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The impact of the green belt in obstruction air pollutants in the holy city of Karbala

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Abstract:

The research was conducted in the Southern Green Belt Project within the center district of the holy city of Karbala to evaluate its environmental impact and efficiency in reducing air pollutants emitted from the industrial area adjacent to the study area. The pollution attenuation factor (Af) was used to measure the effects of the green belt on impeding air pollutants. Measurements were taken every season from winter 2023 to Autumn 2024. The results showed that the best impedance of the green belt is when the wind speed increases in the Spring, as 7 out of 12 pollutants were impeded, and its efficiency decreased as the wind speed decreased. In general, The green belt demonstrated weak performance in impeding pollutants, As no significant differences were observed in pollutant concentrations due to the small width of the green belt, poor distribution of trees, and failure to follow scientific standards when selecting trees and planting sites. The study recommended increasing the width of the belt to 1000 meters and planting trees suitable for absorbing and blocking pollutants, and planting them in a way that helps curb air currents passing through the green belt.The research proposes to evaluate the efficiency of the Southern Green Belt Project implemented in Karbala Governorate and its role in obstructing some air pollutants and its effectiveness in improving the environmental reality of the center district.

Keywords: Green belt, disability factor, Karbala city, Air pollution.

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تأثير الحزام الأخضر في إعاقة ملوثات الهواء في مدينة كربلاء المقدسة

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جامعة بغداد /كلية علوم الهندسة الزراعية / قسم البستنة وهندسة الحدائق

المستخلص

اجريت هذه الدراسة في مشروع الحزام الاخضر الجنوبي ضمن قضاء المركز التابع لمدينة كربلاء المقدسة لتقييم اثرة البيئي وكفائتة في تقليل ملوثات الهواء المنبعثة من المنطقة الصناعية المجاورة لمنطقة الدراسة واستخدمت معادلة معامل تخفيف التلوث *AF* لقياس مدى تأثير الحزام الاخضر على اعاقة ملوثات الهواء ، اخذت القياسات كل موسم من شتاء 2023 وحتى خريف 2024 وأظهرت النتائج ان افضل اعاقة للحزام الاخضر تكون عند زيادة سرعة الرياح في فصل الربيع اذ تم اعاقة 6 ملوثات من اصل 13 بينما قلت كفائتة كلما قلت سرعة الرياح ، وبصورة عامة كان اداء الحزام الاخضر ضعيفا في اعاقة الملوثات ولم تظهر فروقات معنوية بين تراكيز الملوثات نظرا لقلة عرض الحزام الاخضر وسوء توزيع الاشجار فيه وعدم اتباع المعايير العلمية عند اختيار الاشجار ومكان الزراعة . أوصت الدراسة الى زيادة عرض الحزام الى 1000 متر وزراعة الاشجار الملائمة في امتصاص الملوثات واعاقتها وان تزرع بتنسيق يساعد على كبح التيارات الهوائية المارة خلال الحزام الاخضر .

هدفت الدراسة لتقييم كفاءة مشروع الحزام الاخضر الجنوبي المنفذ في محافظة كربلاء ودورة في اعاقة بعض ملوثات الهواء ومدى فاعليته في تحسين الواقع البيئي لقضاء المركز .

الكلمات المفتاحية :

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1.Introduction:

The green belt refers to open spaces encircling cities designed to preserve the natural environment, enhance residents' quality of life, and restrict unplanned urban sprawl. These areas consist of natural, forested, or agricultural land that either already exists or is intentionally developed through coordinated planning around urban regions or within specific zones. Typically crescent-shaped, green belts comprise diverse vegetation, including trees, shrubs, grasses, and windbreaks, and may also feature water bodies, nurseries, and meadows. They often serve as green corridors connecting urban areas to surrounding natural landscapes (Zepp, 2018, p. 8; Muthusaravanan et al., 2018, p. 1350) (Sundus et al., 2024,p1783)

The green belt concept is widely regarded as a universal approach to controlling urban expansion by establishing defined boundaries around cities and their adjacent open lands. This strategy emerged alongside modern urban planning practices in the 19th century. Moreover, green belts are a key urban planning tool for managing urban growth at regional and sub-regional scales (Diener & Mudu, 2021, p. 11).

