

Green wall design to mitigate highway pollution

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ABSTRACT

Recent studies showed that Baghdad City suffers from highly polluted environment. The enormous traffic congestion and highly number of vehicles, especially during peak hours, is the main source of this pollution. This study is focused on stopping this deterioration by suggesting a green infrastructure to the one of main arterial road of the city (Mohamed Al-Qasim Expressway). The amount of pollutants resulted from traffic fleet have been estimated. It was found that the level of pollution is exceeded the acceptable levels. A combination of vegetation (trees) and green wall (shrubs) has been proposed for designing the green infrastructure for a selected section. Three types of trees namely: Neem tree, Ficus benjamina and Conocarpus have been selected after review many types that can be used for this purpose and resist the extreme hot weather. Two types of shrubs: Myrtus communis and Dodonaea viscosa were proposed due to their suitability for this function of filtering the particulate matters. The maximum ideal annual amount of CO₂ sequestration for 1km of trees planted on road sides and median was about 43.2, 10.5, and 9.25 Tonne for the Neem tree, Ficus benjamina, and Conocarpus, respectively.

Keywords: Highway, CO₂ emission, Environmental pollutants, Green infrastructure, particulate matter

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1. Introduction

Urban growth became a common problem throughout the world [1] as people left their rural areas and accumulated in major cities [2]. This growth has good economic benefits but at the same time has many environmental consequences [3]; which affect climate change and increase global warming [4].

Numerous studies have revealed the existence of highly percentage of air pollutants to levels above the standard values [5]. Chen et al. (2007) reported that the main air contaminants found in our environment are particulate matter (PM), ozone (O₃), CO in addition to NO₂, SO₂ and CO₂. In Iraq, especially in capital Baghdad, vast masses of pollutants are emitted in the environment because of many reasons: the trucks run by diesel, buses, heavy-duty building equipment, big number of shared electricity generators of about 15,000 [6] in addition to the highly number of vehicles run by gasoline; which increased after 2003 with a yearly percentage of about 17.5% [7]. Nearly 38% of these vehicles concentrate in Baghdad with about 1.75 million vehicles[5]. Many studies reported that traffic pollutants are the major cause of environmental pollutions all-over the world[6]. These include PM, nitrogen oxides (NO_x), CO and volatile organic compounds (VOCS).

Traffic pollutants increase the environmental pollution and expose people scattered on, and near roads to the risk of lung diseases, cardiovascular morbidity, asthma [7], mortality , cognitive declines (Health Effects Institute [7].

Environmental Protection Agency (EPA) website (EPA, 2020a) reported that about 50 million people in the United States live close to road environment, within less than 100 m from major roads. Similarly, nearly 40% of people in Toronto live up to 500 m from principal arterial (expressway) or up to 100 m from major roads [8].

The concentration of pollutants near roads are affected by different factors such as: distance to the road, its configuration, geometrics of the nearby infrastructure such as noise barriers and green infrastructure[9], wind, temp, elevation and fuel type.

It is important to measure the concentration of air contaminants such as NO_2 , particulate matters ($\text{PM}_{2.5}$ ($\text{PM} \leq 2.5 \mu\text{m}$) and PM_{10} ($\text{PM} \leq 10 \mu\text{m}$)) and CO_2 because they have the most effect in the ambient urban air pollution and are related to many human health risks in the long term [10], especially respiratory diseases for young children [11] and cardiovascular diseases. Moreover, [12] reported that these pollutants affect climate [13] both directly and indirectly. Therefore, these air pollutants need a continuous monitoring and measuring in order to find the best solution needed to mitigate these highly levels. Figure 1 shows the size comparisons for PM particles [14].

Focused on measuring air pollution levels in Baghdad City, especially Mohamed Al-Qasim expressway. They have made a relationship between the volume of traffic and different air pollutants. The results proved that these pollutants are increased above the standard requirements during rush hours of the day [15]. recommended the need for a serious treatment to protect the environment and people from these pollutant risks. Accordingly, this study was focused on finding a reasonable solution for this problem using plants alongside a section of Mohamed Al-Qasim expressway to decrease the concentration levels of pollutants.

