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Original Research

The Impact of Road Transport on CO_2 Atmospheric Concentrations in Gaza City (Palestine), and Urban Vegetation as a Mitigation Measure

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Abstract

Although traffic-borne pollution has been increasing recently in Gaza City (GC), no studies have tackled the issue in a quantitative manner. This study investigated quantitatively the atmospheric carbon dioxide (CO_2) concentrations in three heavily-trafficked streets (sites X, Y, and Z) in GC, using a locally manufactured device. Measurements were performed during a weekday and a weekend in three specific times, including two rush hours. Green-cover was investigated using the top-down approach for photo interpretation in the selected sites. Furthermore, the awareness of the local population toward greening their streets was tested using two questionnaires. Measured atmospheric CO_2 concentrations ranged between 300 ppm and 900 ppm in all selected sites. Atmospheric CO_2 concentrations were highest in site X and lowest in Y. Green-cover percentage was found to be 2%, 3%, and 8% for sites X, Y, and Z, respectively. Generally, higher levels were detected during the working day compared to those detected during the weekend. Additionally, high atmospheric CO_2 concentrations were detected in streets with reduced green-cover as well as streets with workshops flanked on both sides. The questionnaires' analysis illustrated sound awareness among respondents regarding the researched aspect.

Keywords: carbon dioxide, traffic-borne pollution, transportation means, urban vegetation

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Introduction

Urban air pollution has become an increasingly important environmental issue in both developed and developing countries. It has been estimated that 1 billion people are exposed to outdoor air pollution annually, and that around 3.7 million die as a direct result of this exposure [1-4], making air pollution the largest single environmental health risk.

Since the industrial revolution air quality has been on the decline due to increased levels of greenhouse gas (GHG) emissions [5-9], and is experienced more in regions with higher levels of socio-economic deprivation [10-11]. Greater differences can be seen if individual countries are compared as well as within the same country.

In densely populated areas transportation means are identified as a major source of trace gases and pollutants, accounting for 70% of air pollution [12-18]. The main product of fuel burning is CO_2 (the most important anthropogenic GHG), but a wide series of other gases is emitted concurrently [19-23]. Although CO_2 is considered to be a non-toxic gas, exposure to high concentrations can induce health risks. Furthermore, it is believed to be the main driving factor of global warming [24-26].

Globally, transportation means account for 16% of the total atmospheric CO_2 emissions from fossil fuel use. In Europe and the USA it accounts for an approximate of 24% and 27%, respectively, of the latter [27-33]. As for the Middle East, it is currently a small contributor to the world's atmospheric CO_2 emissions. However, it is noted to be in continuous increase and is further predicted to grow threefold by 2030. This is basically attributed to rapid urbanization, increased car ownership, and a lower modal share of public transport [34-37] .

Urban vegetation has been proven to act as "carbon sinks" that remove CO_2 through dry deposition and carbon sequestration and storage [38-53]. However, the type, size, quality, type, and shape of vegetation all influence the level of impact [54-57]. Even though less prosperous communities have more to gain from adding trees, they often have got less space available for them.

Evidence discussed has led many developed countries to formulate and/or enforce strict environmental policies and regulations to enhance air quality [58]. This includes the Clean Air Act of 1963 in the USA and Air Quality Directives developed for the European Union (EU) [59]. Conversely, such efforts and policies are yet to be adopted in most developing countries.

Poor air quality in GC (Palestine; Fig. 1) has been experienced by Gazans for decades. This is mainly due to the rapid population growth, estimated at 3.3% [60], and the expanding number of transportation means (estimated at about 72,000) [61], in addition to water treatment projects and the overuse of generators to compensate for electricity shortages [62]. The unstable political conditions have contributed toward the worsening of the problem [63-70]. Furthermore, poor air quality within the region is caused by the toxic gases produced by Israeli factories and is consequently transferred to the Palestinian airspace by wind [71].

Green areas in this restricted and heavily urbanized area are progressively decreasing, mainly due to the ongoing political conflict. A total of 30% of agricultural land in the Gaza Strip (GS) is assessed to be inaccessible as it lies within the "Security Buffer Zone" imposed by the Israeli side [72]. Furthermore, many agricultural lands have been completely bulldozed in the recent IMOs. According to the Ministry of Agriculture statistics, 3.7 million trees and more than 70,000 dunums (equivalent to 1,000 m^2) have been destroyed in the GS since the beginning of the second Intifada (the second Palestinian uprising against Israel) in 2000 [73]. Other current factors threatening the green areas are the expansion of construction in urban areas – specifically housing projects – as well as poor urban planning.

Globally, previous research conducted has focused more on estimating the economic benefits of improving air quality, rather than quantitatively evaluating the effect of urban vegetation on ambient pollutant concentrations [74-79]. As for GC, previous studies tackling the issue in GC have not been the focus of researchers. Environmental issues, such as those related to water and land resources, have had more attention from researchers as well as governmental and non-governmental organizations. Additionally, practical efforts for controlling air pollutants

