

Assessment of Carbon Dioxide Emissions from Traffic and Its Health Impact in Gaza, Palestine

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Abstract Traffic emission is a major source of air pollution in most urban areas and its effects on public health. The aim of this study was to determine the levels of Carbon Dioxide (CO₂) emissions from the motor vehicles and to investigate the correlations between CO₂ trends and the associated health impacts. Levels of CO₂, humidity and temperature were monitored at the selected intersections during morning peak (7:00-8:30 am), off peak traffic hours (10:30 am – 1:30 pm) and afternoon peak (3:00 – 4:30 pm) by using Kanomax meter and multi-meter. A questionnaire was distributed randomly to pedestrians and drivers at Gaza city to evaluate traffic emissions and their health impacts. The research results revealed that the CO₂ levels at the study locations fluctuating between 291-608 ppm, moreover it was noticed that the CO₂ concentrations in the majority of the monitored sites were higher than the agreeable international level of CO₂ which is 350 ppm. The public health questionnaire results showed that 63% of study population complain from cough and nasal congestion during walking at the streets and 91.8% of sample thought that traffic emission was the main source of air pollution in Gaza city. The findings of this research emphasize importance of taking action to reduce traffic emissions levels in Gaza City, in order to decrease health impacts that the public is exposed to.

Keywords CO₂, Gaza, Health Impacts, Traffic Emission

1. Introduction

Recent investigations indicate that CO₂ concentrations in the atmosphere have risen from pre-industrial levels of 280 ppm to present levels of ~380 p.p.m. Moreover, this increase in atmospheric CO₂ was attributed to the world's expanding use of fossil fuels and is believed to be the main cause of global warming which affects negatively many physical, biological, and human systems [1, 2]. Further research showed that the 270 Giga tons of anthropogenic carbon emissions over the past 200 years would have increased CO₂ concentrations from 280 to 380 ppm [3, 4]. Worth mentioning that the international agreeable guideline of the ambient CO₂ is 350 ppm [5].

Reports indicated that the on-road vehicle emissions constitute the major source of atmospheric CO₂ in urban areas. CO₂ emissions from road traffic worldwide will increase by 92% between 1990 and 2020 [3, 6], where direct energy consumption and CO₂ emissions are increasing faster for urban than for rural households [7]. It was concluded that high volume of traffic, transport consumption of fossil fuels and shortage of adequate public transport system was

responsible for the high CO₂ level in the environment [3, 8].

Outdoor air pollution contributed to various adverse health effects. Whereas some effects may be related to short-term exposure, others had to be related to long-term exposure [9]. Urban atmospheric pollution has a well-known impact on acute and chronic respiratory disease and adverse health effects on cardiovascular system [10]. Currently road traffic was the most used mode of transport, where a high amount of money is spent to improve air quality deterioration results from pollution and environmental effects of transport sector emissions [11]. CO, CO₂, NO and NO₂, VOCs, O₃ and aerosol particles are the most important urban air pollutants in terms of emissions and impact on the environment and human health as well [12, 13].

Globally, people facing increasing risks of respiratory diseases due to smoke and dust in both occupational and industrial sectors [14].

In Gaza strip there are 72232 of registered motor vehicle and there was a rapid growth number of motor vehicle in the last years, especially following the operation of tunnels linking the Gaza Strip and Egypt borderline [15]. From February to November (2013), the fuel consumption in Gaza strip used for the transport sector, both Gasoline and diesel reached 15,248,000 and 9,773,000 liters respectively [15].

The aims of this study were to determine levels of Carbon Dioxide (CO₂) emissions from motor vehicles, to investigate the correlations between CO₂ trends and health effects, and

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to provide suggestions and recommendations for decision makers regarding reducing the CO₂ emissions at Gaza city streets.

2. Methodology

To achieve this purpose, the study monitored traffic CO₂ emissions at Gaza main streets and investigated associated health impacts; descriptive analytical method were used.

