Spatial Analysis of Air Pollutants Emitted from Landfills in Baghdad City/ Iraq

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Abstract

The current study aims to demonstrate the environmental impact on the ambient air in landfills in the city of Baghdad. Measurements of air pollutants (Gases, Suspended Particles) were conducted during the period from January to August 2021. The results showed that the concentrations of gases: Nitric dioxide (NO_2), Carbon dioxide (CO_2), methane (CH_4) and Total Suspended Particles (TSP), Particulate Matter (PM2.5) slightly exceeded and recorded slight pollution in the ambient air of the landfills, except CO_2 exceeded with p-value<0.05. As for methane (CH_4) its concentrations did not exceed national or global limits. The high concentrations of gases measured are due to the decomposition of organic waste, waste-burning operations, and climatic factors. One of the reasons for the increased concentration of particles (TSP, PM2.5) is due to the effect of volatile waste particles in cases of loading or unloading waste, which increases its concentration. It was concluded there were gaseous emissions in varying proportions. So, its effect on the surrounding air is minimal, except CO_2.

Keywords: Air Pollutants, Landfills, Spatial Analysis, GIS, and Baghdad City.

التحليل المكاني لملوثات الهواء المنبعثة من مدافن النفايات في مدينة بغداد/ العراق

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هيئة البحث العلمي / مركز بحوث وتكنولوجيا البيئة والمياه والطاقات المتجددة – بغداد – العراق

الخلاصة

تهدف الدراسة الحالية إلى بيان الأثر البيئي على الهواء المحيط في مدافن النفايات في مدينة بغداد. أجريت قياسات لملوثات الهواء (الغازات، الجسيمات العالقة) خلال الفترة من كانون الاول إلى أغسطس ٢٠٢١. وأظهرت النتائج أن تراكيز الغازات: الميثان وثنائي أوكسيد الكاربون وثنائي أوكسيد النيتروجين (CH_4 وCO_2 وNO_2) والجزيئات الدقيقة والجسيمات العالقة الكلية (TSP, PM2.5) تجاوزت الحدود العالمية والمحلية قليلاً وسجلت تلوثاً طفيفاً في الهواء المحيط بالمدافن، باستثناء ثاني أكسيد الكربون، الذي تجاوز الحد الأقصى بقيمة $p < 0.05$. أما غاز الميثان (CH_4) فلم تتجاوز تركيزاته الحدود الوطنية أو العالمية. إن ارتفاع تركيزات الغازات التي تم قياسها يعود إلى تحلل النفايات العضوية وعمليات حرق النفايات والعوامل المناخية. من أسباب زيادة تركيز جزيئات (TSP, PM2.5) يعود إلى تأثير جزيئات النفايات المتطايرة في حالات تحميل أو تفريغ النفايات مما يزيد من تركيزها. واستنتج من ذلك إلى وجود انبعاثات غازية بنسب متفاوتة، لذا فإن تأثيره على الهواء المحيط يكون ضئيلًا، باستثناء ثاني أكسيد الكربون.

الكلمات المفتاحية: ملوثات الهواء، مدافن النفايات، التحليل المكاني، نظم المعلومات الجغرافية ومدينة بغداد.

Introduction

The pollutant analysis is a scientific analysis that helps to determine the threshold limit (It is the Acceptable Upper Limit of the Concentration of any Hazardous Substance in the Workplace) to know the acceptable moral level of these pollutants (Farmer, 2002). The World Health Organization (WHO) stated in a report that about twenty million children around the world suffer from pollution due to its reaching critical stages of excessive pollution (Kanmony, 2009). European Air Pollution Council as a significant change in the proportions of substances Constituent of the atmosphere when a strange substance is present in it or a substance is introduced into the atmosphere in a form Directly or indirectly, in a size that leaves an impact on the atmosphere, which results in damages to the atmosphere living organisms and ecosystems (Jamal, 2019), and the US Environmental Protection Agency defines air pollution as the existence of Pollutants or polluted materials in the air in a way that affects public health and human welfare or in a way that leads to other harmful environmental effects (Al-Hassan, 2019). Municipal Solid Waste management is a global problem, and its existence is not limited to one region without another in the world, where the decisions and policies taken by the concerned authorities related to the disposal and treatment of waste affect the degree of environmental pollution, as the environmental scientist Robert Morrison says: Man is the most successful living organism in the reconstruction and settlement of the earth, but it is also the most corrupting and polluting organism. The issue of urban waste has become a public and private issue at all levels: global, national, and local, especially if we know that the problem of waste is not an issue of the amount of waste that is collected, transported, and disposed of, but rather an intertwined issue in which many social, economic and administrative dimensions overlap. This phenomenon arose and developed in Algeria, like other countries in which the problem of urban waste has been exacerbated, and it seeks through devices based on urban cleanliness to get rid of this waste, but it did not keep pace with this development and became unable to control and control the conduct of This waste is properly and environmentally sound (Gherbi, 2012). Current global Municipal Solid Waste (MSW) generation levels are approximately 1.3 billion tons per year and are expected to increase to approximately 2.2 billion tons per year by 2025 (Scarlat, *et al*., 2015). This represents a significant increase in per capita waste generation rates, from 1.2 to 1.42 kg per person per day in the next fifteen years. However, global averages are broad estimates only as rates vary considerably by region, country, city, and even within cities. The higher the economic development and rate of urbanization, the greater the amount of solid waste produced (The World Bank, 2012). The composition of waste varies greatly from Mayoralty to Mayoralty (Country to Country) and changes significantly with time.

Solid waste constitutes an environmental problem in itself because it leads to environmental pollution if it is not recycled and utilized instead of being thrown randomly, as is the case with us now, where waste is thrown on the sides and edges of main and secondary roads as well as in agricultural lands, or it is collected from residential areas and from Then it is transferred to the pressing stations spread in Baghdad city, and then

it is transferred to the public dumps to be collected and then landfilled without treatment. Some countries have resorted to using modern technical methods to benefit from solid waste because the current environmental situation calls us to pay more attention to the impact that we leave individually and collectively on the environment.

The aims of this study include measuring Total suspended particles (TSP) in the air, particulate matter (PM2.5), and some gaseous pollutants (CO_2, NO_2, and CH_4) in solid waste landfills, and comparing their concentrations with the national and international permissible limits. Also, evaluating field results to determine the environmental and health impact of dwellers at landfill sites, and study the spatial analysis and discussion of the air pollutants concentrations at the inner and outer of the solid waste landfill sites in the study area.

Materials and Methods

Baghdad is the capital of Iraq. The geographical coordinates of the city are 33.312805 latitude and 44.361488 longitudes, with an area of more than 700 Km2. Its mean elevation is 39m above the mean sea level. The Tigris River divides the city into two parts: Al Rusafa (East of Tigris) and Al Karkh (West of Tigris) (Mohamed Meki, 2020). The city is divided into 131 districts on the east and waste banks of the Tigris River. These districts are further subdivided into many neighborhoods. Baghdad's population is almost 7,500,140, covering a neighborhood of about 205.1 Km^2.