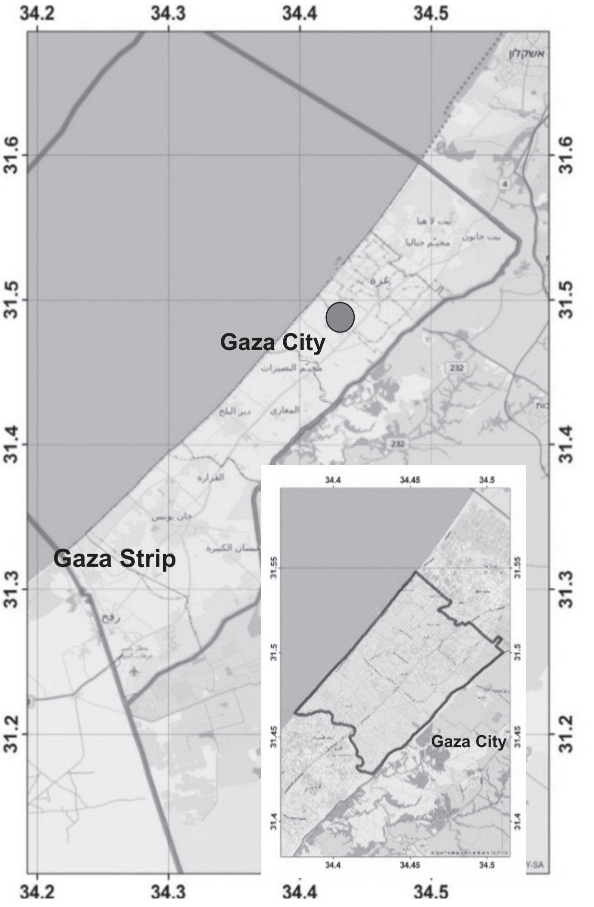


Fig. 1. Gaza Strip map (with Gaza City highlighted).

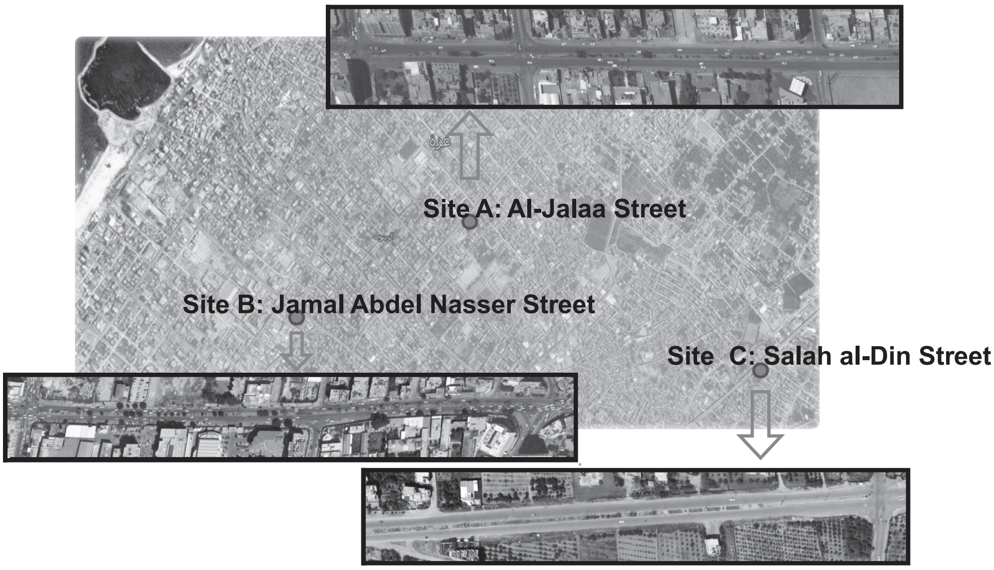


Fig. 2. Sampling sites for this study (sites where atmospheric CO_2 concentration measurements took place).

and mitigating the challenge has been very limited. This may to some extent be due to the lack of monitoring stations and hence reliable data. Furthermore, the institutional incapacity to interpret data and take appropriate action is a key hindering factor toward improving air quality.

Hence this study provides quantitative information of atmospheric CO_2 concentrations in three heavily-trafficked streets. Additionally, it examines the traffic count and the green cover percentage in all selected sites. Furthermore, it highlights the awareness and acceptance level of the local population toward greening their streets. Thus, this study can act as a guide for developing planning and conservation policies on both local and national levels. Moreover, it establishes a basis for other studies in the same field and provides recommendations for all interested parties, including governmental and non-governmental organizations.

Materials and Methods

A descriptive and analytical approach has been used for the purpose of this study. Field measurements for quantifying atmospheric CO_2 concentration have been carried out in three main and heavily-trafficked streets in GC. Measurements have been taken in three different spots along each street over a two-day period (weekday and weekend) and at the following specific times:

– 08:00 (morning period/rush hour).
– 12:00 (midday period/rush hour).
– 18:00 (evening period).

Researchers have also made use of secondary data published in books, magazines, and periodicals.

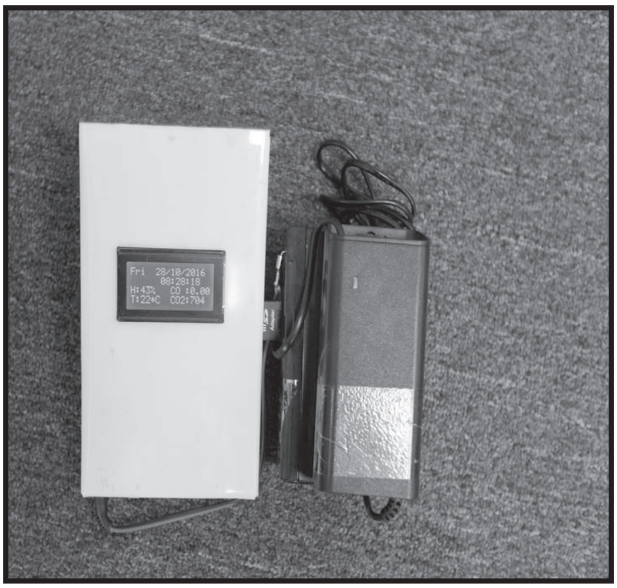


Fig. 3. Locally manufactured and calibrated air quality measuring device (designed and manufactured specifically for this study).