2.1. Site Selection

This research focused on Gaza city as a case study because it is considered as the largest and busiest city in Gaza strip. Four main streets and some minor streets (in between the main streets) are selected (as shown in Figure 1) as the most crowded streets in Gaza city, which are as follows, Jamal Abdel Nasser Street-Al Thalatheni (Location 1), Omar EL-Mokhtar Street(Location 2), EL-Wehda Street (Location 3), EL-Gala'a Street (Location 4) and Several minor Streets (Location 5).

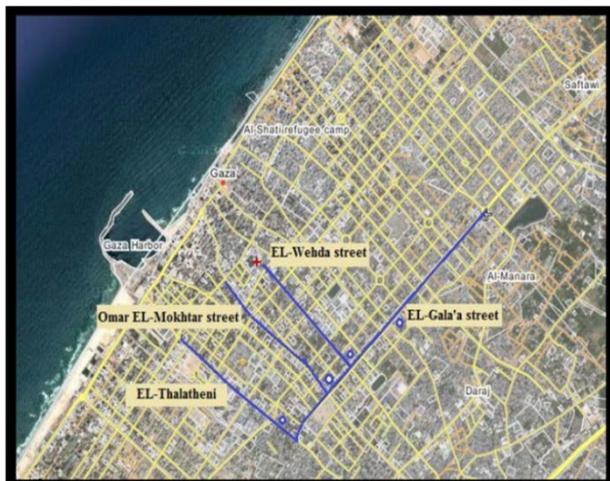


Figure 1. Study Area

2.2. Monitoring

Levels of CO₂ were monitored at each intersection of the selected main streets during various times of the day (10:30 a.m. -1:30 p.m) and (3:30 p.m-6:00 p.m). Monitoring times chosen to capture the range of daily exposure of the streets users. Concentrations were averaged over the 15 minutes measurement period at each intersection. Temperature and Humidity conditions were recorded at the start and end of the monitoring session at each intersection, and readings were averaged. The monitoring was done during the period (1/12/2012 to 10/2/2013).

2.3. Instruments

The Kanomax handheld IAQ monitor, model 2211 was used to measure CO₂ continuously. The device uses a Non-Distributed Infrared sensor (NDIR) with a range of 0 to 5000 ppm, a resolution of 1 ppm, and a response time of 45 seconds (90% responsive, with calibration cover). Its

operating temperature range is between -20°C and 40°C, and its humidity is between 5 and 95%. The sensor had an accuracy of ±3% of display value or ± 50 ppm; whichever is larger at calibration temperature [16]. Temperature (°C) and humidity were measured using the multi-meter and Global Position System (GPS) was used to identify the coordinates of the sampling sites.

2.4. Mapping

Geographic information system (GIS) tool (ArcGIS and ArcView) were used to map the concentration of CO₂ at each sampling station [17].

2.5. Health Data Collection

Data were collected by using health effects questionnaire that was distributed randomly at Gaza city streets, explanation done to the participants before they filled in the questionnaire.

3. Results and Discussion

3.1. CO₂ Levels

The mean concentration of CO₂ ranged from 341 to 518 ppm, and the lowest value recorded was 291 ppm at Jamal Abdel Nasser Street (JAS), while the highest level was 608 ppm at the inner streets. Table (1) summarized the CO₂ concentration in all sampling stations during the monitoring period.

Table 1. Mean, minimum and maximum CO₂ levels

	St.(1) JANS	St.(2) OEMS	St. (3) EWS	St. (4) EGS	St. (5) IS
Mean (ppm)	438	341	365	402	518
Max (ppm)	485	404	525	480	608
Min (ppm)	388	300	291	341	416
Std. Dev.	23.6	27.7	52.4	36.3	45.9

The result in Figure (1) shows that CO₂ concentrations tend to be high all the monitored sites at JANS where it's one of the busiest streets in Gaza city and according to the study of [18], its shown that the traffic volume during weekdays (Wednesday) was 3305 passenger car unit (PCU) at the morning peak while it was 3397 PCU at the afternoon peak. Furthermore, during weekend (Saturday), the traffic counts show that the volume was 2835 PCU in the morning peak and 3191 PCU at the afternoon.