The eastern region borders Diyala watercourse that connects the Tigris River to Baghdad's southwest. The 24Km Military Canal abandons the Tigris within the northern portion of the city and ended within the southern portion of the Diyala River (Mohammed and Al-Ramahi, 2020).

Municipal Solid Waste in Baghdad City

Disposal sites are randomly distributed in Baghdad and don't control the environmental effect. Waste dumps are distributed in the Baghdad governorate between the Karkh and Rusafa districts. In Rusafa, there are currently (5) constructed dumps, (5) under construction, and one landfill site currently operating. In Karkh district, there are (10) dumps distributed as follows: (4) waste collection dumps (Typical Presses), and (5) collection dumps representing regular transformational stations and a site for the final disposal of waste at (the site of Al-Buaitha), which is a sanitary landfill, but it is currently suspended and is part of the Karkh district, and (Al-Nabai Site), which is a regular landfill located outside the administrative borders of the Karkh district. The percentages of different types of waste in the Municipal Solid Waste (MSW) in Baghdad city and Iraq, organic waste was the largest proportion of waste, over 70% whereas plastic and paper come in second and third positions with 5.3% and 5% respectively. Several studies have been carried out to analyze the composition of municipal solid waste generated in Iraq and Baghdad areas. In general, these studies reveal a declining percentage of vegetable and organic fractions, possibly resulting from changing consumption pattern. The amount of normal waste collected in the governorate is large compared to the average amount of waste generated per capita, which in 2020 amounted to (1.5 Kg/day) in the areas located within the services of the Mayoralty of Baghdad and (1.4 Kg/day)

in the areas located on the outskirts of the governorate. (Outside the Boundaries of the Mayoralty of Baghdad), Table (1), necessitates that there are large works by the concerned institutions of the Mayoralty of Baghdad, as well as the municipal departments of the governorate.

Table (1) Amount of Normal Waste Collected and the Average Amount of Waste Generated per Capita in Baghdad Governorate in 2020 (Ministry of Planning, Central Organization for Statistics).

Governate	Population Served by Waste Collection Service	Amount of Normal Waste Removed	Amount of Normal Waste Collected	Amount of Normal Waste Removed	Average Amount of Normal Waste Lifted	Average Amount of Normal Waste Generated Per Capita
	Million	Ton/Year	Ton /Year	Kg/Year	Kg/Day	Kg/Day
Baghdad Mayoralty	5995951	3349960	9178	334996000	9177972.6	1.5
Outskirts of Baghdad	995408	497214.0	1362.2	497214000	1362230	1.4

Field Side of the Study

Fieldwork included conducting environmental measurements using special environmental devices to collect environmental samples, such as the Gas Met device, which detects the level of concentrations of gaseous pollutants (CO_2, NO_2 and CH_4), which is characterized by the speed of taking measurements and the ease of measuring them. Thus, it helps the analyst reduce time and effort and sense the sample directly. suspended particles (PM2.5, TSP) in the ambient air are measured using a device (Aerocet-531). The device is characterized by its small size, ease of transportation, and use in addition to great accuracy in results and speed. Measurements were made for the winter and summer periods and were represented by a point outside the landfill and another inside the landfill. It should be noted that external measuring points were taken at a distance of 200 meters, and other samples were taken to determine the level of concentration of heavy metals in the ambient air inside each landfill using the air sampling device (Sniffer). In addition, all climatic components of the measurement points were taken simultaneously at the time of the air sampling.

Collection Samples of Air Pollutants

Samples for this study were collected during the period (January to August 2021 (On Workers in Waste Landfills (Temporary Transfer Stations), which included 6 sites, represented by five landfill sites (Temporary Transfer Stations) and one control site in the capital, Baghdad (Karkh and Rusafa Districts). The daily work period for workers inside the landfill is 6-10 hours, interspersed with rest hours inside the landfill. Measurements were made for the winter and summer periods and were represented by a point outside the landfill and another inside the landfill. It should be noted that external measuring points were taken at a distance of 200 meters, and other samples were taken to determine the level of concentration of heavy metals in the ambient air inside

each landfill using the air sampling device (Sniffer). In addition, all climatic components of the measurement points were taken simultaneously at the time of the air sampling.

Results

Field measurements of air pollutants emitted from the dumps of transformational stations which included gaseous emissions (CH_4, NO_2, CO_2) and particulate matter (TSP, PM2.5) in all waste dumps (Transformation Stations) under study for the city of Baghdad was conducted. This is to show the level of pollutant concentrations in the study area and match them with the local and global determinants of the winter and summer seasons, and to indicate the most important reasons that led to their emission, as well as to clarify the effect of climatic factors on the dispersion or concentration of these pollutants.

The results of winter measurements of the internal measuring point for carbon dioxide indicated that the highest concentration was (454.89) ppm in the Adhamiya landfill and the lowest concentration (397.65) ppm in the Baghdad Aljadeeda landfill, as shown in Table (2). Summer measurements of internal point recorded the highest concentration of (474.14) ppm for the Baghdad Aljadeeda landfill, while the lowest concentration was (444.995) ppm in the Kadhimiya landfill. Figures (1 and 2) shows the concentrations of (CO_2) gas in all the selected sites for the winter and summer seasons when comparing the concentrations of carbon dioxide (CO_2) during the measurement period. Its emissions in all the landfills for both seasons were higher than the global limit limits of (250) ppm of (CO_2) gas. One of the reasons that led to the highest concentration of carbon dioxide gas in the Adhamiya landfill is the presence of waste residue after daily clearing (i.e., Removing Waste Daily from the Landfill and Transporting it to the Landfill), in addition to the fact that in the winter from time-to-time fires occur in the landfill due to scavengers working in the landfill. They are not allowed to enter the landfill or light a fire for heating, in addition to the landfill sites being close to means of transportation that increase emissions of gas concentrations (CO_2).

The high humidity contributed to increasing the concentration of the gas in these sites. Summer measurements of carbon dioxide gas were also carried out at the external point of the landfills, where the highest concentration was recorded (468.435) ppm in the New Baghdad Landfill and the lowest concentration was (433.525) ppm in the Shuala landfill in the summer season, as shown in Table (2) and Figures (1 and 2).

Table (2) The Concentration of Air Pollutant Gas (CO2 Mean/ppm) in Landfills of the Study Area.