Fig. 4. Screenshot of I-Tree Canopy cover survey.
Source: itreetools.org/canopy/survey.php 02/12/2015

Site Selection and Description

Sections with an approximate length of 300 m within three heavily trafficked urban streets in GC were selected for atmospheric CO_2 concentration measurements. All selected sections have the following in common (specifically considered aspects for study purposes):

- Two-way streets with buildings flanked on both sides (urban canyons), but with different width-to-height ratios.
- Uniform geometric characteristics along the section length and located between two junctions.
- Uninterrupted traffic flow.
- Very little pedestrian and/or animal traffic.

Streets within which sections are selected are illustrated in Fig. 2 and are as follows:

- Al-Jalaa Street (site X): a highway street in the GC with six lanes and that extends over 3.47 km and is 24 m wide.
- Jamal Abdel Nasser Street (site Y; alternatively known as Al-Thalatheeni Street): a main street in the GC that extends over 3.2 km and is 30 m wide. This street has a number of important facilities such as the UNRWA headquarters and the two major universities within the city (the Islamic University of Gaza and A-Azhar University).
- Salah al-Din Street (site Z; alternatively known as the Salah al-Din Highway): the main highway of the Gaza Strip and that extends over 45 km. It spans the entire length of the territory from the Rafah Crossing (the border between the GS and Egypt) in the south to the Erez Crossing (a pedestrian/cargo terminal on

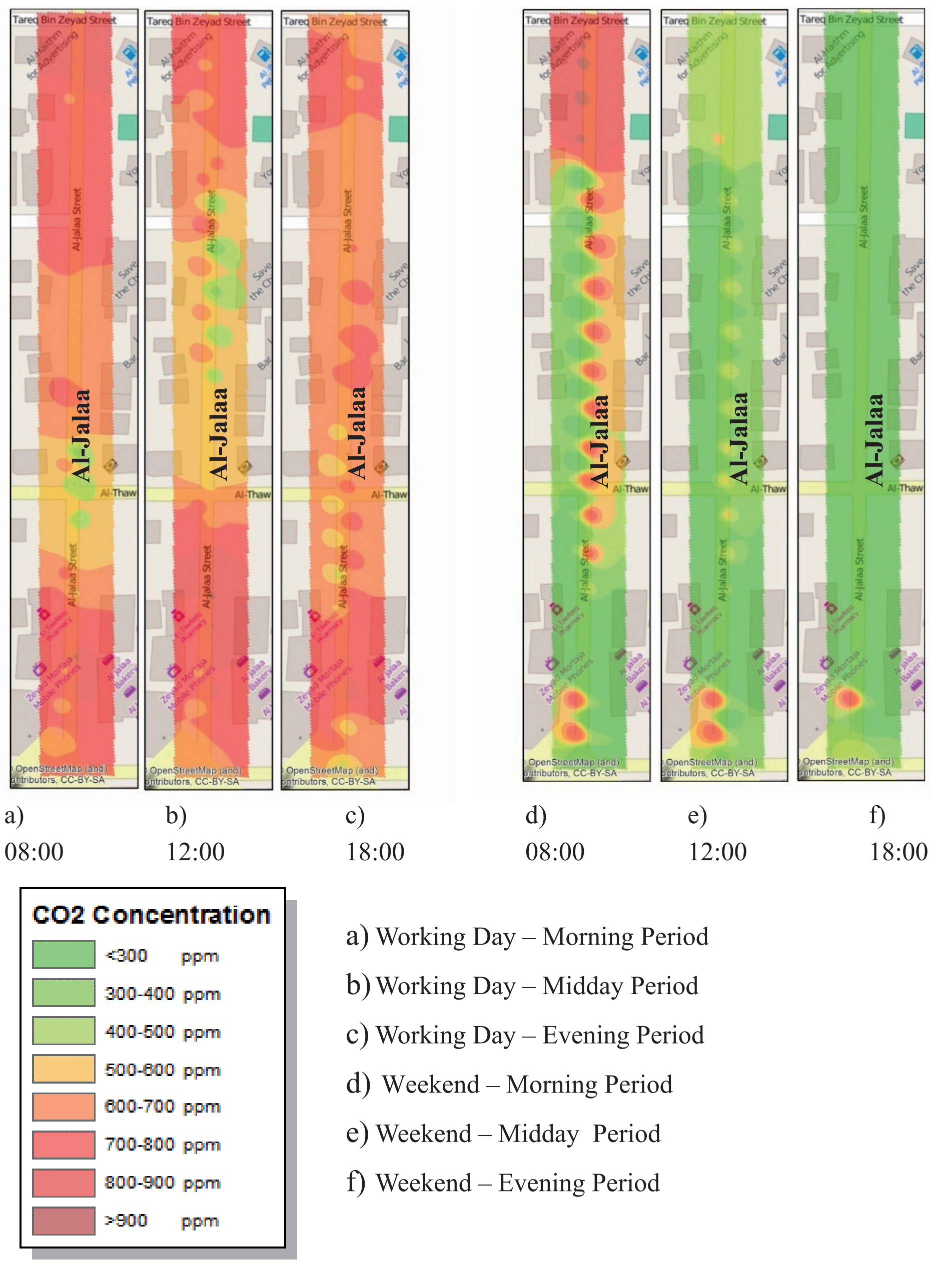


Fig. 5. Mapping measured and simulated atmospheric CO_2 concentrations in site X.

the Israeli Gaza Strip barrier) in the north. The road is named after the 12th-century Muslim general Salah al-Din.

