Acta Chemica Malaysia (ACMY)

**DOI :** https://doi.org/10.26480/acmy.01.2017.08.12

***ISSN: 2576-6732 (Print)***
***ISSN: 2576-6724 (Online)***

# ESTIMATION OF $CO_2$ EMISSIONS OF THE VEHICLES TRANSPORT SECTOR IN THE STATE OF KUWAIT

**Nawaf Aldaihani[1]*, Raslan Alenezi[2]**

***[1]Applied science Department, College of Technological Studies, Public Authority for Applied Education and Training, PO. Box 42325, Shuwaikh 70654 Kuwait.***
***[2]Chemical Engineering Department, College of Technological Studies, Public Authority for Applied Education and Training, PO. Box 42325, Shuwaikh 70654 Kuwait.***
****Corresponding Author email address: nawafdh@gmail.com***



**ARTICLE DETAILS**

***Article History:***

Received 12 August 2016 Accepted 12 December 2016 Available online 17 February 2017

**ABSTRACT**

During the past decades, the State of Kuwait has witnessed population growth, significant economic development and a rise in the level of income. This has resulted in a significant increase in the number of vehicles, which is vital for the local inhabitants and this has led to increased air pollutants, particularly in urban areas. This study aims to estimate the emission of carbon dioxide from the transport sector in The State of Kuwait using IPCC guidelines for national greenhouse gas inventories for the period from 2001 to 2010. According to the policy analysis made, there are no policies directly aimed at reducing the number of registered vehicles which shown an increase of 6% per year for the same period as compared to an annual population growth rate of 2.67%. Finally, contribution of vehicular emissions of $CO_2$, especially in urban areas, was estimated by the results of this study, and thus it is recommended that policies be developed to especially reduce the growing number of vehicles. Additional recommendations include the acceleration of the implementation of high efficiency mass transport projects. Furthermore, the use of awareness campaigns for citizens is highly recommended.

**KEYWORDS**

Air Pollution, Urban Area, Green House Gases.

## 1. INTRODUCTION

The transport sector plays a vital and important role in the economic development of countries that require an integrated transportation system and an advanced network of roads and infrastructure. On the contrary, the transport sector, especially land transport by vehicles, especially in cities and urban areas, has many negative impacts , particularly what vehicles caused of pollution to the environment , through pollutants that release such as carbon monoxide (CO), nitrogen oxides ($NO_x$) and Volatile organic compound (VOC), and what resulting as secondary pollutants such as ozone gas ($O_3$) and their impact on air quality [1,2]. In addition, the problem of wasting time and money in traffic congestion also health damage and deaths due to traffic accidents as a result of increasing in the number of cars and noise pollution caused by vehicles traffic [3,4]. Over the past two decades, Kuwait has witnessed a cultural and developmental progress in various economic fields, as industry, transportation, development and housing sectors. In fact, population growth, steady economic growth and rising per capita income have led to a significant increase in the number of vehicles on roads that reached about 6% per year during the period 2001-2010, and are not in line with the speed of expansion of roads that do not exceed 2% during the same period). (The number of vehicles was 1.5 million in 2010). The increase in the number of vehicles accompanied by the large number of traffic accidents, damage and injuries resulting, moreover the increase in air pollutants from vehicles, aggravation of overcrowd on roads, wasting time, and resulting stress of these problems. The study of shows that urban dwellers spend much of their days traveling in cars, most of them in traffic jams resulting from the large annual increase in the number of vehicles [5]. This also resulting in increase in emission of air pollutants where pollutants increase as the speed of vehicles decreases and traffic density increase [6].

The environmental strategy of the State of Kuwait indicated that although the transport sector is an important pillar for the economic development of the State, however it occupies second place after Industry and Power generation sector as one of a major source of air pollution in the State. Which poses a danger to the health of the individual, the safety of society and the sustainability of development. In addition, vehicles are a significant consumer of fuel in the country, by up to 19% of the total fuel consumed in the country Vehicles are therefore the source of greenhouse gas emissions in the State of Kuwait [7]. Recent studies of climate change have confirmed that the transport sector contributes up to 26% of global carbon dioxide emissions [8]. The contribution of this sector in some urban areas rises to 80% of total GHG emissions, while the IEA considered that the transport sector accounted for 22% of global $CO_2$ emissions during 2008 [9].