Landfills Name	Sampling Sites	CO_2 Mean in Winter Season	CO2 Mean in Summer Season
Kadhimia	External Point	436.675	443.355
	Internal Point	425.84	444.995
Alshuela	External Point	442.09	433.525
	Internal Point	447.255	446.26
Adhamiya	External Point	446.325	453.67
	Internal Point	454.89	446.1
Abu Dashir	External Point	427.435	457.475

	Internal Point	418.505	469.8
Baghdad Aljadeeda	External Point	400.54	468.435
	Internal Point	397.65	474.14
Control	External Point	330.705	426.8
	Internal Point	271.78	421.065
P-value	---	0.02 *	0. 04*

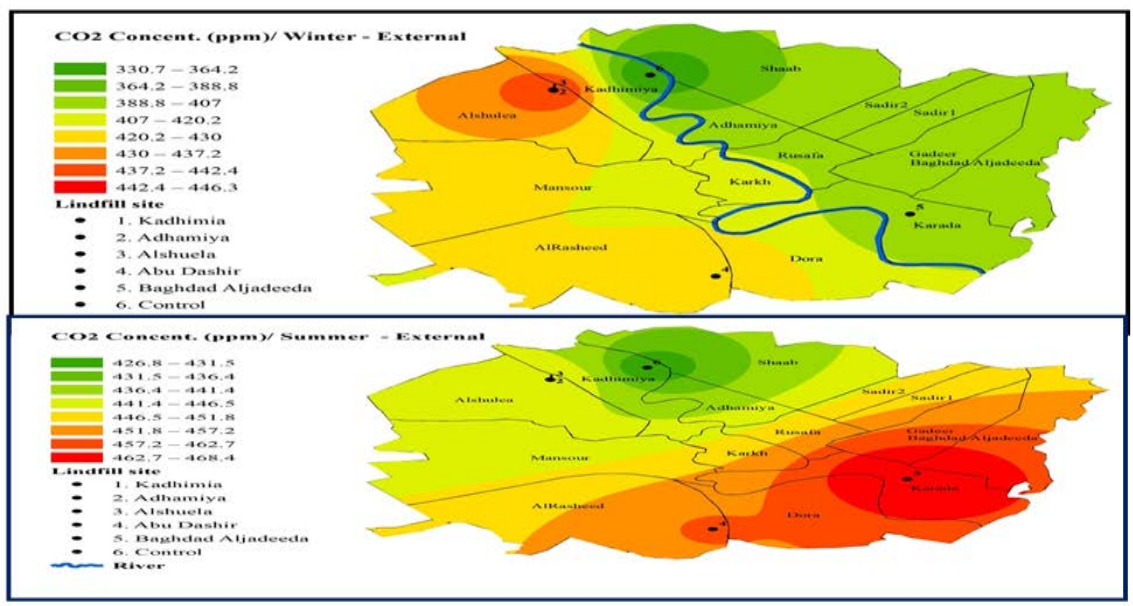

Figure (1) Spatial Analysis of CO_2 Concentrations (ppm) in the Internal Sites of the Study Area during the Summer and Winter Season.

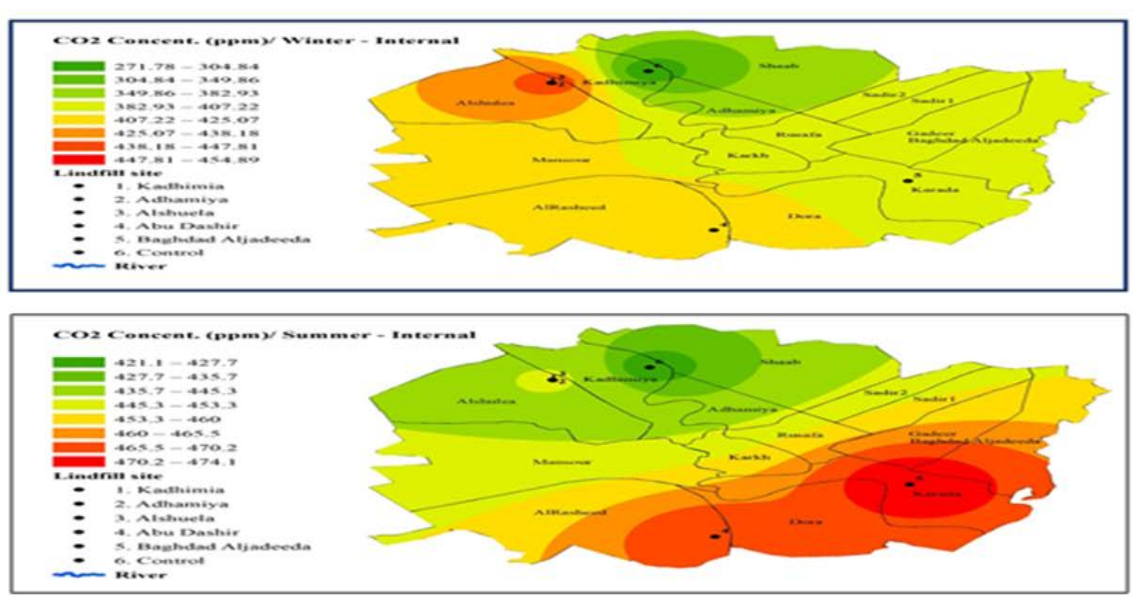

Figure (2) Spatial Analysis of CO_2 Concentrations in the External Sites of the Study Area during the Summer and Winter Season.

Winter measurements of the external sites recorded the highest concentration of (446.325) ppm for the Adhamiya landfill, while the lowest concentration was)400.54 (ppm in the Baghdad Aljadeeda Landfill. When comparing all external measurement sites with the global limiter, we find that they exceeded the limits of the global limiter, for several reasons that helped the increase in gas concentration at this point including the wind factor, which helps carry pollutants from the landfill, as well as the design of the open landfill, which helps facilitate the movement of pollutants to the surrounding area. A fire is often lit in winter for heating, in addition to the presence of a special garage for parking landfill trucks nearby from the landfill, and when comparing the highest concentrations of external points, the landfills with the highest concentrations of the internal point that were measured inside the landfills, we find that most of the measuring external point the landfill recorded higher concentrations than the internal point the landfills, and this is due to the participation of the means of transport near the landfills in the concentration of this gas in the external point. NO_2 gas recorded its highest concentration (1.31) ppm in the Kadhimia Landfill, and its lowest concentration was (0.03) ppm in the Shualaa Landfill. As for Summer measurements at the internal point, the highest concentration was (0.53) ppm in the Abu Dashir Landfill, while the lowest concentration was (0.22) ppm in the Shualaa Landfill, as shown in Table (3). Some concentrations exceeded the limits of the national and international limits, except for the measuring point in the Shualaa and Baghdad Aljadeeda landfills did not exceed the limits, as shown in Table (3). When comparing NO_2 gas concentrations with the national limits represented by (0.1) ppm and the international limits represented by (0.2) ppm. Therefore, the locations where the gas exceeds the limits National and international, can cause environmental and health impacts. As for the external point of the landfills for winter, their highest concentration was (0.915) ppm in the Adhamiya Landfill and the lowest concentration was (0.115) ppm in the Baghdad Aljadeeda Landfill, while the results in the summer season were the highest concentration of (0.86) ppm in the Abu Dashir Landfill and the lowest concentration was (0.01) ppm in the Adhamiya Landfill, and when compared with we find that the national and international limiters exceeded the limits, as in the Adhamiya Landfill and the Abu Dashir Landfill, except for the measuring point in the Shualaa and Baghdad Aljadeeda landfills, which did not exceed the permissible limits locally and internationally. When comparing the highest concentrations of external points, the landfills with the highest concentrations of the sites that were measured inside the landfills, we find that the measuring sites are outside the landfills. The landfill recorded lower concentrations than the internal point of the landfill, and thus we conclude that (NO_2) gas produced from the landfill affects the surrounding air.