Note: sites selected will be referred to as sites X, Y, and Z in the order presented above.

Traffic Count and Vehicle Classification

Traffic-flow count was carried out manually through the visual assessment of vehicles. There are various classification approaches available to various institutions or end users. For the purposes of this study vehicles are classified into six categories:

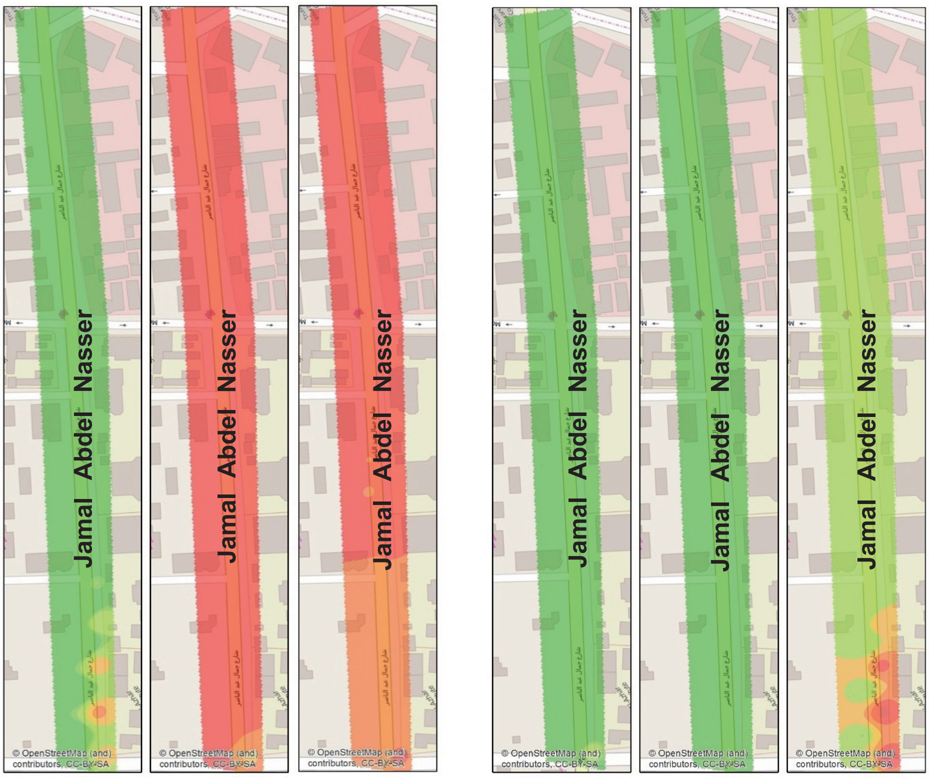
- New privately owned cars.
- Used privately owned cars.
- Minibuses.
- Heavy buses.
- Heavy lorries (more than 10 and less than 20 tons).
- Motorcycles.

Traffic count was carried out at the same time the atmospheric CO_2 concentration was measured. Time intervals were distributed as follows:

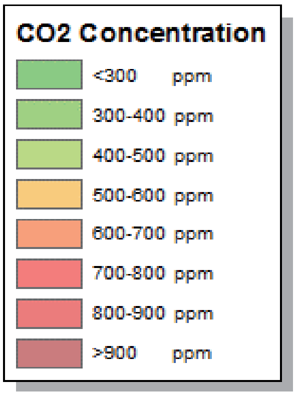
- 07:40-08:20 (morning period),
- 12:40-13:20 (midday period),
- 17:40-18:20 (evening period).

CO_2 Measuring Device Description

A locally manufactured and calibrated air quality measuring device was designed and manufactured specifically for this study (see Fig. 3). It was calibrated using a state-of-the-art device from the Palestinian