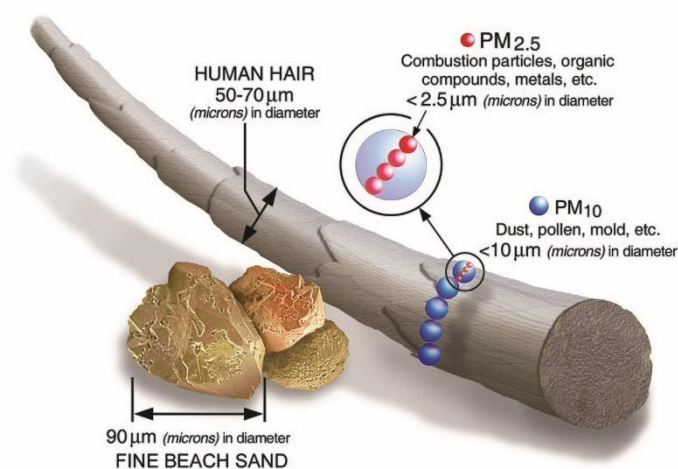


Figure 1. Size comparisons for PM particles [16]

1.1. Background

A number of studies have been conducted to predict a deposition model for simulating the fate of aerosols such as Fowler et al. (2002) study; which planted a grass land with trees in urban areas. They predicted a model expects a decreasing from 5% up to 50% in the contaminant's concentration level. In addition, Fowler et al. (2004) reported that woodland is more efficient in aerosol deposition than adjacent grassland. They found the deposition velocity of environmental pollutants in a woodland; which is about three times that of neighboring grassland. Moreover, Nowak (2006a) reported that urban forest of Washington, D.C. is estimated to store about 526,000 tons of carbon and remove about 540 tons of air pollutant in a year. While the urban forest in Casper, Wyoming, is estimated to store about 37,000 tons of carbon and remove about 50 tons of air pollution per year (Nowak 2006b).

McPherson and Simpson (1999) stated that increasing number of trees from 4700 to 15000 trees per year in a residential land use in Austin, USA, is projected to reduce CO_2 after 12 years of about 33000 tons annually.

Carried out an intensive study to quantify the number of pollutant particles deposited on the leaf surfaces. They focused on the filtering effects of green infrastructure using Environmental Scanning Electron Microscopy (ESEM) photographs [17]. They studied leaves samples; which were taken from two locations: the first location was from near a traffic road and the second location was from woodland. They found a difference in the number of pollutant particles between the underside and upper side of the leaves sample. The main conclusion was that the best way to know the ability of vegetation to absorb pollutant particles from the atmosphere is through using counting method of pollutants instead of weighting leaves.

In Iraq and to date, several studies have been conducted to measure the pollutants concentration levels in Baghdad City such as the study conducted who have measured pollutants concentration levels such as

suspended particles, CO and CO₂, in 22 stations located in different Baghdad regions. These stations were classified according to their land usage [18]. Found that the levels of these contaminants are above the standardized requirements such as the Iraqi standard levels and the World Health Organization (WHO). They stated that these highly concentration levels are due to many reasons such as: high number of vehicles, poor quality of fuel and many of the industrial activities that are practiced within the city.

Contour map of CO₂ concentration (ppm) in the air environment of Baghdad City has been drawn and shown in Figure 2. The concentration levels of CO₂ (ppm) were adopted [18]. It is clear from Figure 2 that highly concentration level of CO₂ was found; which is nearly 400 ppm, especially near the chosen case study. Stated that these high concentration levels are due to many reasons such as: highly number of vehicles, poor quality of fuel and many of the industrial activities that are practiced within the city. Accordingly this study was focused on decreasing these pollutants through designing a green infrastructure along sides a section of Mohamed Al-Qasim expressway (one of the major arterials in Baghdad City). To do so, a comprehensive review has been made to choose plants that are viable in the Environment of Iraq, i.e. extreme weather environment especially the hot and long summer [19].

1.2. Types of Pollutants

There are two major types of pollutants Particulate matters and gases emissions:

Particulate matters: these matters can be classified to two types according to their sizes.

1 - Coarse particulate matters; which are produced mainly from burning of fossil fuel. PM_{2.5} (Aerodynamic size of less than 2.5 μm) and PM₁₀ (Aerodynamic size of less than 10 μm) [19]. Considered PM₁₀ as the main health concern in both developed and developing countries. In addition, PM₁₀ may rise the risk of death due to respiratory diseases [20]. While, reported that PM_{2.5} was the reason for premature mortality for about 1.27 million person in China [21].

2- Fine particulate matters (PM₁); which have different composition than that of coarse PMs. These are tiny diameter particles, more dangerous than coarse particles and found in highly concentration levels in vehicle exhaust [22].

The European Environment Agency (EEA, 2005) stated that PM concentration level is the most significant environmental factor that has a major impact on health in Europe. These concentration levels are responsible for most of the environmental diseases. Air contaminant with high concentration level of PM (WHO, 2020) has the responsibility for up to 725000 deaths per year in Europe [23], more than 4000 deaths per year in London [24] and about 900 deaths per year in Birmingham.

