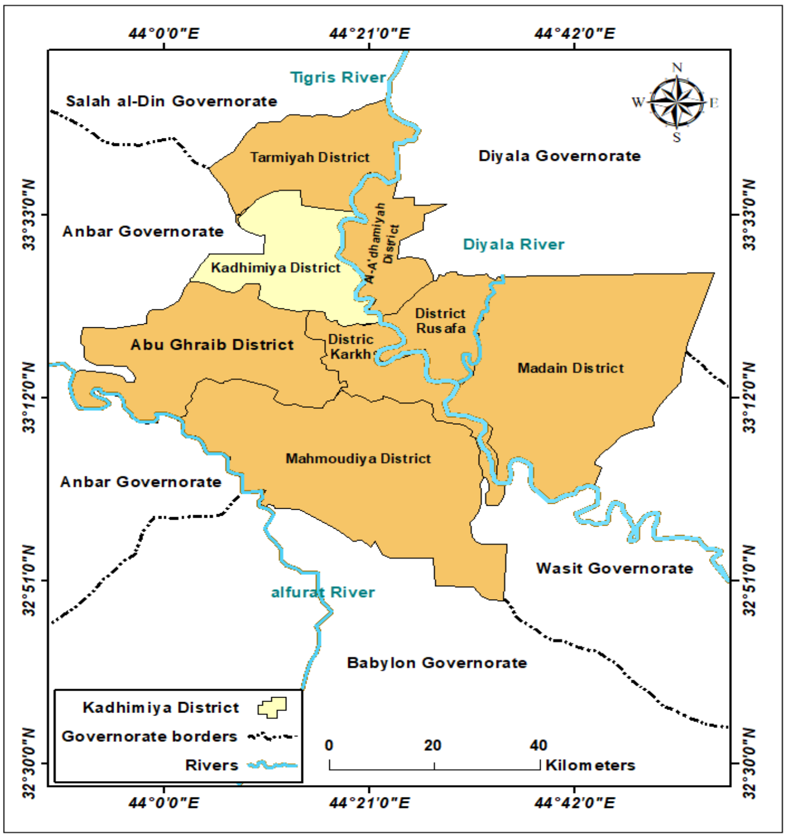

Map (1) shows the location of Al-Kadhimiya District in relation to the administrative units in Baghdad Governorate.

Source: Researcher based on the Ministry of Water Resources, General Authority for Survey, Baghdad Governorate Administrative Map at a scale of 1/500,000, 2017.

Covering 567 km², it makes up 11.7% of Baghdad Governorate's total area of 4,843 km² (Planning of, 2018). The study area includes the Al-Kadhimiya District Center, Dhat Al-Salasil District, and Al-Taji District, as depicted in Map (2).

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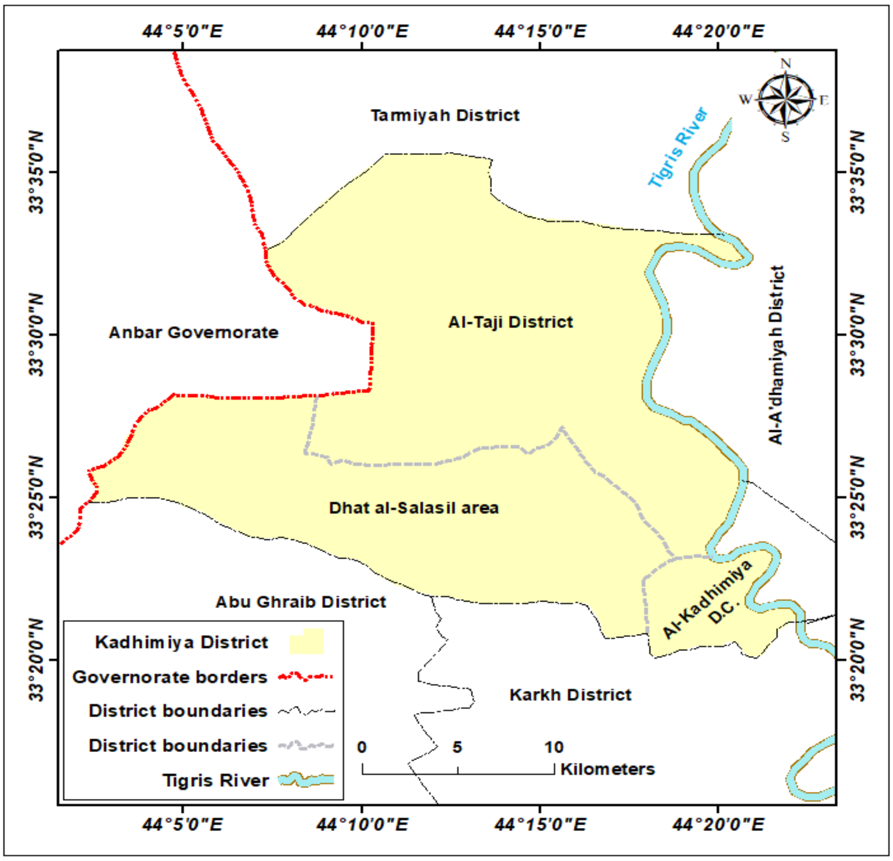