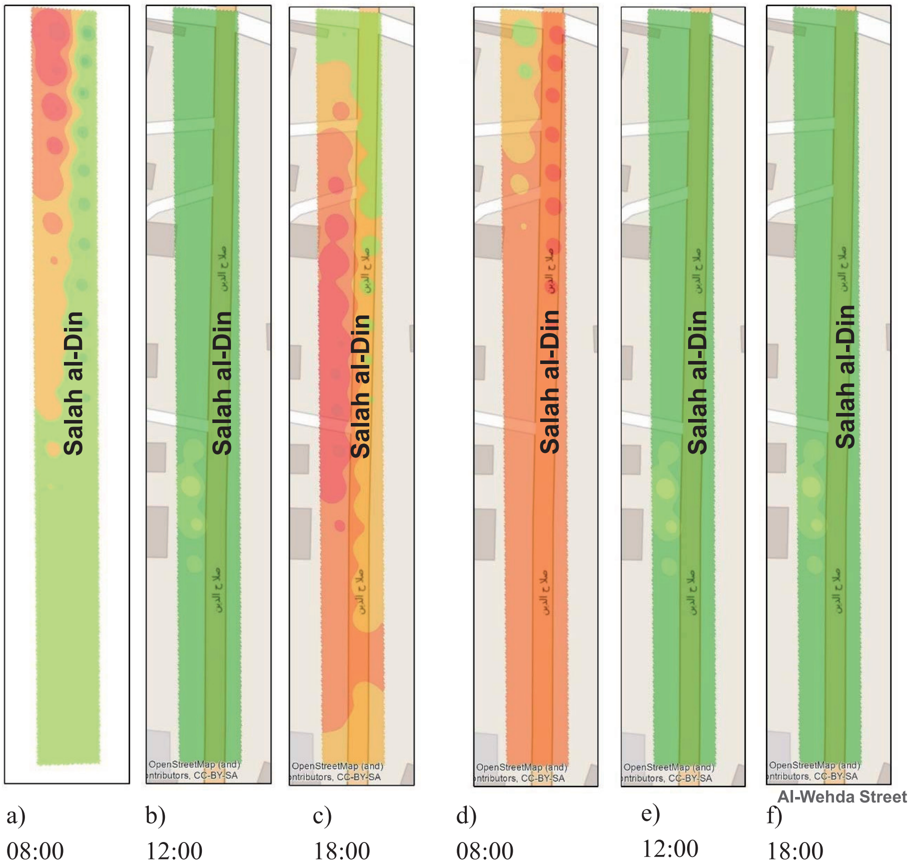


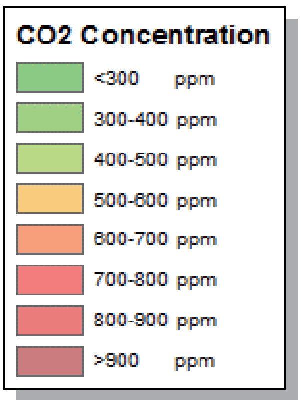
a) 08:00 b) 12:00 c) 18:00 d) 08:00 e) 12:00 f) 18:00



a) Working Day – Morning Period
b) Working Day – Midday Period
c) Working Day – Evening Period
d) Weekend – Morning Period
e) Weekend – Midday Period
f) Weekend – Evening Period

Fig. 6. Mapping measured and simulated atmospheric CO_2 concentrations in site Y.





a) Working Day – Morning Period
b) Working Day – Midday Period
c) Worming Day – Evening Period
d) Weekend – Morning Period
e) Weekend – Midday Period
f) Weekend – Evening Period

Fig. 7. Mapping measured and simulated atmospheric CO_2 concentrations in site Z.

Environment Quality Authority (PEQA). The device can measure temperature, relative humidity, and CO_2 based on a pre-defined time interval using different built-in sensors to collect surrounding air quality results. The collected data sets are stored automatically on an external USB stick and can be exported as a comma delimited file (CSV) for analysis and simulation purposes.

Analysis of CO_2 Field Measurements

The CSV files for the field collected values from the selected sites were prepared and imported into GIS software (ArcMap10.2) for analysis and interpolation purposes. A total of 18 interpolation maps were generated for atmospheric CO_2 concentration levels (six for each site). Three maps were generated for a typical working day and another three maps for a weekend day, for each selected site.

The interpolation technique was the inverse distance weight (IDW) approach. This technique uses a set of data points with coordinates x and y, while the z values include the atmospheric CO_2 concentration. With a predetermined working area (the extents of each site), the tool generates the required values covering the entire targeted area. A pre-defined colored map legend indicates the acceptable and non-acceptable levels of atmospheric CO_2 concentrations in parts per million (ppm). The green grades indicate acceptable levels while the red grades indicate non-acceptable levels, and the cutting edge between the two levels is 300 ppm.

Urban Tree Inventory

Urban vegetation within the study area was surveyed in order to assess its impact on atmospheric CO_2 concentrations in all selected streets. A survey was conducted using the top-down approach. Photo interpretation using aerial-satellite images was carried out to determine the amount and distribution of the green cover. This process produces statistical estimates of cover. Accuracy of such estimates is highly dependent on the number of points considered (a sample of 100 points will produce an estimate with a standard error of about 4.6% compared to 1.4% for a sample of 1,000 points). For the purpose of this study a sample of 40 points was interpreted (collected from the field data). I-tree canopy was used to estimate land cover types using shapefile based on the available aerial photos. I-tree canopy is an online freely available tool that produces a statistically valid estimate of land cover types (e.g., tree cover) using aerial images available in Google Maps. The shapefile contains the feature of the sites including the green cover, streets, sides of the roads, and other features (see Fig. 4).

Questionnaire Design

Two sets of questionnaires were developed in order to assess pedestrians and shop owner air quality problem awareness. Additionally, it tested the respondents' level of acceptance toward greening the city. Both questionnaires were designed to collect qualitative data of the following aspects:

– Personal Information.
– Environmental Awareness (including source of pollution, nature of the place, interaction with circumstances, and awareness of climate change).
– Preferences of pedestrians and property owners.

The sample size for the questionnaire was determined using Eq. (1) (Saunders, 2012):

$$N = \frac{NP}{1 + (NP \times e^2)} \tag{1}$$

…where N is sample size, NP is population size, and e is the errors term = 0.05.

Results

Measured and Simulated Atmospheric CO_2 Concentrations in the Selected Sites

The lowest atmospheric CO_2 concentration was 10 ppm (which is the lowest limit the device can detect), while the highest atmospheric CO_2 concentration was 999 ppm (which is the highest limit the device can detect). A mapping of measured and simulated atmospheric CO_2 concentrations in the three selected sites is illustrated in Figs 5-7.