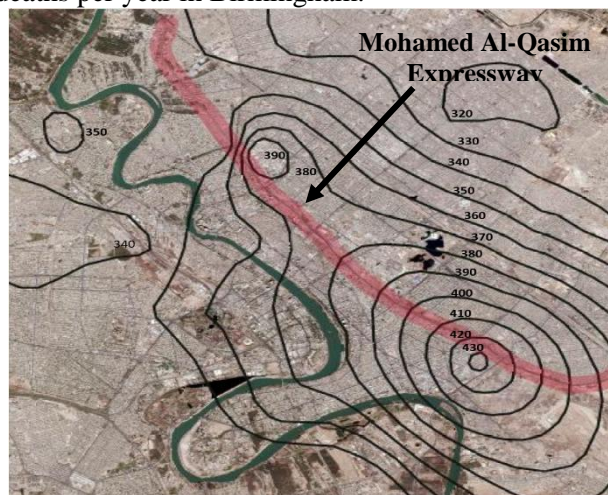


Figure 2. Contour map of CO₂ concentration (ppm) in the air of Baghdad City, showing high level near the case study road

Gases emission: these emissions can be classified in two types:

1 - VOCs; consist of gaseous hydrocarbons in the ambient temperatures; which are emitted from the petrol tanks of vehicles [25] during the burning process of fossil fuels [26]. It is important to mention [27] stated that VOC may contribute to ozone creation; which is one of greenhouse gases.

2 - Greenhouse gas emission: is one of the major results from the extreme using of vehicles. These gasses have produced from burning the fossil fuels in the car engines [28]. Greenhouse gasses include different types

of gases [29] such as CO₂, water vapor (H₂O), ozone (O₃), methane (CH₄), and nitrous oxide (N₂O). In addition to that, one of the pollutant gasses that emitted from the combustion of fossil fuels is SO₂; which is a harmful gas for the human health, especially for those who are suffering from asthma or having any breathing problem. If the concentration level of SO₂ exceeded in the atmosphere, it would be a reason for a permanent damage of the lung. Moreover, H₂S and SO₂ are harmful gases for the human health that can cause severe problem to human life [29] even in a low concentration level (ppm level). In addition, CO₂ has also emitted from burning fuel needed to power vehicles (McPherson and Simpson, 1999) and its amount depends on the amount of carbon in this fuel (United States Environmental Protection Agency (EPA) website (EPA, 2020b). There are 8887 gm of CO₂ in 1 gallon of gasoline and 10180 gm CO₂ in 1 gallon of diesel (EPA, 2020b). Gasoline vehicles run about 22 miles per gallon. Accordingly, 404 grams of CO₂ has emitted from passenger vehicle per mile. In addition, EPA (2020b) stated that passenger car runs about 11500 miles per year; which means 4.6 metric tons of CO₂ has emitted yearly. Accordingly, the main aim of this research was to find a sustainable method to decrease the concentration level of pollutants resulted from the highly number of vehicles in one of major arterial road in Baghdad City.

2. Removal of pollutants

Removal of particles from the atmosphere can be done by dry deposition or wet deposition [30]; which controls air pollutants [31]. Wet deposition means the removal of environmental pollutants by precipitation, or snow scavenging. This type of deposition is dependent on rainfall intensity and diameter of particles [32]. While, dry deposition means the removal of environmental pollutants (particles or gases) from the ambient atmosphere by gravitational settling, interception or diffusion, depending on the size of pollutant's particle and surface-type differences.

2.1. Vegetation

It is important to mention that vegetation has an important role in absorbing different environmental pollutants such as CO₂ and SO₂ [33]. Accordingly, researchers suggest different strategies to mitigate the effect of air pollutants such as:

- Trees have been considered as one of these strategies due to their ability to reduce the concentration levels of PM, O₃, SO₂, NO₂, CO₂ and CO [34].