Figures (3 and 4) show the spatial analysis of (NO_2) ppm concentrations in regular transfer station dumps for winter and summer measurement at all external and internal sites. The results of the study agreed (Ipeaiyeda and Falusi, 2018) with the results of the current study, which indicated the cause of the emission of gases from open waste dumps, which is a major source of air pollution, and the open burning of municipal solid waste is

linked to the emission of gases, which have a direct impact on the environment and human health by exceeding the levels of the national standard air quality limits of the European Union.

Table (3) The Concentration of Air Pollutant Gas (NO_2 mean/ppm) in Landfills of the Study Area.

Landfills Name	Sampling Sites	NO_2 Mean in the Winter	NO_2 Mean in the Summer
Kadhimia	External Point	0.285	0.415
	Internal Point	1.31	0.415
Alshuela	External Point	0.435	0.475
	Internal Point	0.03	0.22
Adhamiya	External Point	0.915	0.01
	Internal Point	0.75	0.26
Abu Dashir	External Point	0.395	0.86
	Internal Point	0.295	0.53
Baghdad Aljadeeda	External Point	0.115	0.435
	Internal Point	0.565	0.5
Control	External Point	0.04	0.095
	Internal Point	0.015	0.04

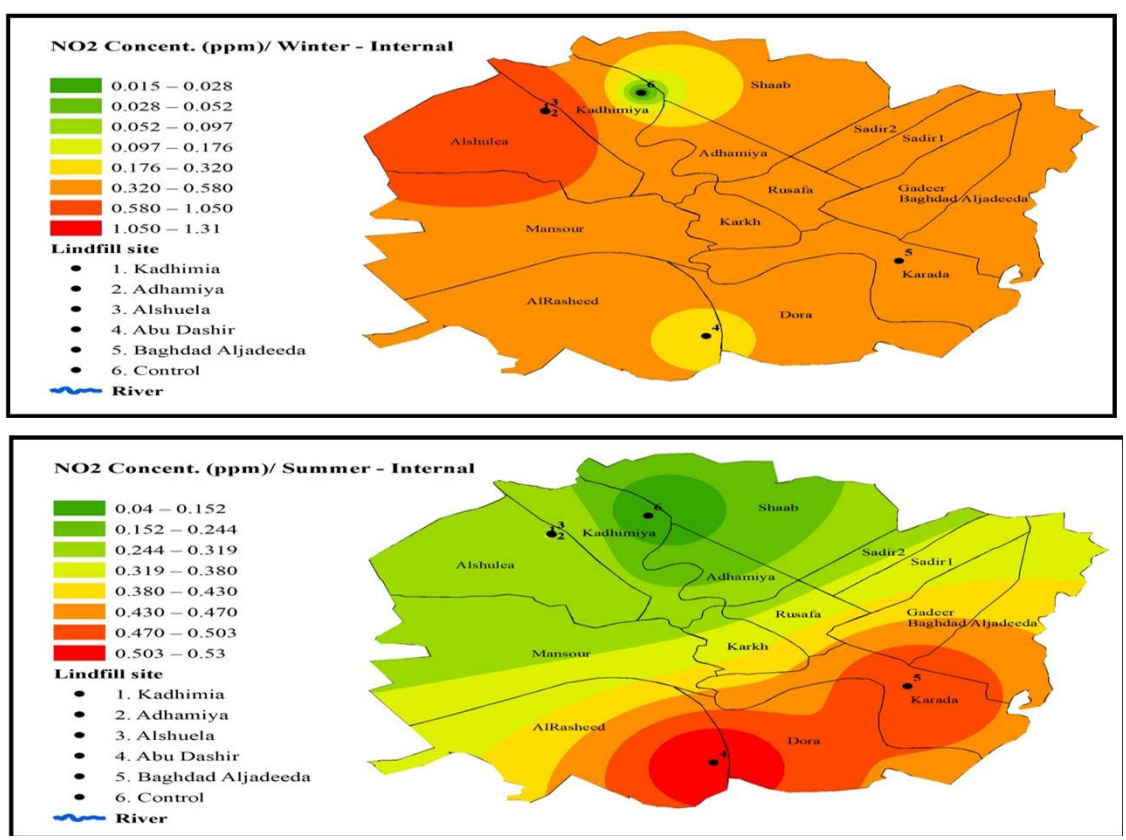

Figure (3) Spatial Analysis of NO_2 Concentrations (ppm) for Internal Sites in Landfills for the Winter and Summer Seasons.

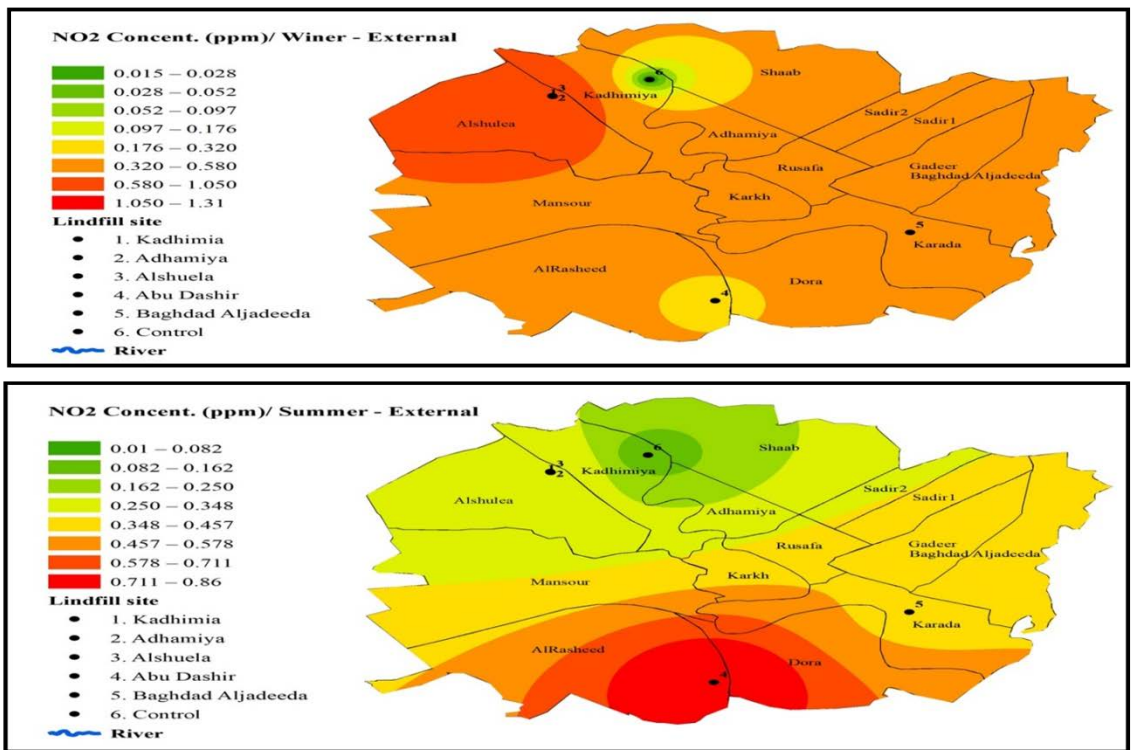

Figure (4) Spatial Analysis of NO_2 Concentrations (ppm) for External Sites in Landfills for the Winter and Summer Seasons.