Working Day Measurements

At site X, atmospheric CO_2 concentrations ranged between 500 ppm and 900 ppm at all measuring times. Whereas at site Y, the latter measured was lowest in the morning, measuring < 300 ppm, followed by > 600 ppm in the evening and > 800 ppm in the afternoon. At site Z, atmospheric CO_2 concentration was lowest in the afternoon, measuring < 300 ppm and highest in the evening, ranging between 500 ppm and 900 ppm. Whereas in the morning, it ranged between 300 ppm and 600 ppm.

Weekend Measurements

At site X, atmospheric CO_2 concentration was highest in the morning, ranging between 300 ppm and 900 ppm. In the afternoon and evening it measured < 300 ppm. At site Y, the latter mentioned was comparatively low at all measuring times – measuring < 400 ppm in the morning and afternoon and < 300 in the evening. In site Z, atmospheric CO_2 concentrations were highest in the morning, ranging between 600 ppm and 900 ppm, whereas the lowest levels were detected in the afternoon – all measuring < 300 ppm.

Traffic-flow Count

Fig. 8 illustrates the Traffic flow count for the three selected sites during a working day and a weekend.

Urban Tree Canopy Assessment

Fig. 9 illustrates the tree cover to non-tree cover percentage. Tree cover was 2%, 3%, and 8% in sites X, Y, and Z, respectively.

Local Population Awareness and Level of Acceptance Toward Greening their Streets

Demographic Profile of Respondents (Pedestrians and Shop-Owners)

As shown in Table 1, the age group 21-30 years accounted for the largest percentage followed by the age group <20 among pedestrians. Females represented slightly more than 50% of the sample. The majority of pedestrian respondents were bachelor degree holders. As for marital status, the majority were single. Furthermore, the monthly salaries were between $0-500 for about two third of the sample.

From shop-owners respondents' point of view, the age groups 21-30 years accounted for the largest percentages, followed by the age group 41-50. The majority were males, representing 99% of the sample. Furthermore, the

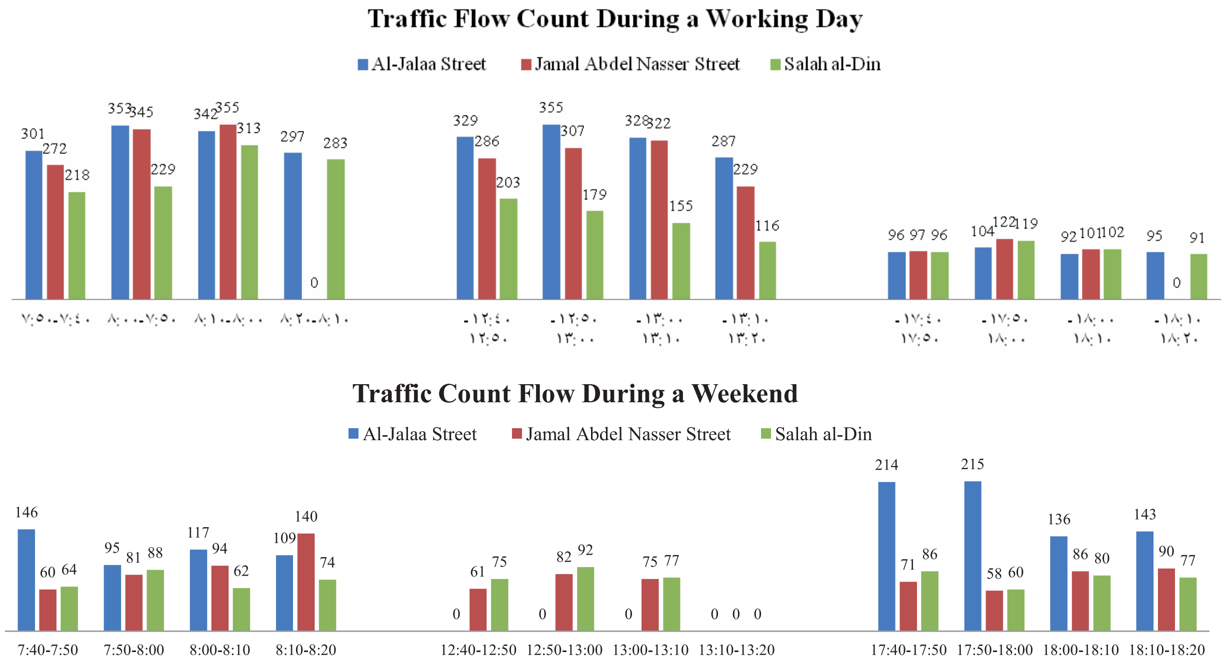


Fig. 8. Traffic flow count for the three selected sites during a working day and a weekend.

majority of shop-owners respondents' were high school graduates or lower. Furthermore, the monthly salaries were between $0-500, representing about two third of the sample.

Environmental Awareness of Respondents

In general, Table 2 demonstrates that the MVs were relatively high at around 4.00 from respondents' (both pedestrians and shop-owners) point of view. The total mean values (MVs) scored 3.97 and 3.99, and the standard deviation values (SDs) scored 0.468 and 0.678 for pedestrians and shop-owners, respectively.

Respondents' Preferences

In general, Table 3 demonstrates that the MVs were relatively high at around 4.00 from respondants' (both pedestrians and shop-owners) point of view. The Total MV generally scored 4.13 and 4.23 and the total SD scored 0.489 and 0.549 for pedestrians and shop-owners, respectively.