Reported that trees are efficient to capture pollutant's particles from the ambient atmosphere by dry deposition [35]. The reason is due to its large surface area that lets pollutant's particles to be collected on it. Moreover, trees remove gaseous air pollution by up taking these gases via leaf stomata [36]. While, some gaseous pollutants are removed via the plant surface [37]. Trees also affect ambient temperature, humidity, and wind speed. These can in turn adjust the air quality and decrease the concentration level of pollutants in urban areas [38]. Moreover, the emission of many pollutants and the formation of ozone are depended on the ambient temperature. As a result, the decrease in the ambient air temperature due to trees can reduce ozone formation. As an example, trees of urban New York City in 1994 removed pollutants of about 1821 metric tons from the ambient air. This amount was more than that removed by trees of Atlanta and Baltimore. The difference in the removal of air pollutant is due to length of in-leaf season, rate of precipitation, ambient temperature, humidity and other meteorological variables . Large size healthy trees with a diameter more than 77 cm can annually remove air pollutants of about 1.4 kg/year; which is about 70 times more than that removed by small size healthy trees with a diameter less than 8 cm (0.02 kg/year). The average of Air quality improvement in USA, New York City via trees during in-leaf season equals to 0.47% for (PM_{2.5} and PM₁₀), 0.45% for O₃, 0.43% for SO₂, 0.30% for NO₂, and 0.002% for CO (Nowak, 2002). For CO₂, trees are considered like sponges that absorb the carbon from the atmosphere. They can decrease its concentration levels in two ways:

- (1) For a well growing actively tree, the rate of CO₂ up-taken through photosynthesis is more than that released through respiration [39]. The result is decreasing the concentration level of CO₂ in the ambient environment;

- (2) Trees planting around buildings can be the reason for reducing the need for heating or cooling these buildings [40], thereby decreasing emissions needed to produce electrical power.

- Shrubs and bushes

Concluded that there are some types of shrubs and bushes have the same ability as trees to fix atmospheric CO₂ into their biomass. They also reported that these sorts of shrubs may be used in highly polluted areas such

as road sides and industry areas to enhance the air quality in these places through reducing CO₂ in the atmospheric and decrease the global warming. They used *acacia rigidula*, *Rhus virens*, *Litsea glaucescens*, *Eryobotria japonica*, *Gochnatia hypoleuca*, *Forestiera angustifolia*, *Rosamrinus officinalis* and *Tecoma stans*. It is important to mention that all types of shrubs and bushes used in Maiti's study [41] are suitable for the weather of Mexico where the study has been done.

2.2. Green wall infrastructure

Green wall infrastructures are vegetated vertical structures (vertical garden) or vegetated wall surface [42]. Green wall is a key component for many environmental problems, especially in dense urban areas. They are mostly categorized as green facades or living wall, as shown in Figure 3.

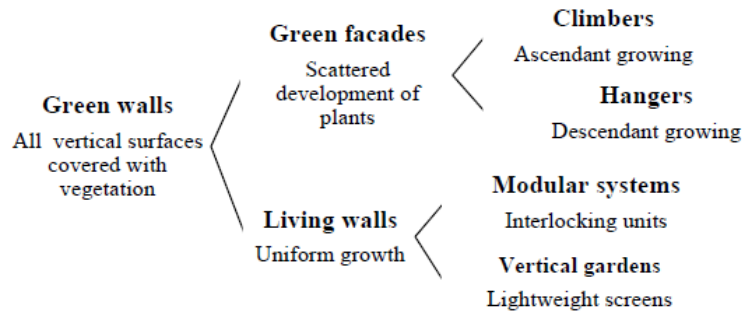


Figure 3. Current green walls systems

Green walls have important benefits for the ambient environment [43] by absorbing pollutants such as CO₂ and metal particles to improve air quality and reducing temperature (Manso and Castro-Gomes, 2015). Green walls are also contributing in shading big buildings [44]. Hence, decreasing the energy needed for heating or cooling these buildings. In addition, green walls are using to improving aesthetics [45], ecological benefits [46] and increasing land values [47]. Green walls aid to achieve sustainable urban formation [48]. More details about the benefits of green walls may be found elsewhere .

Reported that green wall could help Birmingham city, United Kingdom, to be more sustainable through absorbing atmospheric pollution from the ambient environment and filtering out suspended particles. They also stated that these walls have the ability to remove up to 30% of pollutants from the ambient environment. Accordingly, green walls have been applied to several places in the Great Britain, including London and Birmingham. The comparison of green wall systems advantages and disadvantages can be found elsewhere [49].

Another study about green walls presented the effect of green walls on spreading the air pollutants in open road environments [50] as shown in Figure 4.

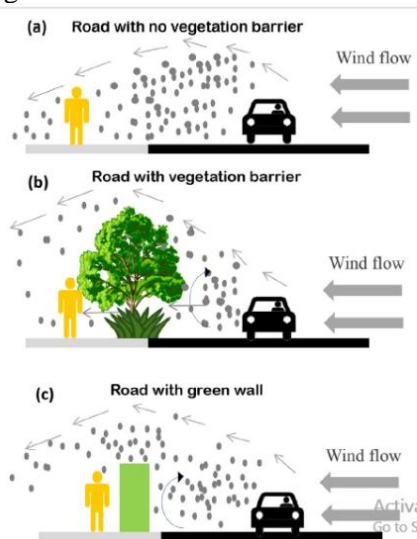


Figure 4. Dispersion patterns of road pollutants under open road configurations (a) without vegetation barrier (b) with vegetation, and (c) with green wall

The cost of green wall can also be varied depending on the selected system type. The system of living wall is more expensive than that of green facades. The cost of green facades can be reached up to 75 €/m² or a little less depending on the material used. The same case is for living walls system, the cost of this system is dependent on the material used for construction, system complexity, application process and the maintenance needs. In some cases, the cost reaches to about 1200 €/m² [51].