Table (4) The Concentration of Air Pollutant Gas (CH4 ppm) in Landfills of the Study Area.

Landfills Name	Sampling Sites	CH_4 Mean in Winter	CH_4 Mean in Summer
Kadhimia	External Point	2.155	2.185
	Internal Point	2.35	2.295
Alshuela	External Point	2.235	2.235
	Internal Point	2.295	2.245
Adhamiya	External Point	2.28	2.25
	Internal Point	2.45	2.285
Abu Dashir	External Point	2.085	2.34
	Internal Point	1.685	2.27
Baghdad Aljadeeda	External Point	1.76	2.23
	Internal Point	1.795	2.245
Control	External Point	1.59	2.17
	Internal Point	1.075	1.915

The methane gas (CH_4) concentrations in the winter measurements of at internal measurement points showed that its highest concentration reached (2.45) ppm in the Adhamiya Landfill, and its lowest concentration was (1.685) ppm in the Abu Dashir. As for summer measurements, the highest concentration was (2.295) ppm in the Kadhimiya, and the lowest concentration was (2.245)

ppm in the Shualaa and Baghdad Aljadeeda landfills. The results were recorded when compared with international standards represented by (3) ppm. We noted that it is less, and thus its emission in the study areas is less than the WHO global limits, as shown in Table (4). The high amount of gas in the Adhamiya, despite the daily zeroing of the landfill, is due to many reasons, including the presence of remaining quantities of decomposing waste, in addition to the fact that most of the waste entering the landfill is organic waste, as it comes from residential areas, which are the main source of emission of this gas as a result of the decomposition of organic waste. Just as there are polluting gases that cause unpleasant odors in the landfill, there are also odorless polluting gases in open waste dumps, such as carbon dioxide and methane gas, which are known as landfill gases, which are emitted due to organic decomposition by bacterial organisms of the garbage inside the landfill, so that the concentrations of these gases reach 60%. For carbon dioxide and 50% for methane (Ezekwe and Arokoyu, 2017). Climatic factors also play an important role in increasing the emission of this gas, especially when the winds calm towards the landfill, which leads to an increase in its concentration in this area. Figure (5 and 6) shows the concentrations of methane gas in regular landfill sites for the winter and summer.

By observing the results of the external point, the landfill for the winter, it becomes clear that the highest concentration is (2.28) ppm in the Adhamiya, while the lowest concentration is (1.76) ppm in the Baghdad Aljadeeda. As for summer measurements of the external points, the highest concentration was (2.34) ppm in the Abu Dashir Landfill, but the lowest concentration was (2.185) ppm In the Kadhimiya, all measuring external points the landfill has very low concentrations of methane gas, less than the possibility of detecting the device of (0.1) ppm, and when compared with the global limiter, we find that they did not exceed the limits of the limiter. When comparing the highest concentrations of external point, the landfills with the highest concentrations of the sites that were measured inside the landfills, we find that the measuring external point of the landfill recorded lower concentrations than the internal point of the landfills, and thus we conclude that the (CH_4) gas produced from the landfills does not have the effect of the surrounding air. Table (4), and Figure (5,6) show the spatial analysis of methane concentrations (CH_4 ppm) in regular transfer station dumps for winter and summer

measurements.

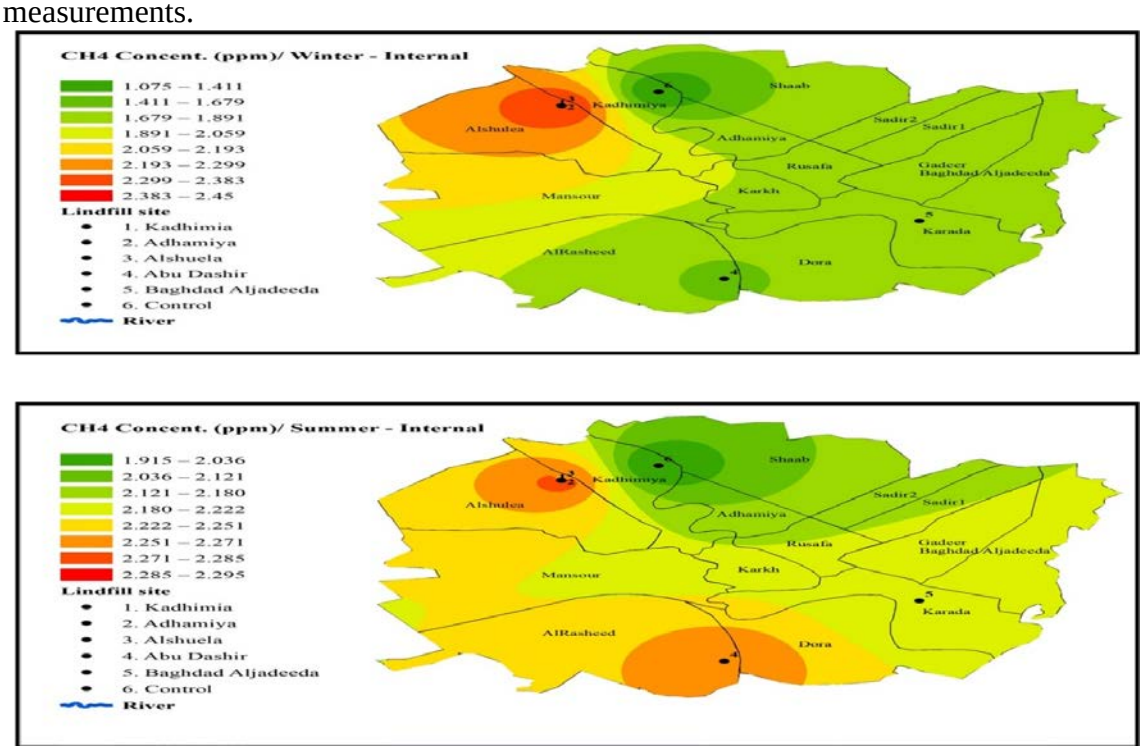

Figure (5) Spatial Analysis (CH_4) Concentrations for Internal Sites in Landfills in the Winter and Summer Seasons.