Despite the modern vehicles of the transport sector in Kuwait, and the annually periodic inspection of the vehicles for their efficiency and their conformity with the technical and environmental conditions upon the traffic law, in the technical inspection department of the General Directorate of Traffic. However, easiness of having vehicles, fuel price subsidies, easiness to get a driving license, and inefficient public transport, all this aggravated the problem of increasing number of vehicles. This was not accompanied by a policy adjustment to curb the increase in the number of road vehicles in urban areas. Which requires the assessment of carbon dioxide emissions out of the vehicles transport sector in the State of Kuwait and to know its impact on the environment and explain it to citizens and decision makers.

### 1.1 Importance of the study

The State of Kuwait pays a great importance to the environmental aspects, as it constantly seeks to preserve the environment and promote human well-being. Over the past two decades, the State of Kuwait has witnessed a cultural and development progress in various economic fields, as industry, transportation, development and housing sectors. In this regard, the transport sector is one of the important pillars of the economic development of the country. At the same time, however, it represents with the industrial sector and power generation the main

sources of air pollution in Kuwait in general, in urban areas moreover it's consider a source of greenhouse gas emissions, which requires continuous monitoring and follow-up to quantify and identify their trend, particularly those related to the vehicles transport sector [10]. The importance of this research comes from handling a very important problem and its reasons that represented in increasing of vehicles numbers in the urban areas of The State of Kuwait and its effects on the environment through the emission of harmful pollutants that threaten human life, health and well-being, in addition to its impact on the global climate and its contribution to global warming.

Global warming, is defined as the gradual rise in the temperature of the nearest layer to the Earth's surface of the atmosphere due to the emission of greenhouse gases [11,12]. Studies indicate that the global climate is changing. Due to human activities, the effects associated with the accumulation of greenhouse gases in the atmosphere such as changes in seasons, changing average temperatures, increasing extreme weather events and others are emerging and are expected to be further exacerbated in the future, which exposing millions of people, especially in developing countries, to shortages of food resources, water resources, sea-level rise and increased risks to health.

Climate change is one of the most serious environmental threats facing the world today. The harsh weather conditions over the past few years in the world have shown that the extreme heat, hurricanes, floods and other floods across the Gulf region are indicative of the effects of this phenomenon on the countries of the region [13,14]. The study of showed that the severe heat waves in the State of Kuwait have increased in intensity and duration during the past decade [15].

Globally, temperatures have risen by 0.6 °C over the past century. The nineties of the last century included the warmest seven years at all. The year 1998 was the warmest one of 140 years. Scientists have warned that temperatures rise about 1 ° to 2 ° Celsius by 2020 and about 2 ° and 5 ° Celsius by 2070, according to the Intergovernmental Panel concerned of Climate Change [11]. The scientific evidences have shown that human activities are among of the main causes of greenhouse gas emissions leading to global warming, hence climate change, and potentially catastrophic damage in some areas. The world of the last century has witnessed a grand industrial and technical development that led to a big leap in the industrial and commercial sector , accompanied by enormous consumption of natural resources and emissions of large quantities of pollutants add to that a massive amount of wastes , which led to many environmental problems, the most dangerous of which are the problem of climate change, environmental imbalance, the depletion of natural resources and degradation of the ecosystem. Which threatens human life and well-being [16,17,13].

Vehicles are the mobile sources of pollution, as well as the source of some greenhouse gases, such as carbon dioxide ($CO_2$) and $NO_x$ [18]. The increased reliance on private vehicles in mobility has increased emissions of Greenhouse Gas (GHG) in the urban areas. Vehicles became the main source of these gases in cities, there are more than 1.2 billion vehicles in the world, most of them in developing countries [19]. The transport sector in the Arab countries is a major consumer of energy, it consumes about 32% of total energy consumption in Arab countries and emitting 22% of that cause global warming [20].

Climate change reports indicate that the transportation sector plays a role in greenhouse gas emissions, the emissions from the transport sector rising by 28% during the period 1990-2005 in European Union countries, offset by a 3% reduction in emissions in other sectors [21]. This increase occurred despite improved engine efficiency and fuel quality used. More likely, this may indicate that the increase in transport is the cause, as the Transport sector as shown by a researcher which is one of the fewer sectors that increase their emissions annually, causing 26% of the world's carbon dioxide emissions.

The International Energy Agency noted that the transport sector has a significant contribution to greenhouse gases emissions in Canada, with a contribution of 25% of the total increase in 2009, an increase of 20% of those recorded in 1990 [22]. while in the United States, greenhouse gases emitted by the transport sector forms 27% of total emissions [23]. The European Environment Agency noted that the emission of Greenhouse Gases by Transport Sector in Europe in 2010 increased at 26% over 1990 [10].