Manso and Castro-Gomes (2015) reported that choosing the appropriate type of green wall depends on several things, including construction and climate restraints, environmental impact and the estimated cost. Stated that green walls system must be developed to be more sustainable through using natural or recycled materials for construction or using plant species that need a little watering.

In this study, two types of shrubs were used for the green wall. They were selected specifically to be suitable to the hot and arid weather of Baghdad City.

3. Problem description

Baghdad, capital of Al-Iraq, is a big city with about 7.2 million capita in 2018 as reported by World Population Review webpage (World Population Review, 2020). Environmental studies for Baghdad City have not received a good attention [52] although it suffers from severe traffic congestion in the last years, especially in peak hours. This is due to many reasons: poor transportation network, lack of road pavement maintenance and absence of improvement project [53].

A major arterial Expressway, Mohamed Al-Qasim, with length of about 20 km (mobility function), located on the eastern part of Baghdad has chosen for the purpose of this study. Figure 5 shows a part of Mohamed Al-Qasim Expressway that mostly congested in different days of the week. This part positioned in front of the University of Technology (one of the big educational institutions in Baghdad); which was selected to be a study area for this research.

The reason for this selection was due to the high traffic volume, i.e. high level of pollutants. Figure 6 shows the average working daily traffic (hourly volume) for Mohamed Al-Qasim Expressway. While, Figure 7 shows the traffic fleet combination.

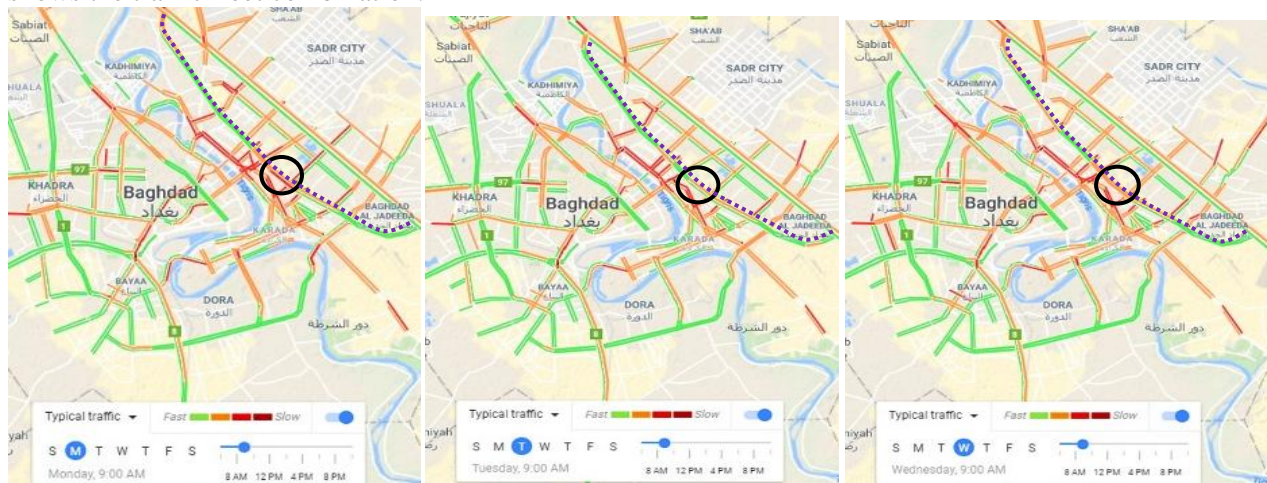


Figure 5. Traffic condition in Mohamed Al Qasim expressway (dotted) and main arterial roads network of Baghdad City at 9:00 a.m. on different working days