Greenbelts face numerous challenges, such as urban and economic expansion and the growing demand for land. Despite these pressures, they remain a vital urban planning tool. Serving as invisible boundaries, greenbelts help preserve natural spaces, enhance air quality, and offer recreational opportunities for urban dwellers. While their effectiveness varies by location and country, their significance as a planning strategy remains indispensable, even in the face of opposition from some planners (Semeraro et al., 2021, p. 18.)

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One of the key environmental benefits of greenbelts is their role in air pollution mitigation. Vegetation within greenbelts functions as a carbon sink, absorbing CO_2, and some tree species are particularly effective at removing air pollutants. These trees can intercept significant dust and industrial emissions (Abdulwahab, 2024, p. 71). Green barriers also reduce noise pollution, serving as sound buffers along busy highways and industrial zones. Additionally, many plants are capable of capturing atmospheric dust and reducing toxic gases like sulfur dioxide (SO_2), carbon dioxide (CO_2), and nitrogen oxides (NO_x). Research has shown that certain tree species can absorb harmful substances such as hydrogen fluoride and SO_2, as well as sequester heavy metals like mercury (Hg) and lead (Pb). Once absorbed, these pollutants are transformed into harmless compounds through natural physiological processes (Grote et al., 2016, p. 545) (Al-Hamd & Jasim, 2024,p.95).

However, not all trees are equally effective in combating air pollution; only species that can tolerate pollutants can serve as pollution attenuation Such as eucalyptus, albizia and oleander (Mahdi & Jasim, 2024,p.2). Expanding vegetation in urban, suburban, and industrial areas offers significant potential to address air quality issues. Plants mitigate pollution through three primary mechanisms: absorbing pollutants via their leaves, trapping particulate matter on leaf surfaces, and reducing airspeed to promote the deposition of particles onto the ground (Watanabe, 2015, p. 171.)

United Kingdom pioneered the concept of greenbelts, incorporating them into its urban planning policy in 1947. This approach has since gained widespread acceptance worldwide, including in Europe, Asia, and the Americas. One notable example is the Seoul Green Belt in South Korea, established in the 1970s.

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Covering over 5,000 square kilometers around the capital, Seoul, this greenbelt curbs urban sprawl, preserves forests, improves air quality, and provides spaces for outdoor activities.

In North Africa, the Great Green Wall project stands out as one of the largest collaborative greenbelt initiatives. Spanning 8,000 kilometers across countries such as Senegal, Mali, and Nigeria, this project aims to combat desertification, mitigate the impacts of climate change, and enhance soil quality and the environment. Similarly, China's Shanghai Green Belt is part of a broader plan to improve air quality and reduce pollution. This greenbelt surrounds the city with expansive forests and parks, enhancing the local climate and offering recreational spaces for residents.

Air pollution originates from both natural and human-made sources. Natural sources include wind-borne dust, volcanic emissions, and sea salt aerosols. In contrast, human activities—such as heavy industry, vehicle emissions, and mining—release vast quantities of pollutants, including SO_2, NO_x, particulate matter, and heavy metals, making them the primary contributors to air pollution (Alwan & Alrikabi, 2021, p. 77.)

evaluate the effectiveness of green belt projects in mitigating air pollution, researchers have developed various measurement methods, including the Pollution Mitigation Factor (Af). This mathematical tool estimates the efficiency of green belts in reducing air pollutant concentrations by comparing the amount of pollutants reaching a specific location with and without the green belt's presence. It has been widely applied in the design of green belts to enhance air quality and protect urban areas (Chaphekar et al., 2021, p. 430).

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In 2003, Shannigrahi and colleagues conducted a study to reduce air pollution around the Victoria Memorial in Kolkata, India. The study aimed to mitigate pollution from nearby industrial sources and protect the monument from environmental deterioration by designing and implementing a scientifically planned green belt. Air quality was monitored during three distinct seasons—summer, winter, and the rainy season—using advanced measuring devices. The researchers employed the Pollution Mitigation Factor (Af) equation, which proved to be a valuable tool for the scientific and effective design of green belts, ultimately contributing to reduced environmental impacts and improved sustainability.

The study recommended establishing a green belt with a width of 50 to 70 meters, composed of dense rows of shrubs about 5 meters tall and taller trees reaching up to 15 meters, selected for their high pollutant absorption capacity. Specific plant species, such as neem (*Azadirachta indica*), acacia (*Acacia ehrenbergiana*), and mango (*Mangifera indica*), were highlighted for their suitability. The researchers also emphasized optimizing the internal distribution of trees to minimize the horizontal and vertical dispersion of pollutants, thereby enhancing the green belt's efficiency in reducing environmental pollution.