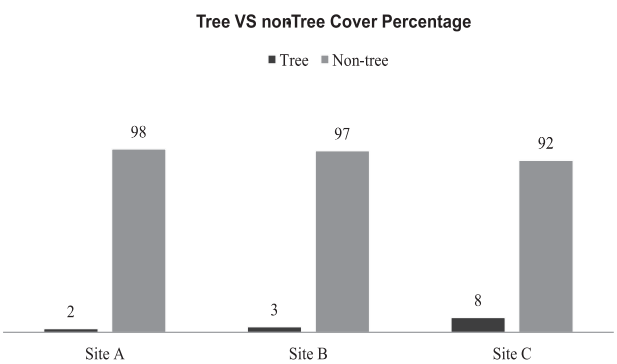


Fig. 9. Tree to non-tree cover percentage in the selected sites.

Poor Air Quality Causes from Respondents' Point of View

Table 4 shows that all respondents (pedestrians and shop-owners) ranked the high number of transportation means as the major cause for air pollution. Furthermore, the pedestrians ranked the lack of well-managed traffic as the second cause, whereas shop-owners believed that the lack of green spaces is the second cause. Finally, the lowest item ranked is the lack of pedestrian areas and the spread of sandy plots by pedestrians and shop-owners, respectively.

Discussion

Generally, higher atmospheric CO_2 concentration was detected during the working day in all three selected sites, compared to that detected during the weekend. This can basically be attributed to the increased traffic volume encountered during working days. Furthermore, variations have been noticed within the same site during the different measuring times in both the working day and the weekend.

For instance, at site X higher atmospheric CO_2 concentration has been detected during the working day – at all measuring times – compared to that at the weekend. This typically can be attributed to the increased traffic volume during the working day. Little variation was detected between the three measuring times within the same working day; even though lower traffic volume was noticed during the evening period. Little variation was

Table 1. Respondent profiles (pedestrians and shop-owners).

Variable	Interval	Pedestrians		Shop-owners	
		Frequency	Percentage	Frequency	Percentage
Age	20 years or fewer	117	29.3	1	17
	21-30 years	181	45.3	49	49
	31-40 years	67	16.8	11	11
	41-50 years	23	5.8	14	14
	51 years and above	12	3	9	9
Gender	Male	198	49.5	99	99
	Female	202	50.5	1	1
Education level	High school or lower	81	20.3	47	47
	Diploma	119	29.8	19	19
	Bachelor's	172	43	32	32
	Master's	17	4.3	1	1
	Ph.D.	11	2.8	1	1
Marital status	Single	240	60	41	41
	Married	141	35.3	54	54
	Widowed	7	1.8	2	2
	Divorced	12	3	3	3
Monthly salary	$0-500	283	70.8	66	66
	501–1,000	61	15.3	25	25
	$1,001-1,500	40	10	7	7
	$1,501-2,000	7	1.8	1	1
	More than $2,000	9	2.3	1	1
Years of Experience	5 years or less	285	71.3	5	5
	6-10 years	69	17.3	24	24
	11-15 years	28	7	13	13
	16-20 years	16	4	8	8
	21 years and above	2	0.5	5	5
Nature of the job	Related to environment	-[a]	-	58	58
	Non-related to environment	-	-	42	42

[a] The dash mark in the table means that the respondent's point of view was not considered for this specific aspect

also detected between the three measuring times within the same weekend, even though traffic volume was highest in the evening period.

At site Y, higher atmospheric CO_2 concentration was detected in the afternoon and evening compared to that detected in the morning during the working day, even though traffic volume in the evening was the lowest. During the weekend lower atmospheric CO_2 concentration was detected at all measuring times with little variation. This can be attributed to reduced traffic volume during the weekend, which happens to be almost consistent at all measuring times.

In sites X and Y, higher atmospheric CO_2 concentrations were measured during times when low traffic volume was detected and can be strongly attributed to other sources that were not considered within the scope of this study (e.g., small-scale generators used to compensate for power cut-offs).

On the contrary at site Z, the highest atmospheric CO_2 concentration was detected in the evening, even though traffic volume was highest in the morning. During the weekend, higher atmospheric CO_2 concentration was detected in the morning even though traffic volume was consistent at all measuring times.

Table 2. Environmental awareness of respondents.

Item	Pedestrians		Shop-owners	
	MV	SD	MV	SD
Pollution Source				
Vehicle exhaust gases affect air quality	4.66	0.702	4.64	0.789
Small power generators in the streets affect air quality	4.02	0.954	4.56	0.743
The dust on the street sides affect air quality	4.04	0.855	4.15	0.957
Other pollution sources (for example barbeque shops, car workshops, …) affect air quality	4.00	0.929	4.03	0.893
Total of pollution source	4.18	0.508	4.35	0.566
Nature of place				
Lack of green spaces affects air quality	4.20	1.040	4.28	0.900
Lack of public spaces (pedestrian spaces) affects air quality	3.75	1.157	3.91	1.065
Planting trees at the expense of public spaces quality is essential to improve air quality	4.09	1.008	3.97	1.058
Lack of planning regulations for buildings affects air quality	3.78	1.009	4.19	0.837
Street width and direction affect air quality	3.85	0.992	4.02	0.964
Total of nature of place	3.92	0.582	4.07	0.675
Interaction of community				
I try to avoid walking in crowded areas due to bad air quality	4.13	0.977	4.09	1.016
I intend to comply with construction regulations to contribute toward good air quality practices	3.81	1.037	-	-
The non-compliance of house owners to proper construction regulations (e.g., not leaving appropriate spaces between structures) affects air quality	-	-	4.02	1.063
I have sound knowledge of regulations related to air quality	3.51	1.112	3.54	1.218
Fines should be issued against non-compliance house-owners related to air quality	3.80	1.053	4.06	0.908
I am willing to comply with the urban greening regulations issued by local specialized institutions	4.00	1.114	4.05	1.068
Total of interaction of community	3.86	0.669	3.95	0.787
Climate change awareness				
I have sound knowledge about climate change concepts	3.99	1.028	3.47	1.201
Air quality is related to climate change	3.96	0.949	3.72	1.045
Total of climate change awareness	3.97	0.768	3.60	1.036
Average of environmental awareness results	3.97	0.468	3.99	0.678

This can be attributed to CO_2 emitted from industrial workshops flanked on both sides of the street (found only in Site Z).