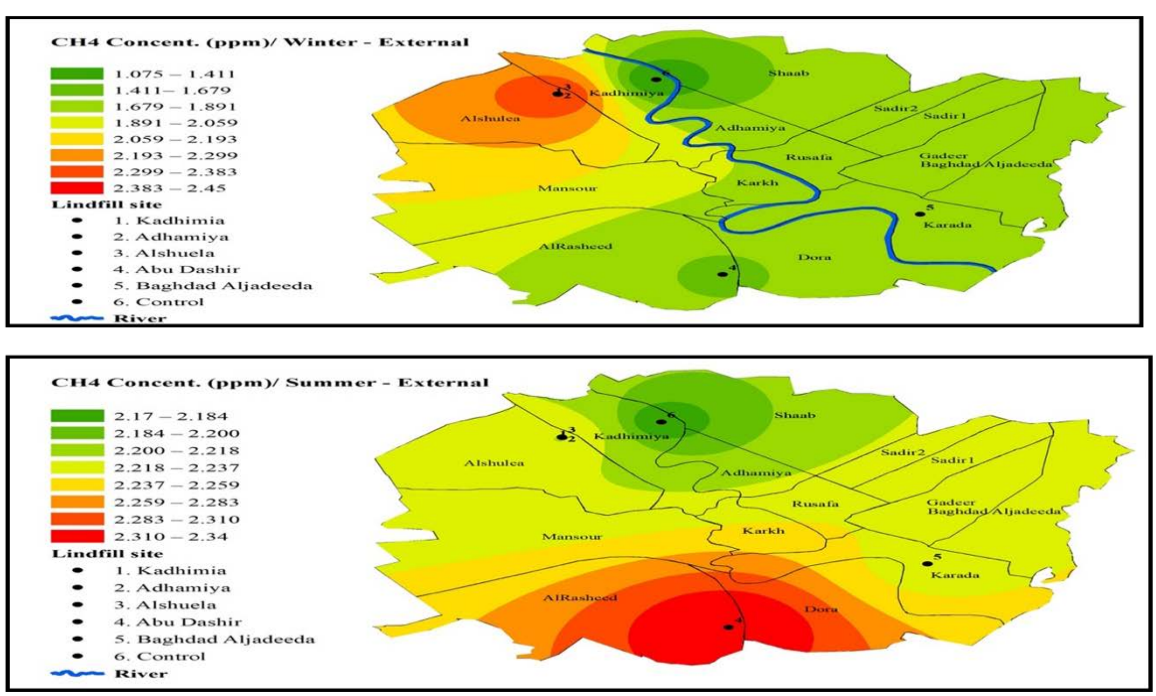

Figure (6) Spatial Analysis (CH4) Concentrations for External Sites in Landfills in the Winter and Summer Seasons.

Winter measurements of internal points in the landfill found that the highest concentration of these particles was in the Abu Dashir, represented by (0.032 µg/m³) and the lowest concentration of suspended particles was in the Baghdad Aljadeeda, represented by (0.018 µg/m³). As for summer measurements of internal points, the highest concentration was recorded. (0.048 µg/m³) in the Adhamiya Landfill, while the lowest concentration was (0.012 µg/m³) in the Baghdad Aljadeeda Landfill. By comparing the highest and lowest concentrations of suspended particles ($PM_{2.5}$) during the chosen measurement period in winter and summer, we noted that its highest concentration was in the Abu Dashir and Adhamiya landfills. Values exceeded the limits of the national limits of (0.015µg/m³ (and the international standards (0.025µg/m³ (for suspended particles ($PM_{2.5}$).As for the winter and summer measurements of external points of the landfill, the highest concentration of external point of the landfill was (0.082 µg/m³) in the Abu Dashir Landfill, while the lowest concentration was (0.003µg/m³) in the Baghdad Aljadeeda Landfill. As for the summer measurements of the external point of the landfill, the highest concentration was (0.032µg/m³) in the Adhamiya Landfill, while the lowest concentration was (0.002 µg/m³) at the Kadhimiya and Shualaa landfills. It also showed that the high concentrations for both seasons exceeded the permissible national and international limits. When comparing the internal point of the highest concentration with the external point, it was found that the internal points were higher than the external point. This confirms the reasons mentioned above, and as shown in Table (5) and Figures (7 and 8) of the measurement results for winter and summer for the external and internal points.

Table (5) The Levels of Particles Matter ($PM_{2.5}$ µg /m³) in Landfills of the Study Area.

Landfills Name	Sampling Sites	$PM_{2.5}$ (µg /m³) Mean in Winter	$PM_{2.5}$ (µg /m³) Mean in Summer
Kadhimia	External Point	0.021	0.002
	Internal Point	0.025	0.015
Alshuela	External Point	0.016	0.002
	Internal Point	0.026	0.025
Adhamiya	External Point	0.017	0.032
	Internal Point	0.019	0.048
Abu Dashir	External Point	0.028	0.026
	Internal Point	0.032	0.045
Baghdad Aljadeeda	External Point	0.003	0.005
	Internal Point	0.018	0.012
Control	External Point	0.002	0.005
	Internal Point	0.004	0.009

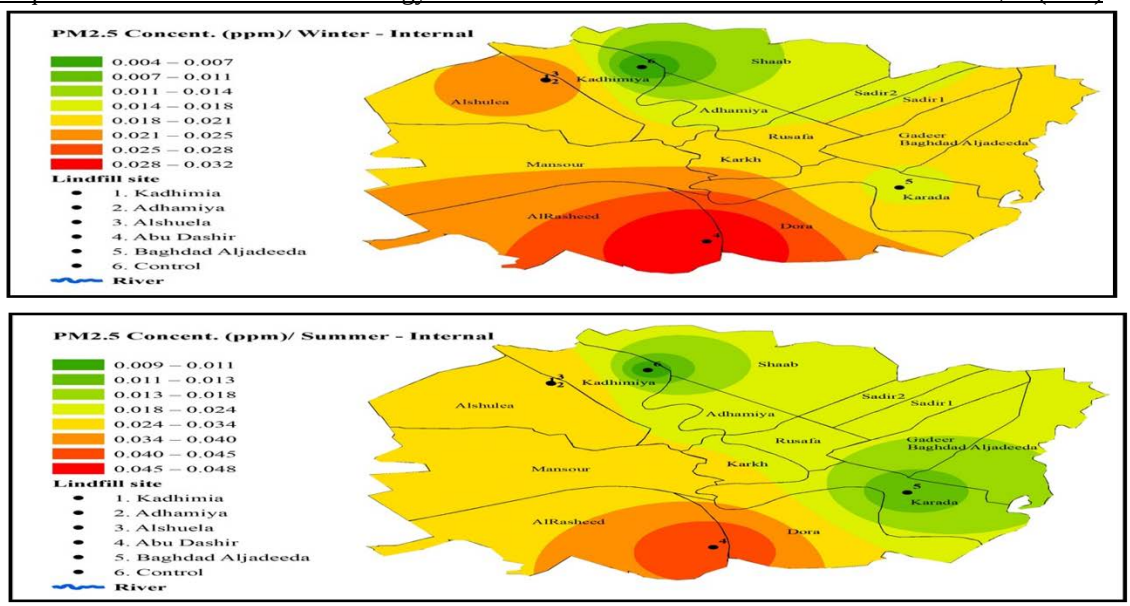

Figure (7) Spatial Analysis ($PM_{2.5}$) Concentrations for Internal and Sites in Landfills in the Winter and Summer Season.