As shown Figure (2), the levels of CO₂ were lower than 350 ppm in most of monitoring points except few main intersections (were higher than 350 ppm) due to the high volume of traffic. It was observed that the traffic volume at OEMS on Saturday were 1942 PCU and 2166 PCU in the morning and afternoon respectively, while on Wednesday the traffic volume was found to be 1986 PCU and 1951 PCU in the morning and afternoon respectively [18].

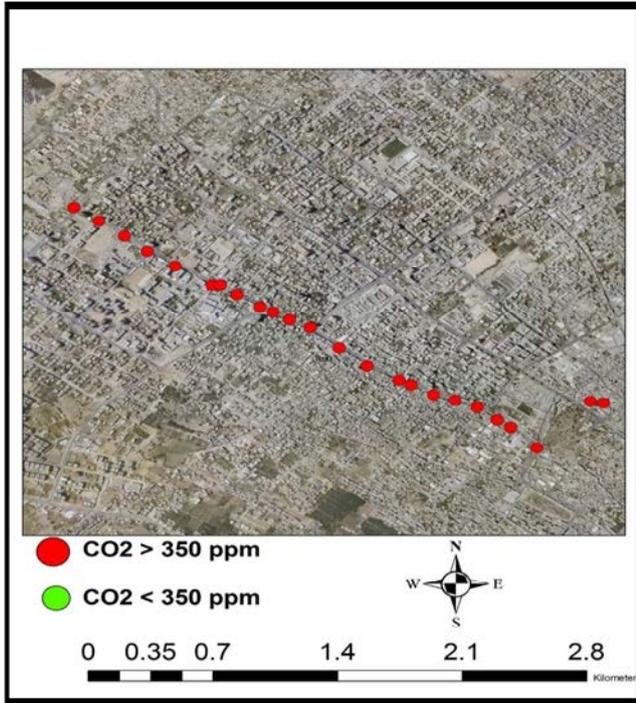


Figure 1. CO₂ at Jamal Abdel Nasser Street (JANS)

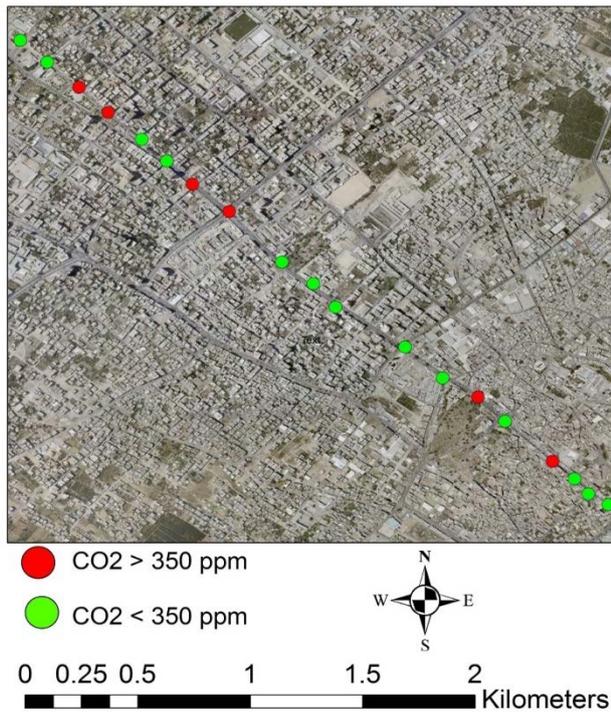


Figure 2. CO₂ at Omar EL-Mokhtar Street (OEMS)

The concentration of CO₂ at OEMS as shown in Figure 2, were fluctuating (up and down from the limit of 350 ppm) due to the changes in traffic flow and lay out of the street. It is obviously seen that the lowest traffic volume observed at OEMS ranges from 1159 to 1927 PCU, because people tend to drive in larger streets as their pathway to their destination to avoid congestion due to its small cross section. Therefore,

the traffic volume was higher during weekday (Wednesday) which was 3714 PCU, compared to weekend (Saturday), which was 2573 PCU.