The urban vegetation cover for the selected sites was estimated at 2%, 3%, and 8% in sites X, Y, and Z, respectively. However, the lowest atmospheric CO_2 concentration was detected in site Y, followed by site Z, and the highest was found at site X. Higher atmospheric CO_2 concentration at site Y can be attributed to CO_2 emitted by industrial workshops flanking both sides of the street. As for site X, reduced urban vegetation cover might have contributed to higher atmospheric CO_2 concentrations.

The questionnaire results revealed a decent level of air quality problem awarness among both pedestrians and shop-owners. Furthermore, it illustrated a general tendency and willingness among respondents toward applying actions to reduce and control air pollution. These actions include complying with any regulations enforced by relevant governmental institutions and local municipalities. Additionally, the analysis revealed that respondents are willing to use any available environmentally friendly technologies that would reduce CO_2 emissions. It also demonstrated that respondents believe that relevant governmental institutions should play the required role in regulating air quality control procedures.

As for poor air quality causes, the highest item ranked among respondents was the high number of cars followed by the lack of well-managed traffic and finally the lack

Table 3. Respondents' preferences for actions to be enforced by local muncipilities regarding enhancing air quality.

Item	Pedestrians		Shop-owners	
	MV	SD	MV	SD
Local municipalities should enforce property construction regulations that affect air quality.	4.36	0.81	4.23	0.723
Relevant governmental institutions and local municipalities should perform awareness campaigns regarding relevant air quality regulations.	4.10	0.965	4.42	0.741
I have the will to volunteer and participate in air quality awareness campaigns.	4.01	0.942	3.90	1.049
Relevant governmental institutions should issue penalties for those who are not complying with air quality regulations.	3.96	0.99	4.24	0.866
Subsidized community-encouraging projects should be performed related to air quality improvement.	4.36	0.80	4.26	0.883
I have the will to use environmentally friendly technologies (e.g., solar panels, low emission vehicles) available in the market to reduce air pollution.	4.26	0.88	4.29	0.998
Shop owners should provide required spaces for implementing air pollution enhancement projects within their own properties.	-	-	4.21	0.88
The relevant governmental institutions (ministry of transportation) should enforce traffic reduction strategies, especially at traffic nodes.	3.85	0.955	4.13	0.939
The relevant governmental institutions (EQA) should increase green areas in heavily trafficked, densely polluted areas.	4.19	0.852	4.43	0.795
Average of pedestrians and shop-owners preferences	4.13	0.389	4.23	0.549

Table 4. Respondents' perception of poor air quality causes.

Item	Pedestrians		Shop-owners	
	Frequency	%	Frequency	%
High numbers of transportation means	161	40.3	58	58
Lack of well-managed traffic (traffic congestion)	43	10.8	4	4
Lack of green spaces (public gardens)	35	8.8	10	10
Lack of pedestrian areas (middle and sides of streets)	7	1.8	2	2
Repeated Israeli intrusions and attacks on public infrastructure in the Gaza Strip	78	19.5	11	11
The spread of sandy un-urbanized plots (non-fenced plots)	22	5.5	2	2
The existence of many sandy (un-paved) roads	21	5.3	1	1
The excessive use of power generators	31	7.8	11	11
Other, please specify	2	0.5	1	1

of green space availability. This supports the findings from field observations and collected air quality data, as there was a high inter-correlation between the number of transportation means and the levels of atmospheric CO_2 concentrations. There was also an inter-correlation between the levels of atmospheric CO_2 concentration and the urban vegetation cover percentage.

Conclusions

The findings presented in the study suggest that transportation means is the first major source of CO_2 in the study area. An inter-correlation was found between the levels of atmospheric CO_2 concentration and the urban vegetation cover percentage. Lower atmospheric CO_2 concentration was detected in areas with increased green cover (except for site Z). However, in the latter-mentioned site, industrial workshops flanking both sides of the street may have strongly contributed to increased levels of atmospheric CO_2 concentrations.

Furthermore, the questionnaire analysis supported the findings from field observations and collected air quality data. Respondents (pedestrian and shop-owners) illustrated a general tendency toward applying actions and fullfilling any air quality control regulations to control air pollution with a relatively high mean value of around 4.00.

It would be fruitful to pursue further research to quantitatively estimate carbon sequestration by urban street trees using tree volume and biomass allometric equations. This will aid in specifying the type, location, and number of trees to be planted in urban street canyons. Furthermore, quantitatively evaluating other main pollutants (particulate matter, nitrogen oxide, and ground-level ozone) will facilitate identifying other possible mitigation measures.

If policymakers were to take this study seriously, they might issue and/or enforce regulations regarding traffic-management to reduce CO_2 emissions and hence enhance air quality. Additionally, they might issue policies regarding increasing the green cover, especially in heavily trafficked street canyons.

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