Moreover, the study extended its findings to assess a green belt project implemented in the Karbala Governorate. It focused on measuring the green belt's role in obstructing air pollutants, particularly those emitted by a nearby industrial zone. The evaluation demonstrated the project's effectiveness in improving the city's environmental conditions, further highlighting the importance of scientifically planned green belts as sustainable solutions for urban pollution challenges.

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3.Materials and Methods

3.1 Study Area:

Karbala Governorate is situated in Middle Iraq, approximately 105 km south of the capital, Baghdad. The region experiences a desert climate, with summer temperatures often exceeding 45°C, while winters are relatively mild (Table 1). Karbala is one of the governorates most affected by dust storms and desertification throughout the year due to its proximity to the western plateau. These challenges are compounded by the expansion of industrial and mining activities, the increasing number of vehicles, and population growth at the expense of wetlands (Alhesnawi et al., 2019, p. 9342).

To address these environmental challenges sustainably, the local government of Karbala has undertaken initiatives to expand green spaces, particularly in the city center this focus on increasing vegetation and urban greenery became a priority, especially following the year 2003.

(Salman, 2016, p. 260) Also, the reuse of the green belt as an environmental means to reduce air pollution and limit desertification. The green belt was included in the basic design of the city in 1977. It was approximately 200 m wide and bordered the new neighborhoods from the south. There is also a part from the east with the same width to cover the industrial neighborhood area, Figures (1) and (2). The presence of the green belt became fixed in all subsequent designs as a basic element in the design*

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*Archive of plans and designs in the Urban Planning Department - Karbala

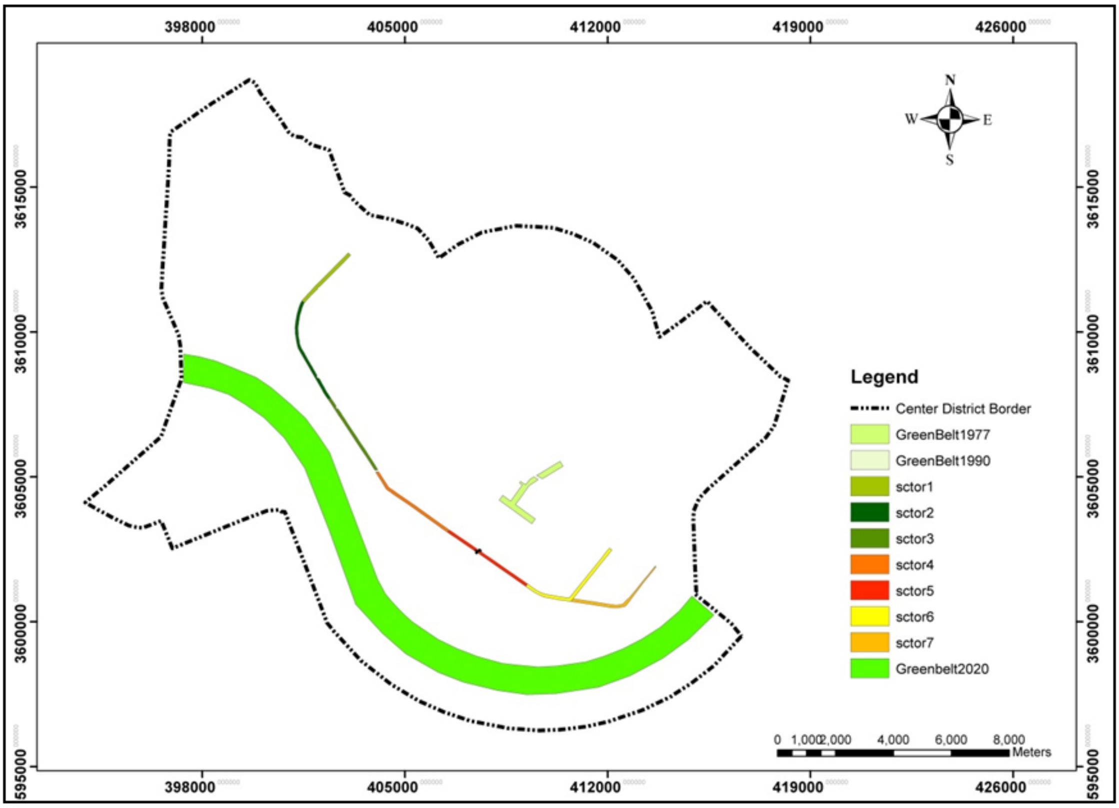

Figure 1: The greenbelt1977,southern-eastern greenbelts1990 with sectors and greenbelt2020 (*Source : Researcher, ArcMap 10.7 program &Urban Planning Department, Karbala*).