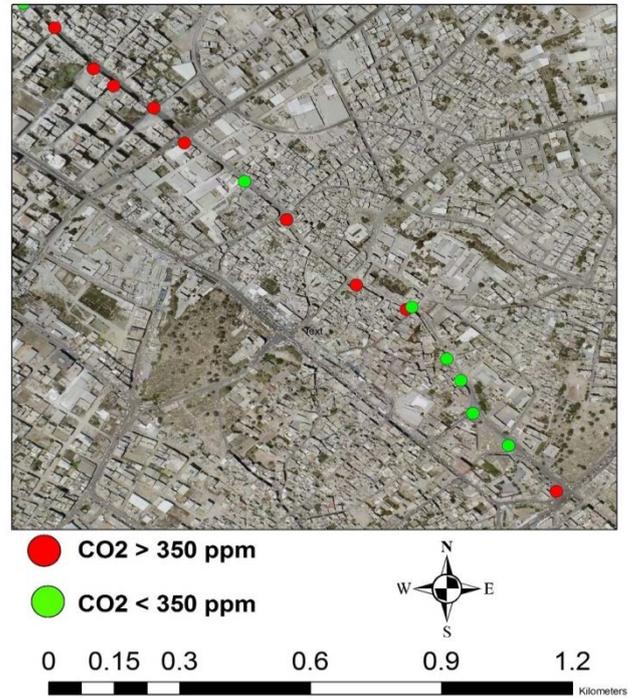


Figure 3. CO₂ at El-Wehda Street (EWS)

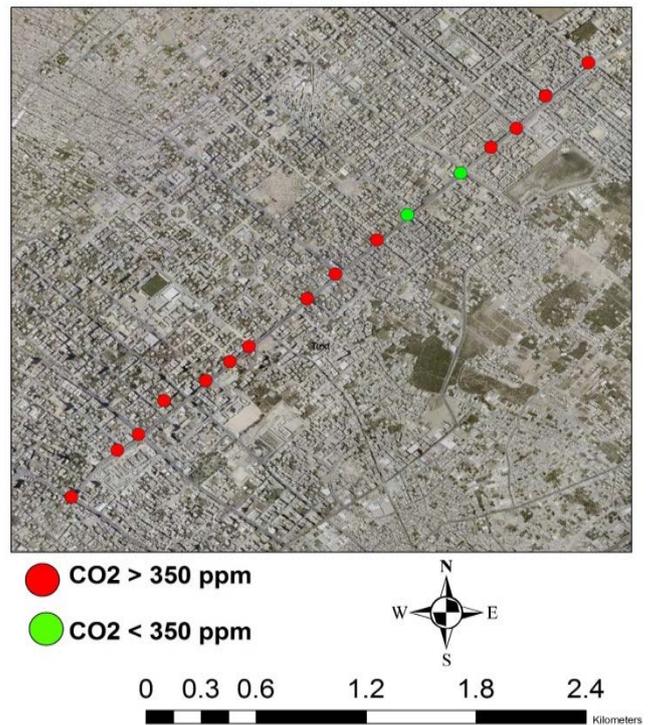


Figure 4. CO₂ at El-Gala'a Street (EGS)

The concentration of CO₂ (in figure 4) was more than 350ppm in most of the monitored locations along the street, where EGS considered one of the main arterial streets that

connect North Gaza with Gaza city, traffic count study shows that the traffic volume at EGS on Saturday were 2959 PCU and 3528 PCU in the morning and afternoon respectively while on Wednesday the traffic volume was 4233 PCU and 4443 PCU in the morning and afternoon respectively.