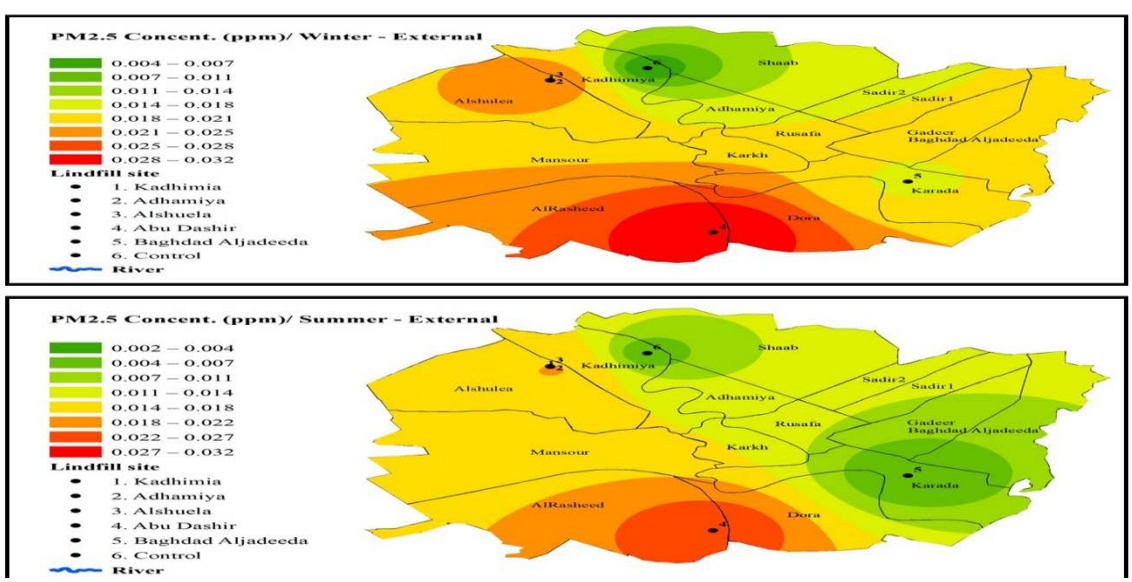

Figure (8) Spatial Analysis ($PM_{2.5}$) Concentrations for External and Sites in Landfills in the Winter and Summer Seasons.

Winter and summer measurements of the measurement sites for total suspended particles (TSP) in Table (6) showed the highest concentration for these particles, the Al-Shualaa Landfill was (1314.48 µg/m³), and the lowest concentration for these particles was (92.54 µg/m³) in the Baghdad Aljadeeda Landfill. As for the readings recorded in the summer, the highest concentration was (2.914 µg/m³) in the Abu Dashir Landfill, while the reading was lower concentration was (0.524µg/m³) in the Baghdad Aljadeeda for the concentrations of suspended particles (TSP) at the selected sites about the regular landfill sites for the winter and summer.

Table (6) The Concentrations of (TSP) µg/m³ of Landfills for the Study Area.

Landfill Name	TSP (µg/m³) Mean in Winter	TSP (µg/m³) Mean in Summer
Kadhimia	433.33	1.702
Alshuela	1314.48	1.865
Adhamiya	214.81	1.216
Abu Dashir	494.66	2.914
Baghdad Aljadeeda	92.54	0.524
Control	158.98	201.77

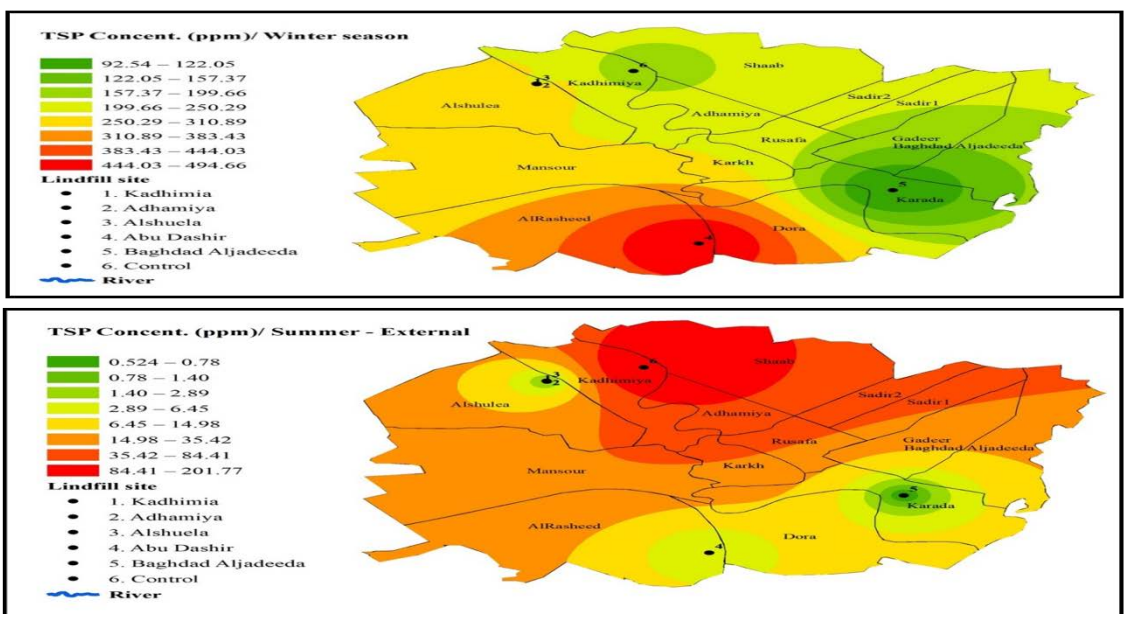

Figure (9) Spatial Analysis of (TSP) Concentrations in Landfills in the Winter and Summer Seasons.

When comparing TSP concentrations with the national limits of (0.35µg/m³) and the international limits (0.09 µg/m³), we notice that the highest concentration was in Al-Shualaa, where it exceeds the limits of the national and international limits, while the lowest concentration was in the Baghdad Aljadeeda, where it exceeded the limits of the national and international limits.

Figure (9) shows the spatial analysis of the concentrations of total suspended particles (TSP µg/m³) in the dumps of regular transfer stations for winter and summer measurement. The reason for increase in the concentration of total suspended particles (TSP) in the Shualaa is due to several reasons, including the particles scattered from the waste during loading or unloading of waste, which increases the concentration of particles in the air, as well as the movement of trucks used inside the landfill, which contributes to its increase. In addition to some other factors that also led to an increase in the concentrations of particulate matter in this landfill more than others, its location, which is characterized by proximity to the movement of transportation means, as there is a private parking lot inside the landfill near the landfill. The movement of trucks and vehicles leads to an increase in the total particulate matter

concentrated in the air. as well as the presence of a small factory between the landfills that recycles all the plastic materials collected from the landfill waste by the scavengers which contribute to these increasing pollutants in the surrounding air. In addition to the prevailing climatic factors, including the prevailing winds in the direction of the landfill and the relative calm that it enjoyed throughout the day in which the measurement was made, which helped to concentrate the particles near the landfill, and the high relative humidity and lack of vegetation around the site helped to increase the concentration of particles. In addition to the open design of the landfill, which helps facilitate the movement of particulate matter to the surrounding area, the movement of trucks carrying waste near the landfill, which coincides with its collection at the time of measurement, helped to concentrate the particulate matter in the air surrounding the landfill.