The southern green belt, which serves as the study area, is situated along the administrative borders of the central district municipality. It borders the city from the south and extends partially to the east and west, with a width of 100 meters and a length of approximately 23.5 km, covering an area of 2,350,000 m². This green belt was incorporated into the city's master

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3.2 Selection of a Green Belt Section for Air Sampling

To collect air samples and measure the Pollution Mitigation Factor (Af) for the southern green belt in the holy city of Karbala, a specific section of the belt was chosen within sector No. 4. This particular section is strategically located 3.6 km west of the city's primary industrial area, which includes various heavy and medium industries such as paint manufacturing, construction materials production, and asphalt factories. These industries emit significant amounts of fumes and pollutants into the air(Mahdi et al., 2020,p1162).

On the opposite side of the green belt lie residential areas, with the prevailing wind direction blowing perpendicularly from the industrial zone towards the residential areas. This positioning enhances the green belt's critical role in acting as a protective barrier, reducing the spread of air pollutants and dust to the nearby urban areas (Figure 2).

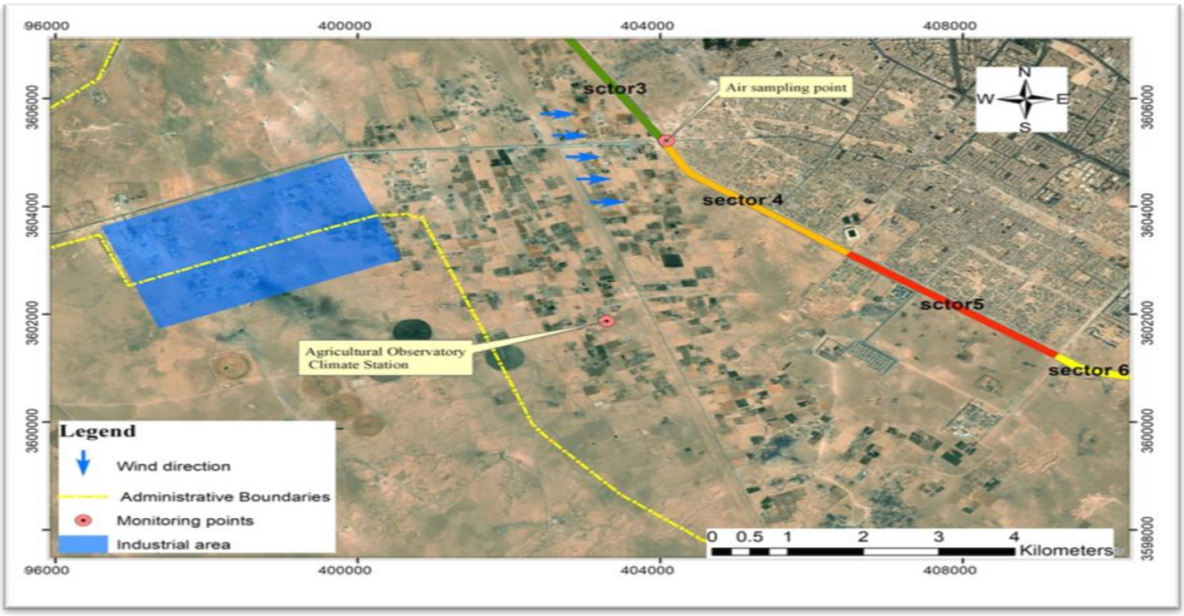

Figure 2: Air sampling site and industrial area in the center district (study area) (*Source: Researcher, ArcMap 10.7 program*).

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3.3 Measuring the Pollution Attenuation Factor (Af):

To determine the pollution attenuation factor (Af), the equation proposed by Shannigrahi et al. (2003) was applied:

$$Af = \frac{QWB}{QW} \quad \text{.....(1)}$$

Where:

- **Af** = Pollution attenuation. factor
- **QWB** = Pollutant mass flux reaching a distance in the absence of the green belt
- **QB** = Pollutant mass flux reaching a distance in the presence of the green belt
- When the attenuation factor (Af) ≤ 1, there is no effect.
- When the attenuation factor (Af) > 1, the green belt has an effect in reducing the pollutant concentration.