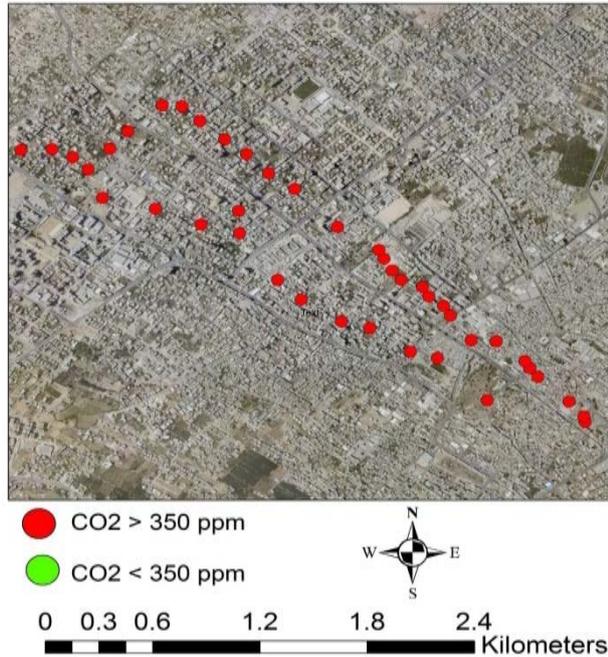


Figure 5. CO₂ at the Inner Streets (IS)

Its shown in figure 5, that at the monitored locations in the inner streets (in between the main streets), the CO₂ concentration was higher than the 350 ppm level; this was due to the traffic emissions at both sides and the street canyon effect as well.

3.2. Public Health Assessment

The study population included pedestrians and drivers selected randomly, the sample size was 200, and the questionnaires were distributed and collected in early May 2013.

3.2.1. Response Rate

From the 138 questionnaire subjects, 118 subjects had responded, with a response rate of 68%.

3.2.2. Prevalence of Health Outcomes

Pedestrian and drivers were asked on the symptoms they feel while walking or driving at Gaza city streets, as shown in figure 6; it can be noticed that 74% of the study population complained of nasal discharge, 71% felt eyes itchiness, 67% had a dry throat and 5% suffered breathing difficulties. This research results come in line with the results of a study conducted by [19] who found associations of asthma-related hospital morbidity with ambient CO, NO₂, NO_x, and PM_{2.5}, particularly during the colder seasons. Moreover the results of a study by [20] show significant associations between air

pollutants and respiratory hospital admissions, and stronger effects were observed for females and aged ≥65 yrs.

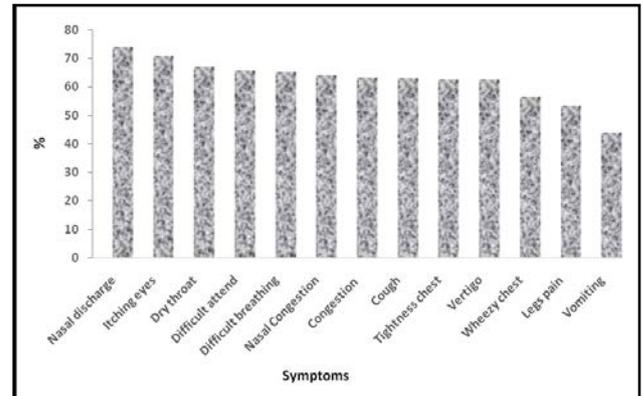


Figure 6. Health Symptoms due to Traffic Emissions

3.2.3. Outdoor Air Quality

In this section, they survey examined the views of the road users on the outdoor air quality, as shown in table 2; 89% of the interviewed people said that they could see air pollution physically; 92% of the subjects thought that traffic emissions is the main source of air pollution; 95% believed that good air quality is important for health; and 75% of them agreed to enforce the laws to limit the number of cars running on the streets especially old vehicles.