There a study noted that the emissions by the road transport sector influences air quality and climate change [24]. These pollutants are rapidly increased in developing countries, also there is a close relationship between the environment and economic development. Since economic development that is not care for absorptive capacity of ecosystems and its environmental efficiency leads to degradation, which is the inability of the environment to repair the imbalance, that in turn leads to exacerbates the problem which impact not limited to the current generation but shall extends to the next generations.

The World Bank in a study related the transport sector in Asian countries during the period 1980-2005, showed that Vietnam's transportation sector contributed more to carbon dioxide emissions from 14 % to 24 and 92 % of these emissions come out from land transport. The most important driving forces to increase these emissions from the transport sector were economic growth, population growth and increased energy consumption in the transport sector [25].

### 1.2 Defining the problem

The increase in population in the State of Kuwait between 2001 and 2010 averaged 4.1% per annum and the increase in development projects in the country led to an increase in the number of vehicles with an average annual growth rate between 2001 and 2010 about 6% , while the average of the annual growth of roads lengths during the same period about 2% (Central Administration of Statistics, 2011) This has resulted in increasing of traffic congestion in urban areas, also increase in the rate of emissions of air pollutants (including greenhouse gases) and the consequent health, economic and social impact [26].

Despite the measures taken by the State of Kuwait to handle the problem of increasing the number of vehicles through the enactment of many laws and regulations to alleviate it, however the problem remains, and even worsens, requiring an integrated environmental assessment.

## 2. RESULTS AND DISCUSSION

Calculation of $CO_2$ emissions from the transportation sector in the State of Kuwait through applying the guidelines Equation (Eq. 1) of the Intergovernmental Panel concerned on Climate Change through using of data on energy consumptions for the motor transport sector [7,18]. Then, the calculation of emissions of ($CO_2$) out of combustion of used fuel in the transport sector according to the default emission factors of fuels used in the vehicles as shown in table 1. The method of calculation is considered as illustrated in the following items:

1- Conversion of the consumed fuel unit from litre to barrel by dividing by 159 (barrel = 159 litre).
2- Conversion of barrels per ton equivalent, considering the density of gasoline fuel and diesel fuel (diesel ton =7.46 barrels, ton of gasoline = 8.53 barrels).
3- Conversion of the equivalent ton to an energy unit, the Net Calorific Value (NCV), for use in the equivalence of the methodology of the Intergovernmental Panel on Climate Change (IPCC, 2006) (Diesel: 43 tera Joule per 1000 tons, gasoline: 44.3 tera Joule for per 1000 tons).
4- Calculate $CO_2$ emissions for each type of fuel by applying and using emission factors from Table 1 that was proposed by the Intergovernmental Panel on Climate Change (IPCC) as follows:

**Table 1:** $CO_2$ default emission factors from the fuel used in land transport (IPCC).

| Fuel type | Emission factor (kg/ TJ) |
|---|---|
| Gasoline | 69300 |
| Diesel | 74100 |

$$\text{Emissions} = \sum [\text{Fuel a} \times \text{Ef a}] \qquad \text{(Eq. 1)}$$

Emissions = total CO2 emissions (kg)

Fuel a = the amount of energy produced from fuel sold from vehicle fuel stations (TJ)

EFa = emission factor for fuel type (kg / TJ) a = fuel type (gasoline or diesel or gas).

**2.1 Contribution of vehicles to greenhouse gas emissions $CO_2$**

The amount of carbon dioxide emitted from the vehicles for the period 2001-2010 was estimated in the State of Kuwait by collecting data of the quantities of fuel consumed by the vehicles in the State through the statistics of Ministry of Oil of the quantity of fuel sold (gasoline and diesel) in Kuwait for the period 2001 to 2010. That Calculated based on the fiscal year beginning in April of each year and ending at the end of March of the following year. It becomes clear that the annual increase in fuel consumption during the study period is due to the annual increase in the number of vehicles (**Figure 1**).