Discussion

The gas (CO_2) produced from the landfills affects the surrounding air. When explaining the causes of the emission of polluting gases from landfills, the current study showed its agreement with a study of (Moghadam, *et al*., 2021) conducted in different regions of Iran, which showed that the emission of greenhouse gases from municipal solid waste disposal calculates the amount of waste that enters the landfills based on the rate of population growth and waste generation, and the difference is due to the emission greenhouse gases, including carbon dioxide, are due to differences in climate factors, including relative humidity and wind, as well as organic decomposition. The reason for the high concentrations of NO_2 gas in some study landfills is that the landfill sites are located near the highway, which is part of the increase in gaseous emissions, in addition to the decomposition of the organic waste remaining in the landfill and the waste burning operations that occur in some periods. Another important reason is the climatic factor, especially the winds represented by their direction towards the landfill and their speed, which helps to carry pollutants played a major role in causing gas emissions and not dispersing them. The results of the study agreed with (Ipeaiyeda and Falusi, 2018) which indicated the cause of the emission of gases from open waste dumps, which is a major source of air pollution, and the open burning of municipal solid waste is linked to the emission of gases, which have a direct impact on the environment and human health by exceeding the levels of the national standard air quality limits of the European Union.

The low concentrations of (CH_4) gas in the landfills, by comparing it with the global parameters for methane gas, is due to many reasons, including the location of the landfill, which helps the movement of wind and the lack of concentration of pollutants, as well as the technical management represented by daily zeroing of the landfill, which prevents the accumulation of waste, which reduces emissions. In addition, lower temperatures reduce the decomposition of materials' residual organic matter, which is the main cause of gas emissions from landfills. which is the main source of emission of this gas as a result of the decomposition of organic waste. Just as there are polluting gases that cause unpleasant odors in the landfill, there are also odorless polluting gases in open waste dumps, such as carbon dioxide and methane gas, which

are known as landfill gases, which are emitted due to organic decomposition by bacterial organisms of the garbage inside the landfill, so that the concentrations of these gases reach 60%. For carbon dioxide and 50% for methane (Ezekwe and Arokoyu, 2017).

One of the reasons for the increased concentration of ($PM_{2.5}$) in some landfills in Baghdad city. This is due to the effect of volatile particles of waste in cases of loading or unloading waste, which increases its concentration, as well as the movement of truck vehicles used inside the landfill, which contributes to its increase. A study by (Peter and Nagendra, 2021) showed that the deterioration of the ambient air is primarily due to open dumps and the activities that occur in them, including burning waste, as well as nearby residential areas where waste is burned. Thus, burning waste in the open air contributes to increasing levels of suspended particles of ($PM_{2.5}$). This is consistent with the results of the current study. The reason for an increase in the concentration of total suspended particles (TSP) in some landfills is due to several reasons, including the particles scattered from the waste during the loading or unloading of waste, as well as the movement of trucks used inside the landfill. In addition to some other factors such as climatic factors, including the prevailing wind direction in the landfill and the relative calm with which the measurement was made, which helped to concentrate the particles near the landfill, and the high relative humidity and lack of vegetation around the site helped to increase the concentration of particles (Yang, *et al*., 2022).

Conclusions

It was concluded from the results of the study that the concentrations of pollutants emitted from the dumps of regular transfer stations have a varying impact on the surrounding air, as most of the pollutants (NO_2, CO_2, $PM_{2.5}$, TSP). emitted exceeded the limits of national and international limits, except the concentration of CH_4, which did not exceed the permissible limits of national and international limits.

References

Al-Hassan, S. I. (2019) An Introduction to Environmental Science and Its Problems, 2nd Edition, Dar Al-Maarif for University Books, Basra.

Ezekwe, I. and Arokoyu, S. (2017). Landfill Emissions and Their Urban Planning and Environmental Health Implications in Port Harcourt, South-South Nigeria. Desenvolvimento e Meio Ambiente.42.10.5380/dma.v42i0.52098.

Faleh, N. M. and Azzawi I. D. J. (2018). Design of Solid Waste Separation Equipment in Baghdad City. Journal of Mechanical Engineering Research and Developments, 41(3), 01-05

Farmer, A. (2002). Managing Environmental Pollution. New York, USA: Taylor and e - Library. 3-18.

Gherbi, M. (2012). Problematic of Environment Protection in Algerian Cities. Energy Procedia, 18, 265-275.

Ipeaiyeda, A. R., and Falusi, B. A. (2018). Monitoring of SO_2, NO_x and NH_3 Emission from Burning of Solid Wastes at Awotan and Lapite Dumpsites, Ibadan, Nigeria. South African Journal of Chemistry, 71, 166-173.

Jamal, Q. (2019). Air Pollution Concepts and Effects, Afaq Scientific Journal, (1), 1-10.

Kanmony, C. (2009). Human Rights and Health Care. New Delhi, India: Mittal Publication. 73-76.

Karamieh, N. (2017). Sustainable Development as an Approach to the Problem of the Environment and Urban Solid Waste Management: The Case of an unhappy City. A Magister Message That is not Published. University of Larbi Ben M'hidi- Oum El Bouaghi - Institute of Management of Urban Technologies. Algeria.

Moghadam, M. A.; Feizi, R.; Panahi Fard, M.; Haghighi Fard, N. J.; Omidinasab, M.; Faraji, M., and Shenavar, B. (2021). Estimating Greenhouse Emissions from Sanitary Landfills using Land-GEM and IPCC Model Based on Realistic Scenarios of Different Urban Areas: A Case Study of Iran. Journal of Environmental Health Science and Engineering, 19(1), 819–830.

Mohammed A. A. K. and Al Ramahi F. K. M. (2020). A Study of the Effect of Urbanization on Annual Evaporation Rates in Baghdad City Using Remote Sensing. Iraqi Journal of Science. 61(8), 2142-2149.

Peter, A.E. and Nagendra, S. S. (2021). Dynamics of $PM_{2.5}$ Pollution in the Vicinity of the Old Municipal Solid Waste Dumpsite. Environ. Monit. Assess. 2021 (193), 1–16.

Scarlat, N.; Motola, V.; Dallemand, J. F.; Monforti-Ferrario, F., and Mofor, L. (2015). Evaluation of Energy Potential of Municipal Solid Waste from African Urban Areas. Renewable and Sustainable Energy Reviews, 50, 1269-1286.

The Ministry of Planning/ Central Statistical Organization/ Environmental Statistics/ Iraq. (2020). Environmental Statistics for Iraq/ Municipal Services Sector for the Year 2020.

The Worldbank (2012). What Awaste. A Global Review of Solid Waste Management. The Urban Development Series Knowledge Papers. Washington, DC. USA.

Yang, Y.; Zhang, R., and Lou, Z. (2022). Bioaerosol Emissions Variations in Large-Scale Landfill Region and Their Health Risk Impacts. Frontiers of Environmental Science and Engineering, 16(12), 158.