Map (2) shows the geographical location of Al-Kadhimiya District

Source: Researcher based on the Ministry of Water Resources, General Authority for Survey, Baghdad Governorate Administrative Map at a scale of 1/500,000, 2017.

The administrative units within this area are as follows:

1. Al-Kadhimiya District Center: This urban center covers 5.6% of the total study area of 567 km²

and includes neighborhoods such as Al-Kadhimiya, Al-Zahraa, Al-Atifiya, Al-Fajr, Al-Salam, Al-Tobji, and Al-Hurriya, as detailed in Table (1).

2. Dhat Al-Salasil District: This district is part of the Al-Kadhimiya district center and occupies 26% of the total study area. It includes neighborhoods in Baghdad such as the southern parts of Al-Sabiyat, Al-Salamiat, and parts of Al-Thaniya, as well as areas outside Baghdad like Mudalila, Al-Tajjaj, Al-Musalaha, Al-Gharibawi, Kuwaima, and Yariya, the western parts of Al-Thaniya) outside the borders of the city of Baghdad.

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3. Al-Taji District: This district makes up 68.4% of the total study area of 567 km². It includes neighborhoods within Baghdad such as Al-Tajiyat, Abu Al-Jadhail, Al-Arkiya, Fadhil, and the northern parts of Al-Sabiyat, and extends outside Baghdad to include areas like Sabaa Al-Bour, Abu Azam, Al-Hamamiyat, Hor Al-Basha, Al-Mazrafah, Al-Hasawa, Al-Dabai, Maksar Al-Faras, Al-Masoud, and Abu Sariwil.

Table (1) shows the administrative units and their areas in Al-Kadhimiya District.

<table>
<tr><th>Administrative unit</th><th>Area km^2</th><th>Percentage %</th><th colspan="2">Neighborhoods and districts</th></tr>
<tr><td>Al-Kadhimiya District Center</td><td>32</td><td>5.6</td><td colspan="2">Al-Kadhimiya - Al-Zahraa - Al-Atifiya - (Fajr and Peace) Al-Tobji - Al-Hurriya</td></tr>
<tr><td rowspan="2">Dhat al-Salasil area</td><td rowspan="2">147</td><td rowspan="2">26</td><td>Within the city limits of Baghdad</td><td>Outside the city limits of Baghdad</td></tr>
<tr><td>1. The southern parts of Al-Sabiyat, including Al-Sha'la, Jukuk, Al-Kasirah, Umm Najm, Al-Rawad, and Al-Ustadh.
2. Al-Salamiyyat and parts of Al-Thaniya.</td><td>Madlila - Tajaj and Musalaha - Al-Gharibawi - Kouima and Yaria - the western parts of Thaniya</td></tr>
<tr><td>Al-Taji District</td><td>388</td><td>68.4</td><td>1. The northern parts of the Sabians.
2. The Tajyat.
3. Abu al-Jadayel.
4. Al-Arqiya and Fadil.</td><td>Sabaa Al-Bour - Abu Azam - Hamamiyat Hor Al-Basha - Al-Mazrafah and Al-Hasawa - Al-Dabai - Maksar Al-Faras - Al-Masoud - Abu Sariwil</td></tr>
<tr><td>Total</td><td>567</td><td>100</td><td colspan="2"></td></tr>
</table>

Sources of Total Suspended Particles (TSP) in the air

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Researcher's work based on: General Authority for Survey, map of the establishment of administrative units according to districts in Al-Kadhimiya District, for the year 2017.