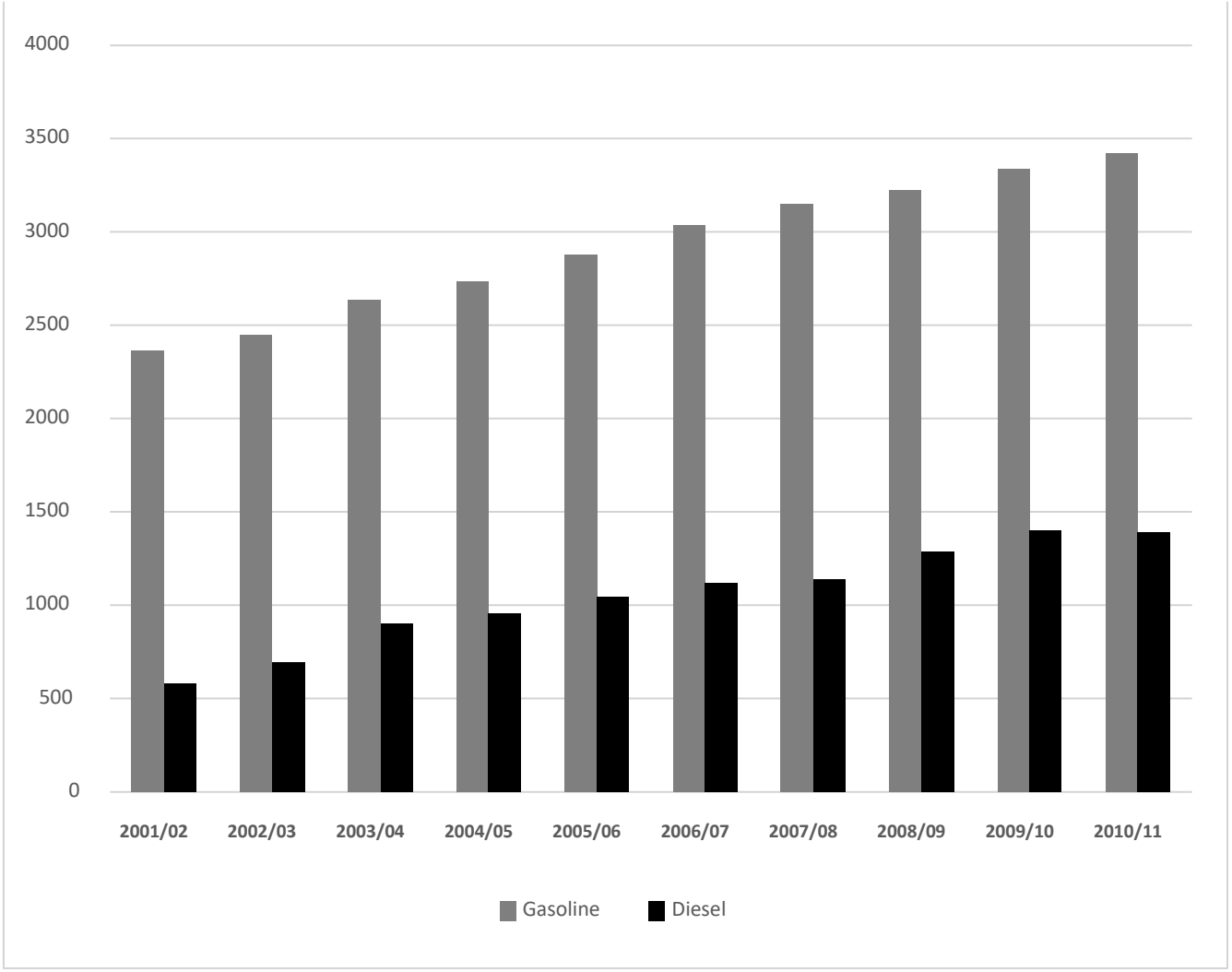


**Figure 1:** Fuel sales in Kuwait during the period from 2001-2010 [7]

Carbon dioxide emissions from the sold fuel (gasoline and diesel) has been calculated by applying the formula adopted by the Intergovernmental Panel on Climate Change [18]. **Table 2** shows the quantities of $CO_2$ emissions during the period 2001-2010 due to the use of fuel (gasoline and diesel) that sold in the local market and consumed in the State of Kuwait.

**Figure 2** shows that $CO_2$ emissions have increased over time because of increasing of energy consumption in the transport sector by vehicles, also emissions from gasoline consumption are higher than that from diesel fuel consumption, however, the diesel emission factor is higher than the gasoline emission factor. Due to using of gasoline fuel by most vehicles in the State of Kuwait in the same time the use of diesel is often limited to heavy transport vehicles. Moreover, the fuel vehicles are highly subsidized in the State of Kuwait as compared to other countries worldwide.