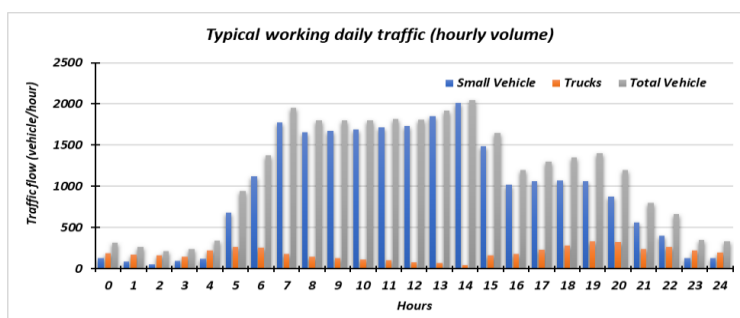


Figure 6. Average working daily traffic (hourly volume) for Mohamed Al-Qasim Expressway

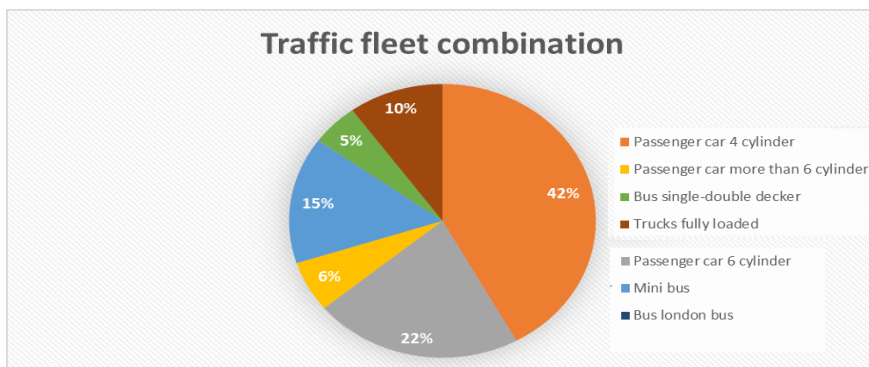


Figure 7. Traffic fleet combination

Studied the same Expressway section, they measured the ambient pollutants along 4 weeks by installing measuring instruments just 1 meter from the Expressway section. The measure included working days as well as holidays to ensure counting all the pollutants in the ambient environment. They stated that the concentration of these pollutants was above the standardized requirements in addition these concentrations were increased during the beginning and ending of the working days[42]. Have measured pollutants concentration levels such as suspended particles, CO and CO₂, in 22 stations located in different Baghdad regions; which classified according to their land usage. They found that the levels of these contaminants were above the standardized requirements such as the Iraqi standard levels and the World Health Organization (WHO), especially for the chosen study area. This is due to the highly number of vehicles in Baghdad City. Table 1 shows the average CO₂ emission for different vehicle types. According to Table 1, the emission of traffic fleet has been estimated for each hour as presented in Figure 8. The highly values for CO₂ emission revealed the need treatment urgently for this roadway section to protect people from this contaminant’s risks. Green walls have been recommended in recent studies as an important solution for reducing emissions from the atmosphere [40].

Table 1. Average CO₂ emission for different vehicle types (adopted from fuel consumption guide, 2018)

Vehicle Type	Engine size	% of Traffic	gm CO ₂ /Km	Average	gm CO ₂ /Km	gm CO ₂ /m
Passenger car	4 cylinder	42	160-220	190	289	0.289
	6 cylinder	22	240-300	270		
	More than 6 cylinder	6	300-420	360		
Mini bus		15	260-380	320	0.164	
Bus	Single-double decker	5	890-1350	1120	0.05	
	London bus		1600			
Trucks	Fully loaded	10	610-880	745	745	0.745

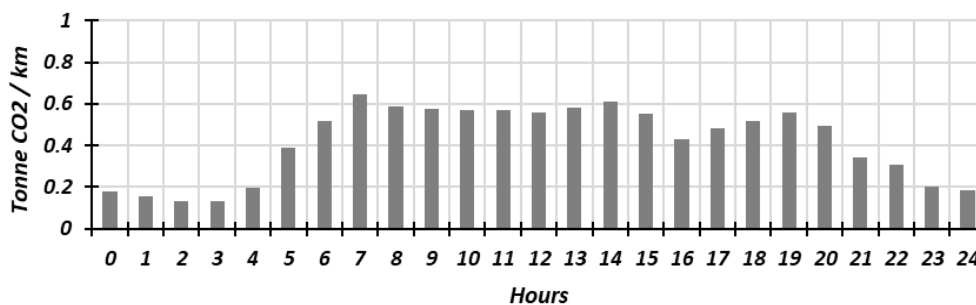


Figure 8. CO₂ Emission for hourly traffic fleet

Accordingly, this study proposed a combination of vegetation (trees) and green wall (shrubs) for designing a green infrastructure for the roadway selected section. All these plants were chosen to be able to resist the extreme weather condition of Baghdad as mentioned earlier.