Table 2. Views on Outdoor Air Quality

No.	Items	Weighted Average (%)
1	Can you see any type of air pollution	89
2	Cars were the main source of air pollution	92
3	Burning rubbish is a main source of air pollution	93
4	Penalties should be used improve the air quality	85
5	Air quality is important to my health	95
6	There was almost a nasty smell while walking at streets	90
7	I am pleased with the air quality in Gaza city streets in general.	59
8	I agree to use law to limit the number of cars in the Gaza city streets	75

A similar study conducted by [21] and found that there was an association between the traffic-related air pollution and self-reported prevalence of respiratory illness, specially wheezing, ear/throat/nose infection, and reporting physician-diagnosed asthma and flu or serious cold. Another study by [22] found that living within approximately 90 m of a main road is associated with a proximity-related increase in the risk of wheezing illness in children. One more research conducted by [23] concluded that living or attending schools near high traffic density roads exposes children to higher levels of motor vehicle air pollutants and increased the incidence and prevalence of childhood asthma and wheeze.

The results of this research showed that there is a strong

correlation between CO₂ levels and occurrence of the traffic related health symptoms, where the ambient air quality in the research area was found to be poor (beyond the international standards) and consequently the residents might experience respiratory illness.

The results of Analysis of Variance (ANOVA) showed that there was no statistical difference ($p > 0.05$) between gender, place of residence and prevalence of the emission health symptoms.

4. Conclusions

This study examined the trends of CO₂ emitted from traffic vehicles (as an indicator of traffic emissions) and investigated the associated health impacts at Gaza city. The results showed the CO₂ levels exceeded the international agreeable limit which is 350 ppm in the majority of the monitoring sites where the CO₂ concentrations ranges from 291 to 608 ppm. The high level of CO₂ attributed to the high volume of traffic at Gaza, adding to the narrow streets width and the street canyon effect due to the layout of the residential building at both streets sides.

The overall air quality of the area was found to be poor and there were general and respiratory health effects reportedly experienced by the people in the area. The public health survey results showed that 63% complain from cough and nasal congestion while walking at the Gaza city streets and 92% of the sample thought that traffic emission was the main source of air pollution in the city.

These negative health effects urges the decision makers to adopt traffic emission control strategies. Reducing the contribution of CO₂ emission from traffic would be the most beneficial mitigation measure; this reduction can be achieved by eliminating the old vehicles from running on the streets and a periodic maintenance to be done for vehicles which are in good conditions. It is necessary to improve the public transport infrastructure to encourage the people to use such transport means, which will help in reducing transportation CO₂. One more effective measure is to plant more trees at the roadside, where the trees absorb CO₂ during the photosynthesis process [24].

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REFERENCES

[1] Beggs PJ, Bennett CM. Climate Change, Aeroallergens, Natural Particulates, and Human Health in Australia: State of the Science and Policy, *Asia-Pac J Public HE*. 2011; 23(2) 46S–53S.

[2] Hana EG, Bell E, King D, Woodruff R. Climate Change and Australian Agriculture: A Review of the Threats Facing Rural Communities and the Health Policy Landscape, *Asia-Pac J Public HE*. 2011; 23(2) 105S–118S.

[3] Kakouei A, Vatani A, Idris AKB. An estimation of traffic related CO₂ emissions from motor vehicles in the capital city of, Iran, *Iran J Environ Healt*. 2012; 9(13), 1-5.

[4] Hayashi K, Gao J. Demographic Impact on Environment - A Case Study Focusing on CO₂ Emission in China, *Asia-Pac J Public HE*. 1998; 10 (92), 81-87

[5] U.S. Environmental Protection Agency (USEPA). National Ambient Air Quality Standards (NAAQS), edited, EPA. (U.S. Environmental Protection Agency), 2013.

[6] Alnawaiseh NA, Hashim JH, Isa ZM. Relationship between Vehicle Count and Particulate Air Pollution in Amman, Jordan. *Asia-Pac J Public HE*. 2012; DOI: 10.1177/1010539 512455046.

[7] Gilman L. Global Warming, edited by Lerner, Gale Virtual Reference Library. Gupta, M. D. 2014, Carbon footprint from road transport use in Kolkata city, *Transport Res D-TR E*. 2009; 32, 397–410.