Particles in the atmosphere are either primary, released directly from their sources, or secondary, formed from new compounds after emission. Primary particles come from places like power plants (Revich, 2001), cement factories, coal mines, and other industries that release suspended materials into the air. Secondary particles include ammonia sulfides, found in both urban and rural areas (Dheiba, 2010). Overall, the air around Baghdad polluted with total suspended particulate matter (TSP). Dry regions often face dust storms due to high dust levels and unstable atmospheric conditions. Iraq affected by northwesterly winds that lift fine dust, causing dust storms driven by changes in pressure systems and stronger winds. These storms can come from distant areas and reduce visibility to 1000 meters when wind speeds exceed 7 meters per second (Khadir S., 2010).

High winds can trigger intense storms that lift dust or sand, influenced by the type of terrain. These storms are typically more prevalent in the spring and fall, while they occur less often in the summer and winter. Their primary cause is the movement of a cold air front that forces air upward, especially when the ground is dry (Al-Samarrai Q. , 2008). Changes in climate also disrupt air masses, causing them to shift towards warmer regions. Iraq is among the countries affected by this issue (Al-Qadi T. , 2001), with two key areas of dust accumulation: west of Basra and north of Baghdad The main sources of this dust are the western and southern deserts(Al-Halou, 1990).
Multiple studies indicate that dust storms primarily take place between February and August. The dust from these storms is composed of calcite, gypsum, quartz, limestone, and organic matter. In Baghdad's urban areas, the primary contributors to pollution are vehicles, along with emissions from refineries and power plants (Smith, 1974). Dust particles categorized by size: inhalable (under 15 microns), small (under 2.5 microns), and small (under 1 micron). Rapid fluctuations in atmospheric pressure create air vortices that can lift larger and medium-sized dust particles up to 15 meters when wind speeds range from 15 to 20 km/h (Yassin A. , 2008). Rain plays a crucial role in clearing these particles from the atmosphere.

Health effects of total suspended particles (TSP) in the atmosphere

Primary particles are tiny, suspended particles that form from the condensation of dust, typically measuring between 0.1 and 1.0 microns and having a short lifespan (Musa, 2006). Secondary particles, on the other hand, are created through reactions

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involving ammonia, sulfuric acid, and nitric acid. These particles have a longer lifespan and can be transported over distances ranging from tens to thousands of kilometers, with rain being the primary means of their removal from the atmosphere (Ismail S. , 1999). Larger particles, measuring between 1 and 10 microns, are mainly produced through physical processes, such as the erosion of road surfaces due to tire friction. Particles larger than approximately 15 microns do not penetrate the respiratory system but can affect the nose and throat (Al-Omar, 2000). Dust storms can negatively impact human behavior by exacerbating health issues related to air pollution, particularly increasing rates of asthma and respiratory allergies, as these storms can penetrate deep into the lungs, with the extent of penetration depending on the particle size and entry method (Al-Shammari I. a.-K., 2012). Table (2) illustrates the correlation between particle size and inhalation. Additionally, dust storms can carry bacteria and viruses, obstruct sunlight, and threaten vision (Mikhlif, 2009). They also pose risks to agriculture by creating a barrier around plants that reduces sunlight exposure and diminishes crop yields. In Iraq, particularly in Baghdad (Hamada E. M., 2007), frequent dust storms have significant effects on various aspects of daily life (Suleiman, 2009).

Table (2) illustrates the correlation between particle size and inhalation

T	Molecular size (micron)	Inhalable Percentage %
1	≤ 2	90-100
2	2.5	75
3	3.5	30
4	5	25

Source: Researcher's work based on the Ministry of Environment, Environmental Assessment Policy Booklet, 2000.

The hands-on Aspect

TSP samples gathered from seven locations, situated 3 to 5 meters above ground and away from transportation sources. The sampling lasted for 24 hours. The researcher weighed the particles and collected samples following ASTM guidelines. Metal concentrations assessed using an atomic absorption spectrometer. Map (3) illustrates the station locations. The study evaluated TSP concentrations in three areas: brick manufacturing facilities, Al-Dabash, and near Al-Muthanna Bridge. Table (3) presents the average TSP concentration values. Additionally, Table (3) displays the levels of suspended particles in the air around Baghdad from three stations in 2018 and four stations in 2019.

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An examination of the findings presented in Table (3) regarding the analysis of suspended particle concentrations in the study area for the years 2018-2019.

1. In the Al-Kadhimiya District, the highest daily concentrations reached 3,500 micrograms/m3, surpassing any air quality standards set by the WHO

2. In 2018, there were 18 days when concentration exceeded 1,000 micrograms/m3, accounting for 21% of the total measurements (one-fifth).