**Table 2:** Carbon dioxide emissions in kilograms calculated during the period 2001-2010.

| | Diesel | | | Gasoline | | |
|---|---|---|---|---|---|---|
| Year | Diesel | Net calorific value (NCV) | Carbon dioxide emissions | Carbon dioxide emissions | Net calorific value (NCV) | Carbon dioxide emissions |
| | T.j $x10^5$ | equivalent Ton $x\ 10^4$ | Kg $x\ 10^9$ | equivalent Ton $x\ 10^6$ | T.J $x\ 10^4$ | Kg $x\ 10^9$ |
| 2001 | 4.90 | 2.11 | 1.56 | 1.74 | 7.72 | 5.35 |
| 2002 | 5.86 | 2.52 | 1.87 | 1.81 | 8.00 | 5.54 |
| 2003 | 7.62 | 3.27 | 2.43 | 1.94 | 8.60 | 5.96 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2004 | 8.06 | 3.47 | 2.57 | 2.02 | 8.94 | 6.2 |
| 2005 | 8.84 | 3.80 | 2.82 | 2.12 | 9.40 | 6.51 |
| 2006 | 9.43 | 4.06 | 3.01 | 2.24 | 9.92 | 6.87 |
| 2007 | 9.58 | 4.12 | 3.05 | 2.32 | 1.03 | 7.13 |
| 2008 | 1.08 | 4.66 | 3.46 | 2.37 | 1.05 | 7.30 |
| 2009 | 1.18 | 5.08 | 3.7 | 2.46 | 1.09 | 7.55 |
| 2010 | 1.17 | 5.04 | 3.73 | 2.52 | 1.12 | 7.75 |

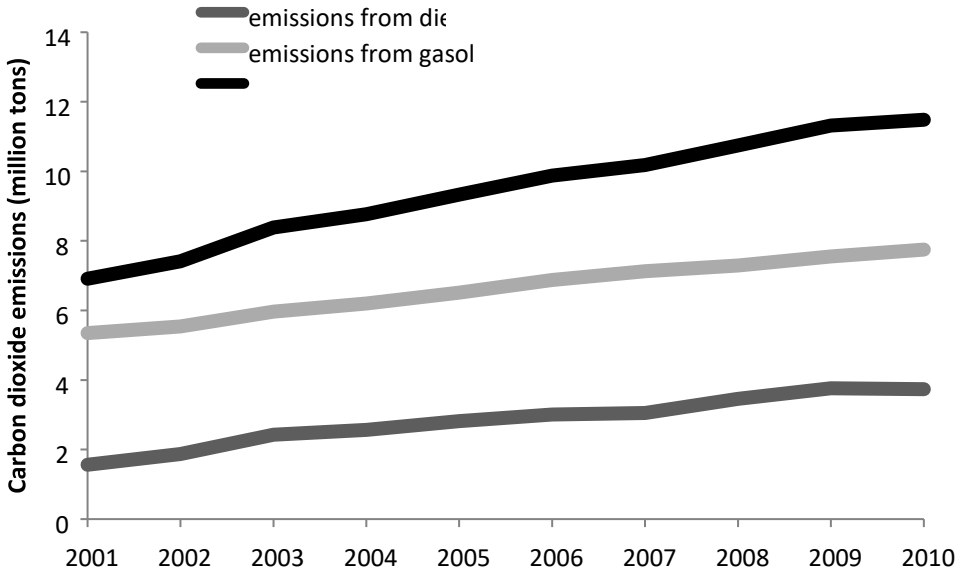


**Figure 2:** Emissions of $CO_2$ from the land transport sector annually in Kuwait for vehicles using gasoline and diesel fuel for the period 2001-2010.

These results are consistent with the International Energy Agency calculations for carbon dioxide emissions from land transport sector in Kuwait amounting to 11.6 million tons in 2009 [22].

## 3. CONCLUSION

In conclusion, the results showed that traffic was a major source of pollution in the city of Kuwait in the period of studied from 2001 to 2010 and expected to be the same in the future. The major issue in Kuwait is acute problem of traffic which increases fuel consumption, high pollutant emission and mental tension among the people that severely influence their day life base.

The suggested strategy to solve the heavy traffic problem is to introduce policies that developed to especially reduce the growing number of vehicles which cause this deterioration. Additional recommendations included the acceleration of the implementation of high efficiency mass transport projects, such as a metro, along with the shifting of industrial and service zones, especially those with heavy traffic, away from residential areas. Furthermore, the deployment of awareness campaigns for citizens is highly recommended. These campaigns should be regarding the importance of public transportation in solving the problem of traffic congestion that causes pollution which effects human health and the environment.

## ACKNOWLEDGEMENTS

The author acknowledges, with thanks, Kuwait - Ministry of Oil for providing the data of study.

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