The Gaasmet DX4040 device (Appendix 1) was employed to measure pollutant concentrations. This portable gas analyzer uses FTIR (Fourier-transform infrared spectroscopy) technology to analyze air composition by examining the light spectrum emitted from samples. This method allows the device to detect a wide range of gases and measure their concentrations with high precision.

The Gaasmet DX4040 can quickly and accurately detect more than 25 different gaseous compounds, including volatile organic compounds (VOCs), carbon dioxide (CO_2), carbon monoxide (CO), ammonia (NH_3), methane (CH_4), and others. Its versatility makes it suitable for various applications, including

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environmental monitoring, industrial emissions analysis, and occupational health and safety assessments (Kohl et al., 2019, p. 3324).

To ensure the consistency of readings, wind direction was monitored using meteorological data from the Razzazah station of the Government Agricultural Observatory (Figures 4 and 5). Additionally, data from global climate platforms linked to reliable official sources, such as the Global Forecast System (GFS) and the European Centre for Medium-Range Weather Forecasts (ECMWF), were utilized. Remote sensing techniques were also employed, providing real-time monitoring and spatial analysis capabilities. These tools enabled the extraction of critical indicators to confirm that the wind direction was perpendicular to the selected section of the green belt where measurements were conducted (Ebraheem et al., 2021; Hussein, 2023, p. 95).

3.4 Procedure for Air Sample Collection:

To collect air samples, a field team consisting of an observer, a device operator, and an assistant was assembled. The team used a mobile station equipped with the Gasmet DX4040 device, which was mounted at a height of three meters above the ground in front of the green belt. The device was left running until the readings stabilized. Once stabilized, the data logger recorded the readings on a pre-prepared sheet, which included details such as the date, time, and climate conditions (e.g., temperature, wind direction, humidity, and atmospheric pressure). The sheet also listed the various gases and pollutants that the device could measure(Al-Fatlawi & Jasim, 2019,p175)

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After transferring the data from the device to the field worksheet, the accuracy of the entries was verified by another team member as part of a double-checking process. Upon confirmation, the reading was approved, and the device was powered down (Bandara et al., 2021, p. 8).

Then, the site is moved to a location at the same distance from the pollution source, but without the green belt, and the process is repeated again. The measurements were taken on four dates: (01/28/2024), (04/24/2024, (07/03/2024, 10/06/2023)), in order to represent the diversity of the seasons of the year.

3.5 Statistical analysis:

The concentrations of pollutants were analyzed using an independent samples t-test to compare measurements taken in the presence and absence of the green belt. The analysis was conducted with a 95% confidence level ($\alpha = 0.05$) utilizing the SPSS statistical software(Al-Ataby & Altmimi, 2021,p5)

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4.Results and discussion

Table 1. Climate Data for the Study Area During the Sampling Period

(Source: Website of the Agricultural Observatory, Ministry of Agriculture)

Minimum Temperature (°C)	Maximum Temperature (°C)	Average Temperature (°C)	Relative Humidity (%)	Rainfall (mm)	Average Wind Speed (m/s)	Month
8.1	20.6	13.9	62	9.9	5.43	Dec-23
6.42	19.79	12.81	59.6	1.1	5.4	Jan-24
7.64	19.29	13.42	65.8	41.5	5.59	Feb-24
9.16	24.06	16.51	50.6	10.9	6.73	Mar-24
16.92	33.67	25.29	35.4	6.7	7.85	Apr-24
19.85	35.45	27.84	33.5	29.7	7.39	May-24
27.39	45.43	36.65	32.35	0	7.17	Jun-24
27.94	44.89	36.77	16.72	0	8.22	Jul-24
27.39	45.44	36.65	16.34	0	4.43	Aug-24
23.84	42.44	32.79	21.6	0	1.52	Sep-23
19.2	34.06	26.27	34.63	1.1	1.43	Oct-23
13.4	25.77	18.86	55.98	8.1	1.55	Nov-23

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Table 2: presents normal value (N.V) , the measured pollutant levels with and without the presence of the old green belt and the Pollution Attenuation Factor (Af) across four seasons during the study period.