3. Concentrations exceeded 500 micrograms/m3 on 50 days out of 76 measurements, which is 58%.

4. There were 67 days with concentrations above 350 micrograms/m3 out of 86 measurements, representing 78%.

5. The highest monthly average for TSP concentrations was 1,454.6 micrograms/m3 in November.

6. The maximum annual average TSP concentrations were 630 and 681.6, with an overall average of 655.8 µg/m3, which exceeds any air quality standard.

7. During the summer months (June to October), average TSP concentrations ranged from 990.65 to 845.9 µg/m3, while winter averages, starting in November, were significantly lower at 372.41 µg/m3.

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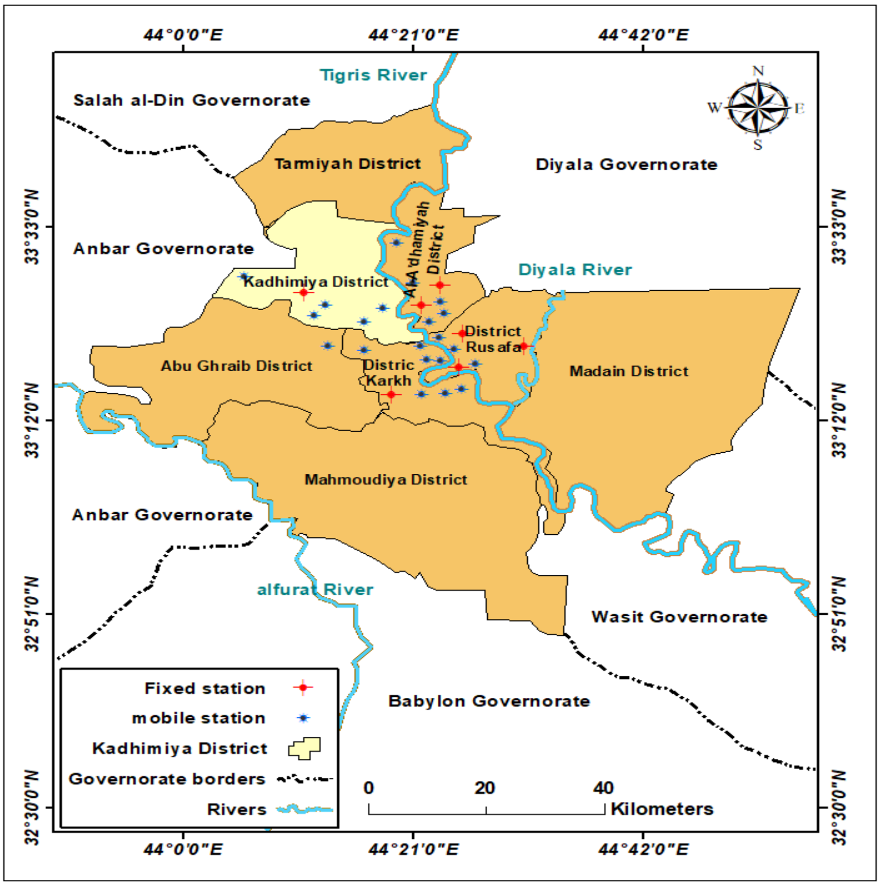

Map (3) shows the location of stations measuring the concentrations of suspended particles in the air

Source: Researcher based on:

1- Ministry of Water Resources, General Authority for Survey, Baghdad Governorate Administrative Map at a scale of 1/500,000, 2017.

2- Ministry of Transport and Communications, Iraqi General Authority for Meteorology and Seismic Monitoring, Climate Department

Table (3) shows the concentrations of suspended particles in the study area.

Year	2018			2019			
Station / Month	Station2	Station3	Station4	Station1	Station3	Station4	Station5
January	317.7 258.7	-	162.0 84.8	-	92.7 76.2	190.1 152.2	-
February	221.3 192.8	-	174.8 101.5	-	184.8 174.7	168.2 153.6	-

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March	185.9 119.7	-	621.8 471.5	197.8 179.3	-	-	313.8 276.8
April	768.6 361.5	-	605.2 375.8	2633.4 1047.0	-	-	464.0 405.9
May	1125.4 850.2	-	382.3 318.2	1056 566.8	-	-	1708.1 1024.5
June	535.2 504.9	-	607.5 525.8	617.2 557.6	-	-	-
July	875.3 806.6	1161.5 885.0	1178.8 793.8	-	-	-	-
August	1116.3 921.7	496.9 486.04	815.2 805.9	-	-	-	-
September	674.1 649.7	461.2 445.2	633.2 595.7	-	-	-	-
October	1617.6 1499.8	632.2 545.0	1458.6 885.7	-	-	-	-
November	355.2 345.2	306.3 296.6	467.2 370.6	-	-	-	-
December	386.8 290.9	72.5 56.9	480.5 324.3	-	-	-	-

Source: Researcher's own work based on:

1- Results of air sample analyses at the Central Environmental Laboratory.