[8] Yang C, McCollum D, McCarthy R, Leighty W. Meeting an 80% reduction in greenhouse gas emissions from transportation by 2050: A case study in California, *Transport Res D-TR E*, 2009;14 (3):147–156.

[9] Ayi Fanou L, Mobio T, Creppy E, Fayomi B, Fustoni S, Møller P, Kyrtopoulos T, Georgiades P, Loft S, Sanni A, Skov H, Øvrebø S, Autrup H. Survey of air pollution in Cotonou, Benin—air monitoring and biomarkers, *Sci Total Environ*. 2006; 358(1-3), 85-96.

[10] Maitre A, Bonnetterre V, Huillard L, Sabatier P, Gaudemaris RD. Impact of urban atmospheric pollution on coronary disease, *Eur Heart J*. 2006; 27, 2275 –2284.

[11] Victoria T, Mihaai D. Air quality assessment based on road traffic pollutants dispersion modelling: Giurgiu – Ruse Bridge Case study *Incas Bulletin*. 2012; 4(4): 171-181.

[12] Raducan G, Stefanescu I. A Qualitative Study of Air Pollutants from Road Traffic, edited, InTech, Croatia, 2012.

[13] Lee S C, Change M. Indoor and outdoor air quality investigation at schools in Hong Kong. *Chemosphere*, 2000, 41 (1-2): 109-113.

[14] Aljeesh, Y. Al Madhoun, W. El Jabaly, S. Effect of Exposure to Cement Dust on Pulmonary Function among Cement Plants Workers in the Middle Governorate, Gaza, Palestine, *Public Health Research*, 2015,5(5):129-134,DOI:10.5923/j.phr.20150505.01

[15] Ministry of Transport (MOT), Palestine. Number of vehicles in Gaza strip, edited, Ministry of Transport, Gaza, 2013.

[16] KANOMAX. IAQ MONITOR, MODEL 2211, Operation Manual, edited by Kanomax Japan Inc, Kanomax, Japan, 2012.

[17] Garcia SM, Domingues G, Gomes C, Silva AV, Almeida SM. Impact of Road Traffic Emissions on Ambient Air Quality in an Industrialized Area, *J Toxicol Env Heal A*. 2013; 76(7), 429-439.

- [18] Al Madhoun WA, Rashid M, EL-Khuzundar S, EL-Helou S. Assessment of Lead Pollution in Urban Roadside Environment of Gaza City. Proceeding of the Fifth International Conference on Engineering Sustainability, Gaza, Palestine, 2014.
- [19] Delfino RJ, Wu J, Tjoa T, Gullesserian SK, Nickerson B, Gillen DL. Asthma Morbidity and Ambient Air Pollution, *Epidemiology*. 2014; 25(1), 48-57.
- [20] Tao Y, Mi S, Zhou S, Wang S, Xie X., Air pollution and hospital admissions for respiratory diseases in Lanzhou, China, *Environ Pollut*. 2014; 185, 196-201.
- [21] Brauer M, Hoek G, Van Vliet P, Meliefste K, Fischer PH, Wijga A, Koopman LP, Neijens HJ, Gerritsen J, Kerkhof M, Heinrich J, Bellander T, Brunekreef B. Air Pollution from Traffic and the Development of Respiratory Infections and Asthmatic and Allergic Symptoms in Children, *AM J Resp Crit Care Med*. 2002.;166(8), 1092-1098.
- [22] Venn AJ, Lewis SA, Cooper M, Hubbard R, Britton J, Living Near a Main Road and the Risk of Wheezing Illness in Children, *Am J Resp Crit Care Med*. 2001; 2177-2180.
- [23] Gasana J, Dillikar D, Mendy A, Forno E, Ramos Vieira E. Motor vehicle air pollution and asthma in children: A meta-analysis, *Environ Res*. 2012; 117, 36-45.
- [24] Al Madhoun WA, Rashid M. An Overview on the Mutual Relationship between Forests and Air Pollution – Gain and Loss. National Conference Royal Belum (NCRB), Gerik Perak, Malaysia, 2014.