Equation 1 was used in this study to estimate CO₂ that resulted from the traffic volumes of the selected Expressway's section. This equation was adopted from [15] and was based on the value of PCI; which can be obtained from its relation with the International Roughness Index (IRI) as shown in Equation

$$CO_2 \text{ Emission} \left(\frac{g}{Km} \right) = 9.4609 (PCI)^2 - 1573.6 (PCI) + 2000000 \dots\dots\dots (1)$$

$$\log(PCI) = 2 - 0.43 \log(IRI) \dots\dots\dots (2)$$

Table 2 can be used to determine the value of IRI; which is depended on the roadway pavement conditions.

Table 2. The pavement condition status based on IRI

IRI Value	Pavement Conditions	IRI Value	Pavement Conditions
IRI < 4	Good	8 ≤ IRI ≤ 12	Bad
4 ≤ IRI ≤ 8	Fair	IRI > 12	Poor

The pavement condition for the chosen roadway section was obtained from field evaluation and the result was fair pavement condition. Accordingly, the obtained value for CO₂ would be 1947438 g/Km/hr. It is important to mention that Equation (1) was developed for multilane roadway-two lanes in each direction. Hence, the averaged value for CO₂ for 1 lane would be about 0.5 tonne/Km/hr. This value is close to the emission value resulting from the traffic fleet of the chosen roadway section.

4. Suggested green infrastructure design

As mentioned previously, different studies such as [17] recommended the potential abilities of green walls and trees in the removal of the environmental pollutants. Three types of trees and two types of shrubs were chosen according to their suitability to live in a hot and arid atmosphere of Baghdad City, especially during summer season, these include:

1) Myrtus communis plants (Common Myrtle)

This plant is an evergreen shrub [26] with green leaves of small size. It has a good fragrance due to its white flowers; which then turn into blackberries. The height of this plant ranges from 2.4 m to 3.6 m. Its width can reach up to 3.6 m. The needing for water ranges from low to average. Moreover, this plant needs full exposure to sunlight (Gardenia, 2021) or light shade. Accordingly, this plant can be considered ideal for living in an atmosphere similar to that of Baghdad City.

2) Dodonaea viscosa (Hop bush)

Dodonaea viscosa is an evergreen easily grown shrub or small tree with leaves of up to 12 cm long [23]. It can be considered as a good choice for planting in warm, tropical, subtropical and arid regions due to the low need for water. This plant needs full exposure to sunlight [23]. The spreading of this plant ranges between (3 – 4.5 m) and its height ranges between (3 - 5 m). As a result, this plant is good for living in the atmosphere of Baghdad City.

3) Ficus benjamina (Weeping Fig)

Ficus benjamina is an easily grown and evergreen shrub or tree that reaches to about 15 m length and up to 9 m width [26]. It needs full or partial exposure to sunlight and average needing for water.

4) Conocarpus is an evergreen shrub or tree, see Figure 9. It can be considered as a good choice for planting in tropical and subtropical regions of the world. It can be grown to reach up to 10 m height and 7 m width [23].



Figure 9. Using Conocarpus as a green wall in Baghdad City

5) The Neem tree (margosa tree or Indian lilac)

It is an evergreen tree that can grow in tropical and subtropical regions of the world. Neem tree can withstand severe drought and it can grow well in a poor soil. It is a fast-growing tree that can reach up to 25 m height and 20 m width.

The neem tree is useful for afforestation and wood production [52]. In addition, it has other usage where it is used in the manufacture of shampoos, soaps and creams that take care of skin. The properties of Green walls (shrubs) and trees that suggested to be used in the proposed study area are shown in Table 3.

Table 3. Properties of Shrubs and Trees that suggested to be used

Shrubs	Spreading	Length	Trees	Spreading	Length
Myrtus communis	3.6 m	2.4 – 3.6 m	The Neem tree	20 m	25 m
Dodonaea viscosa	3 – 4.5 m	3 – 5 m	Conocarpus	7 m	10 m
			Ficus benjamina	9 m	15 m

The proposed green wall has two main functions:

- 1) Controlling the dispersion pattern of pollutants and sequestration of gases.
- 2) Enhancing the environmental condition by reducing CO₂ and increasing the Oxygen.

In general, CO₂ sequestration refers to the amount of CO₂ stored annually in one growing season [52]. This amount is proportional to the trees biomasses and is affected by their diameters and density [52]. Moreover, the Shodor’s Educational Foundation (SEF) website (SEF, 2020) reported that the amount of carbon sequestration depends on the tree’s characteristics such as:

1. The growth and mortality characteristics;
2. The planting conditions;
3. The amount of wood. This depends on the tree’s age. It is important to mention that the preference age is the young stage because CO₂ has accumulated speedily for several decades from planting trees and then the annual sequestration decreased . Accordingly, healthy trees absorb more CO₂ than that of stressed or aged trees.