2- Ministry of Transport and Communications, Iraqi General Authority for Meteorology and Seismic Monitoring, Climate Department.

Regarding the analysis of suspended particle concentrations in the study area for 2019, measurements of total suspended particulates (TSP) taken from four fixed stations from February to June. The findings revealed that:

1- On particularly dusty days, the highest daily TSP concentrations reached 10,370 µg/m3, with other readings surpassing 5,000 µg/m3.
2- The peak monthly average for TSP levels at the stations in June ranged from 1,056 to 1,708.1 µg/m3.
3- The TSP concentration data indicates that the first half of 2019 experienced more dust than the same period in 2018. Regarding heavy metal analysis, the concentrations of six elements (lead, iron, copper, chromium, cobalt, and cadmium) were determined by examining 23 TSP samples collected from the stations. These samples analyzed using an atomic absorption spectrophotometer, as detailed in Table (4).

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Table (4) shows the concentrations of heavy elements in the air of the study area.

T	Element	Concentration value (µg/m3)		
		Minimum Limit	Maximum Limit	Average
1	lead	0	6.064	0.8019
2	Iron	0	7	1.7029
3	Copper	0	6.14	0.8705
4	Chrome	0	5.6	1.267
5	Cobalt	0	4.7204	0.7145
6	Cadmium	0	0.3	0.02174

Source: Researcher's own work based on:

1- Results of air sample analyses at the Central Environmental Laboratory.

2- Ministry of Transport and Communications, Iraqi General Authority for Meteorology and Seismic Monitoring, Climate Department.

Table (4) indicates that there are no significant concentrations of any metals, except for a notable increase in lead levels, particularly in urban air. This lead found as small inorganic particles under 1 micron, such as chlorides and carbonates, with only about 10% or less existing as organic lead from petroleum sources. The key findings summarized as follows:

1. There is no correlation between lead levels and total suspended particulate (TSP) concentrations.
2. Lead levels are higher than the WHO average, although in some areas, the annual average is below 1 microgram/m3, which is still within WHO standards.
3. In certain locations, lead levels can exceed 6 micrograms/m3 on a daily average, which is significantly higher than WHO guidelines. Therefore, it is essential to reduce these levels in Baghdad. The recommended concentrations are:

- 24-hour average: 2 micrograms/m3
- Annual average: 0.7 micrograms/m3

These suggested values align with WHO standards and fall within the range of lead concentrations in the air around Baghdad, except for some instances that surpass permissible limits, which do not pose a risk to human health.

Based on the analyses presented in Tables 3 and 4, proposed air quality standards for the area around Baghdad, including the Kadhimiya district, can established concerning the levels of suspended particles (TSP). These standards show in Table 5.

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Table (5) shows the proposed standards for the quality of the air surrounding the city of Baghdad and the district of Kadhimiya in relation to (TSP).

Particle diameters (TSP) less than 10 microns			
T	Duration	Rate/Time	Concentration
1	Short Period	30 Minutes	500 micrograms/m^3
		Daily average	150 micrograms/m^3
	Long Period	Yearly average	80 micrograms/m^3
Particle diameters (TSP) for all Volumes			
2	Short Period	60 Minutes	750 micrograms/m^3
		Daily average	500 micrograms/m^3
	Long Period	Yearly average	300 micrograms/m^3
3	**Fe – Cu – Cr – Co –Cd**	-	

Source: Researcher's work based on the results of analyses of suspended particulate matter (TSP) concentrations in Table (3) and Table (4).

These standards created for all days except those with dust, and the rationale for establishing elevated values for (TSP) is:

1. **Dust is a frequent occurrence in Iraq, leading to dust storms in Iraqi governorates, particularly in the summer. Additionally, most sand particles are larger than 10 microns, which means they do not penetrate the lungs.**
2. **Since dust storms are a natural event, there is no effective method to reduce their impact in Baghdad Governorate and the specific study area.**

Employing the direct approach to evaluate the environmental effects of air pollution in the Al-Kadhimiya area, focusing on total suspended particles (TSP).