06/10/2023/Autumn			03/07/2024/Summer			24/04/2024/Spring			28/01/2024/Winter			DATE	
10.00AM		9.15AM	9.25AM		9.12AM	10.15AM		10.00AM	9.45AM		9.15AM	TIME	
Af	outside	inside the belt	*Af*	outside	inside the belt	*Af*	outside	inside the belt	*Af*	outside	inside the belt	N.V ppm*	Variables
1.00	401.36	399.72	1.01	415	412.76	1.01	421.5	418	1.00	410.72	410.78	-300 400	CO2
	0	0		0	0		0	0.22		0	0	-0.5 0.1	CO
1.12	0.19	0.17	1.08	0.26	0.24	0.80	0.24	0.3	0.97	0.28	0.29	0.3	N2O
	0	0	0.94	1.74	1.85	0.99	1.69	1.7		0	1.49	-1.9 1.7	CH4
0.95	0.55	0.58	1.44	0.46	0.32	0.71	0.17	0.24		0	0	0.1>	Butan
	0	0	0.78	0.38	0.49	1.63	0.26	0.16		0	0	-0.5 0.1	Benzene
1.05	0.22	0.21		0	0		0	0		0	0	-0.5 0.1	Eethyl benzen
1.07	0.3	0.28	0.85	0.23	0.27	1.00	0.21	0.21		0	0	-0.5 0.1	M-xylene
	0	0	0.29	0.02	0.07		0	0.03		0	0	-0.5 0.1	Acitic Acid
1.00	0.25	0.25		0	0		0	0.07	1.85	0.24	0.13	-0.05 0.01	Formaldehhyde
1.04	0.29	0.28	1.03	2.12	2.06	1.93	1.37	0.71		0	0	-0.05 0.01	Acetaldehyde
	0	0	0.90	0.37	0.41	1.25	0.25	0.2	1.55	0.17	0.11	0.1>	Hydrogen cyanide
	0	0	1.75	0.35	0.2		0	0		0	0	0.1>	Chlorobenzene
	0	0		0.01	0		0	0		0	0	0.1>	phosgene
1.08	0.13	0.12	0.97	0.56	0.58	1.54	0.57	0.37	0.47	0.07	0.15	-0.5 0.1	Amonia
1.17	0.14	0.12		0	0		0	0		0	0	-0.5 0.1	HCL
	0	0	0.82	0.14	0.17		0	0		0	0	-0.5 0.1	HF
	0	0		0	0	1.52	0.35	0.23	0.90	0.26	0.29	-0.5 0.1	NO2
	0	0	0.00	0	0.36	1.38	1.37	0.99	1.45	2.36	1.63	-0.5 0.1	NO
1.28	0.09	0.07	0.88	0.07	0.08	0.90	0.44	0.49	1.01	0.7	0.69	-0.5 0.1	SO2
ave.			ave.			ave.			ave.			N.V	microclimat
29	29	29	38.5	38	39	34	35	31	10.5	11	10	40-10	TEMP C
315	315	315	315	315	315	315	315	315	315	315	315	365-0	WD deg
4.11	3.8	4.43	4.43	4.43	4.43	4	4	4	2.1	2.1	2.1	-0.5 10	WS km/h
28.5	28	29	42	42	42	66.5	67	66	67	68.5	65	70-15	RH%
	1001	1001		1001	1002		1004	1000		1013	1013	-1000 1020	PRESS mbar

***sours** EPA,WHO world health statistics 2024

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4.Results and Discussion:.

Table 2 shows that the highest values of the Pollution Reduction Factor (Af) were observed during the Spring season. The green belt was able to reduce the levels of seven out of twelve measured air pollutants and also lowered the temperature, The best (Af) of pollutants was 1.93 in Acetaldehyde after attenuation.. During autumn, six out of the ten measured pollutants showed a reduction in concentration. Similarly, during the summer season, a decrease was observed in five out of the 14 analyzed pollutants.