Selection of tree species is an important issue needed to increase CO₂ sequestration [53].

The estimated value for the amount of carbon sequestered by trees can be calculated using Equations (3-7) (Sharma et al., 2020); which depend on the above-ground and the below-ground biomass.

$$AGB (Kg) = 34.4703 - 8.0671 D + 0.6589 D^2 \dots\dots\dots (3)$$

Where:

D: Diameter of tree

$$BGB (Kg) = AGB * \left(\frac{15}{100}\right) \dots\dots\dots (4)$$

$$Total\ Biomass = AGB + BGB \dots\dots\dots (5)$$

$$Carbon\ Content\ (Kg) = 0.5 * Total\ Biomass \dots\dots\dots (6)$$

$$CO_2 = \frac{(Carbon\ content*44)}{12} \dots\dots\dots (7)$$

The amount of CO₂ sequestered by the proposed trees can be seen in Table 4

Table 4. Annual CO₂ Sequestered by Different Trees Proposed in this Study

Tree Species	Diameter (m)	AGB (Kg)	BGB (Kg)	TB (Kg)	Carbon (Kg)	CO ₂ EQ (Kg)
The Neem tree	20	136.7	20.5	157.2	78.6	288
Conocarpus	7	10.3	1.545	11.845	5.92	21.72
Ficus benjamina	9	15	2.25	17.25	8.63	31.63

In this study, a combination of trees and shrubs were chosen due to their ability to repel air pollutants and prevent these pollutants from reaching the sides of the road where many humans are located in nearby areas.

The lands available for planting these green walls and trees include median and road sides of the selected road.

To complete the design of the green infrastructure, drip irrigation system has been chosen to irrigate these plants. In order to make the green infrastructure sustainable, recycled materials is intended to be used to decrease the cost of construction. According to the trees characteristics, the number of trees that would be planted in 1 km of road is as shown in Table 5. Accordingly, the annual CO₂ Sequestered by different types of trees is as shown in Table 6.

Table 5. Number of trees in 1 Km of selected road

Trees	Number of trees planted in roadside	Number of trees planted in median	Total number of trees
The Neem tree	100	50	150
Conocarpus	284	142	426
Ficus benjamina	222	111	333

Table 6. Annual CO₂ sequestered by each type of trees

Trees	Sequestration of CO ₂ (Kg)
The Neem tree	43200
Ficus benjamina	10532
Conocarpus	9253

It is important to mention that these values are calculated for trees when they reach the maximum size.

5. Discussion

Due to the urbanization problem, the green wall and vegetation are used for roads to enhance environment and reduce the pollution [7]. Stated that green walls have been considered as an innovation and creativity in the field of ecology and improving the atmosphere of the city through decreasing the atmosphere pollutants [46], i.e. they can be considered as sinks for carbon contaminated in the urban atmosphere. In addition, road users favour views of vegetation than views of road structures [54] due to the aesthetic properties of these plants. The importance of green strips alongside road structure is noticeable [55]. They help in the stabilization of lands, i. e. minimize soil erosion [52]. They provide as road barriers to offer wind breaks [56]. They mitigate urban air pollution concentrations and decrease the environmental effect from traffic emissions. They have a positive impact on the mood and safety of the road users . Research suggests that exposure to vegetation can facilitate recovery from stress and fatigue [47].

This should explore the significance of the results of the work, not repeat them. A combined results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

6. Conclusions

The following points may be addressed from this study:

- A combination of trees and green wall can be considered as the best solution for decreasing the concentration of pollutants in in urban areas.
- There are different types of trees that fit with severe Baghdad weather such as: Neem tree, Conocarpus tree and Ficus benjamina.
- The best type of tree that can be planted in Baghdad is the Neem tree. In 1 Km length of the selected road that planted with this type of tree, the amount of annual sequestration of CO₂ (Kg) is about 43200 Kg.
- The second type of tree that chosen to be planted in Baghdad hot weather is the Ficus benjamina. In 1 Km length of the selected road that planted with this type of tree, the amount of annual sequestration of CO₂ (Kg) is about 10532 Kg.
- The third type of tree that chosen to be planted in Baghdad hot weather is the Conocarpus tree. In 1 Km length of the selected road that planted with this type of tree, the amount of annual sequestration of CO₂ (Kg) is about 9253 Kg.
- There are two types of shrubs suitable with Baghdad's atmosphere such as: Myrtus communis and Dodonaea viscosa.

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