The environmental impact of total suspended particles (TSP) evaluated using the direct method, as shown in Tables (4) and (5). This method allows the researcher to easily evaluate the effects of these pollutants using descriptive terms like (negative impact, beneficial impact, no impact). Table (6) will highlight the key elements affected by these suspended pollutants by examining changes in their properties (physical, chemical, biological), including air, soil, plants, surface water, and public health and safety. This will help estimate the level of environmental damage caused to various environmental components.

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Table (6) shows the assessment of the environmental impact of total suspended particulate matter (TSP) on the various environmental elements in the study area.

Environmental Impact Assessment Indicators	Nature of Impact		Impact classification		Size of the Impact	Exposure duration		Sphere of Impact		Cumulative Impact		Type of Impact
environmental element	negative	Positive	Direct Impact	Indirect Impact		Extended period	Short period	Regional	Local	Available	Not available	
Air	√		√		Big		√	√	√	√		Air pollution caused by total suspended particles (TSP), such as dust and heavy particles, poses a serious risk to human health. These particles can trigger various illnesses, especially asthma and allergies, by changing their natural properties, as shown in Tables 4 and 5.

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Soil and plants	√		√		Big	√	√	√	√	√		The deposition of suspended materials containing heavy elements on soil impacts both the soil and the plants growing in it. These particles contaminate the soil and can remain for extended periods without breaking down, affecting the organisms living there. They also form a layer on plant leaves that blocks sunlight. As a result, plant growth slows, productivity drops, and their ability to resist disease weakens.
Surface water	√		√		Big	√	√	√	√	√		Pollutants released into the air or mixed with rain cause surface water to become contaminated. This pollution changes the water's natural qualities and lowers its quality. As a result, the water becomes unsafe for human use and harms aquatic life, especially fish.

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Health and Safety	√		√		Big	√		√	√	√		Dust storms cause harmful effects from start to finish. The air pollution they produce linked to increased cases of asthma and respiratory allergies. When these storms return, they can also cause skin and eye problems, including cracking skin.

Source: The researcher based on

1- **Sameh Ghraibeh, Yahya Al-Farhan, Introduction to Environmental Sciences, 4th ed., Dar Al-Shorouk for Publishing and Distribution, Amman, Jordan, 2002, p. 434.**

2- Results of the analyses mentioned in Tables (4) and (5)

Conclusions

1- Baghdad lacks a specific program to monitor air quality due to insufficient stations and equipment, indicating a need for an air quality management system in the city.
2- Total Suspended Particulate (TSP) levels indicate that all areas of Baghdad are affected by dust pollution, with the Kadhimiya district recording concentrations as high as 3,500 micrograms/m3, which exceeds international standards.
3- The majority of TSP originates from natural sources, such as dust storms and airborne dust.
4- Heavy traffic and industrial zones contribute to the dispersion of fine particulate matter, particularly lead.
5- In 2018, the highest monthly average TSP concentration was 850 µg/m3 in June, July, and August, while the average for October was 1500 µg/m3. In 2019, the concentration peaked at 1024.5 µg/m3 in June, with the lowest monthly average recorded at 70.2 µg/m3 in January 2019. These figures are considered elevated compared to international standards.
6- The first half of 2019 experienced more dust than in the same period in 2018.

Recommendations

1. The research suggests that Baghdad should enhance its air pollution monitoring by increasing the number of stations and devices, thereby establishing an air quality management system.
2. The research advocates the expansion of green spaces and the planting of large,

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evergreen trees in urban areas to help mitigate the severity of dust storms.

3. The research recommends offering training programs for personnel involved in air pollution measurement, focusing on quality assessment and familiarization with modern pollution measurement devices to ensure accurate data collection instead of relying on estimates from specific weather conditions.

4. There should be ongoing efforts to raise environmental awareness among citizens about essential preventive measures during dust storms, such as installing window filters to lessen dust exposure and reduce the risk of suffocation, particularly for individuals with allergies and asthma.

5. Hospitals and health centers should be equipped to treat dust-related illnesses, and a specialized medical team should be deployed in urban areas during severe dust storms to address the health risks they pose to the public.

6. Municipal and environmental departments need to regularly wash and clean streets, sidewalks, and trees to minimize dust accumulation following each storm.

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