Table3 :the amount of deference in pollutant concentrations after dilution

Winter	spring	summer	autumn	Variables
Conc.ppm	Conc.ppm	Conc.ppm	Conc.ppm	
-0.06	3.5	2.24	1.64	CO2
0	-0.22	0	0	CO
-0.01	-0.06	0.02	0.02	N2O
-1.49	-0.01	-0.11	0	CH4
0	-0.07	0.14	-0.03	Butan
0	0.1	-0.11	0	Benzene
0	0	0	0.01	Eethyl benzene
0	0	-0.04	0.02	M-xylene
0	-0.03	-0.05	0	Acitic Acid
0.11	-0.07	0	0	Formaldehhyde
0	0.66	0.06	0.01	Acetaldehyde
0.06	0.05	-0.04	0	Hydrogen cyanide
0	0	0.15	0	Chlorobenzene
0	0	0.01	0	Phosgene
-0.08	0.2	-0.02	0.01	Amonia

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0	0	0	0.02	HCL
0	0	-0.03	0	HF
-0.03	0.12	0	0	NO2
0.73	0.38	-0.36	0	NO
0.01	-0.05	-0.01	0.02	SO2

Table 3 reveals that carbon dioxide exhibited the most significant reduction, with a decrease of 3.5ppm. In contrast in spring, the lowest reduction values were observed during the winter season in October, where only four out of eight pollutants showed a decrease. Among these, nitrogen monoxide NO demonstrated the highest reduction, with a concentration decrease of 0.73 ppm..

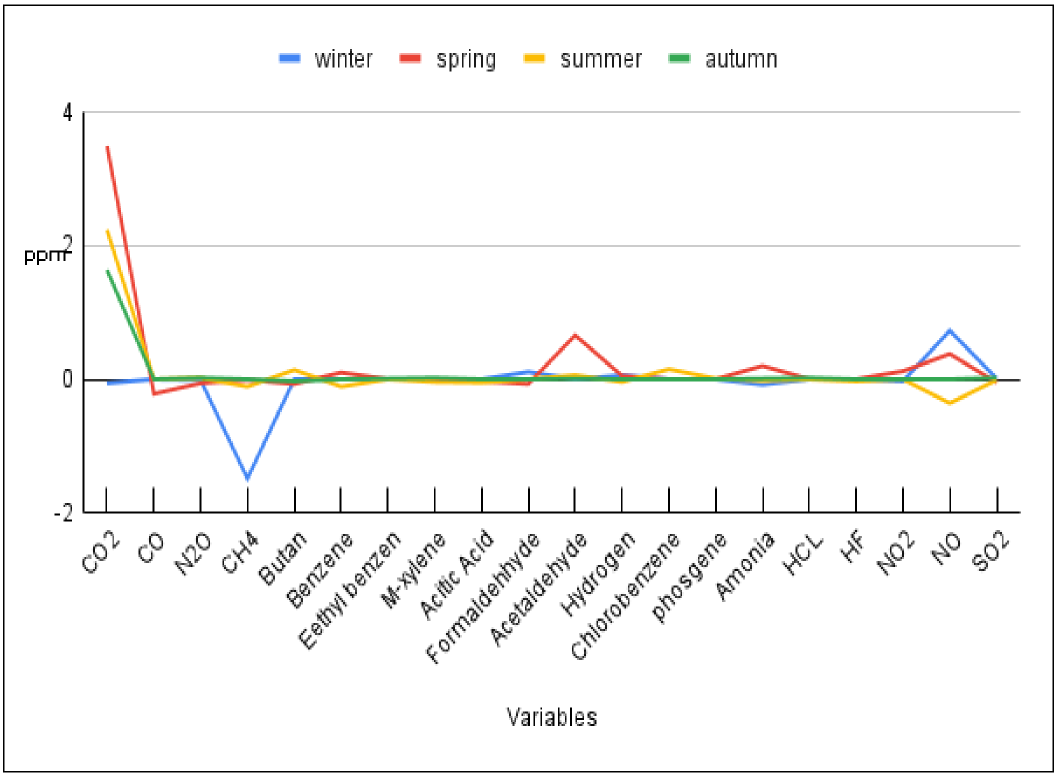

Figure (3) The amount of difference in sample concentration according to the seasons of the year in (ppm) As depicted in Figure 3, the highest concentration

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difference was observed for CH_4 during the winter, with a value of -149 ppm. The best results for concentration differences among the seasons were recorded in spring and autumn, ranging between 0.01 ppm for SO_4 and N_2O, and 1.64–2.24 ppm for CO_2.

Table (4) shows the (t-test) results with a 95% confidence level (α = 0.05) for the concentration of pollutants with and without the green belt for all seasons

Independent Samples Test				
		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Variables_spring	Equal variances assumed	.868	-7.44033-	44.16716
	Equal variances not assumed	.870	-7.44033-	44.77837
Variables_Autumn	Equal variances assumed	.998	-.15636-	51.22773
	Equal variances not assumed	.998	-.15636-	51.22773
Variables_ Summer	Equal variances assumed	.183	51.64723	37.82312
	Equal variances not assumed	.164	51.64723	35.30168
Variables_ Summer	Equal variances assumed	.999	.08444	64.45687
	Equal variances not assumed	.999	.08444	64.45687

Table 4 illustrates that no statistically significant differences were observed in pollutant concentrations with and without the green belt across all seasons, as determined by the Independent Samples t-test analysis at the 0.05 significance level.

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Wind speed measurements, recorded at 4.43 m/s, highlight the significant role of wind and ventilation in enhancing the efficiency of green belts or green barriers. These elements contribute to the dispersal of gases and suspended particles in the air (Xing & Brimblecombe, 2019, p. 79; K. H. Alwan & Omran, 2023, p. 3). However, despite the advanced age and vitality of the trees, the green belt's impact remains limited. This can be attributed to the narrow width of the belt, which is only 100 meters (Figure 2). This width is insufficient, particularly given that the surrounding area is dominated by heavy industry.

Figure (3) Part of Section No. (4) within the old southern green belt project in the center district affiliated with the holy Karbala Governorate / study area. (Researcher, photographed by drone)

Studies from European countries suggest varying green belt widths depending on the proximity to pollution sources. In Germany, green belts range from 100 meters around commercial centers to 2,000 meters around heavy industries, especially those located in isolated areas known for significant pollution. In the

Netherlands, green belt widths range from over 500 meters for heavy industries to 50 meters for lighter, non-polluting industries (Z. Zhang et al., 2022).

Additionally, the tree planting arrangement did not fully account for the conditions required for effective windbreaks and green barriers. The trees were planted in parallel rows, which allowed wind to pass through, with palm trees spaced 10 meters apart and olive trees in between (Figure 6). According to Ely (2010, p. 52), tree planting should follow a triangular pattern to improve effectiveness, with a spacing of 4.5 meters between plants and rows for smaller trees, and 6-7 meters for medium trees. Larger trees should be placed further apart, with distances of 8-10 meters depending on available space. Planting at closer distances is recommended to increase tree density, thus expanding the leaf surface area exposed to pollutants.

The green belt consists of three tree species: olive (*Olea europaea*), eucalyptus (*Eucalyptus camaldulensis*), and date palm (*Phoenix dactylifera*) figure 3 , While these trees are classified as having a high Air Pollution Tolerance Index (APTI) (Alhesnawi et al., 2019, p. 9345), The palm tree does not fulfill the necessary criteria required for the effective construction of windbreaks. and dust-trapping plants should have specific characteristics that align with the requirements of the green belt. These include a rapid growth rate, fast canopy and leaf development, strong branches, and a sturdy canopy that can withstand storms. Trees with large leaf sizes, high leaf density, and interwoven leaves are preferable The plants should be perennial, evergreen, and possess a large leaf area to maximize pollutant retention. Dense, branched limbs also contribute to better pollutant trapping. Moreover, trees should have long lifespans to ensure the longevity of the green belt. Local plants that are adapted to the area and resistant to known air pollutants are ideal, as they help maintain the environmental and hydrological balance (Muerdter et al., 2018, p. 598).

While vegetation can offer some benefits in improving air quality, it should be noted that the role of plants in removing pollutants is limited, with removal rates generally around 2%. Studies show that the clean, fresh air in gardens is primarily due to dispersion and ventilation processes, rather than the deposition of pollutants on plant leaves (Tang, 2023, p. 10) (Hussain & Jasim, 2019,p973)

5.Conclusion:

- The findings indicate that the southern green belt in Karbala City does not have a significant effect on reducing air pollutant concentrations.
- If the distribution of plants within a green belt is not adequately dense and follows a pattern that permits unimpeded air flow, the effectiveness of the green belt in reducing air pollutant concentrations is significantly diminished.

6.Recommendations:

- Increase the width of the green belt to 1000 meters, as the surrounding area includes heavy and medium industries.
- Plant tree species suited for absorbing and obstructing pollutants, ensuring the planting arrangement helps mitigate air currents passing through the green belt.

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- Conduct additional studies in other sections of the green belt, focusing specifically on the role of plant density in influencing the extent of pollutant mitigation.

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