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Study of Carbon Emission by Vehicles and its Impact on Environment and Climate on BP highway

Susan Nayaju [a], Prashant Lakhemaru [b,c], Khem Narayan Poudyal [a], Nawraj Bhattarai [d]

[a] *Department of Applied Sciences and Chemical Engineering, Pulchowk Campus, IOE, TU, Nepal*
[b] *Department of Automobile and Mechanical Engineering, Thapathali Campus, IOE, TU, Nepal*
[c] *Department of Mechanical Engineering, North Dakota State University, Fargo, ND, USA, 58102*
[d] *Department of Mechanical and Aerospace Engineering, Pulchowk Campus, IOE, TU, Nepal*
Corresponding Author: [a] susanhero55@gmail.com

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Abstract:

Climate catastrophes like global warming and the rise in air temperature have increased as a result of a rise in emissions of greenhouse gases like carbon dioxide. The fundamental cause of climate change is a spike in carbon dioxide concentration, and many nations are implementing strategies to reduce this pollutant level. The transport industry is proven to be the main source of carbon dioxide emissions. As a result, the basis for this study is the assessment of carbon dioxide gas emissions generated by the busiest roadway in Nepal. Thus, the various reports, journals, and books were reviewed relevant to the determination of emission of carbon dioxide gases from transport sector. Likewise, a survey was done by using questionnaire at chosen locations located on BP highway route near Kathmandu Valley. Similarly, the various parameters were also estimated from the survey and utilizing Weibull Distribution equations for VKT (Vehicle kilometre travelled), energy demand and emission factor etc. In order to ascertain the relationship between the atmospheric temperature at Mangaltar and the emission of carbon dioxide by the transport sector, the study was also carried out at the Mangaltar station, one of the stations of the BP highway. The results showed a positive connection with a correlation coefficient of 0.46 and a significance level less than 0.05, which is 0.01. Moreover, the projections study for carbon dioxide emissions showed a value of R2 comparable to 0.98, demonstrating the reliance of carbon dioxide emissions on a yearly rise in the number of vehicles. Furthermore, the combined result of all strategies demonstrated that electrifying the transportation sector and a decline in the overall number of personal vehicles may reduce carbon dioxide emissions load by 90.24% by the year 2041 A.D. As a result, it has been determined that if this pattern continues, emissions will rise to approx 46727 tons/year by 2041, which could contribute to the further rise in temperature as anticipated by other researchers. However, by modifying policies and methods, emissions can be reduced to zero in the upcoming years.

Keywords: BP highway, Carbon emission, Transportation

1. Introduction

For the past ten years, the production of greenhouse gases, acceleration of global warming, and climate change have become the country's major concerns. The industrialization and technological sectors' quick development has increased the generation of greenhouse gases like carbon dioxide. The increase in carbon dioxide emissions causes a shift in climate and a rise in temperature by trapping heat on earth. [1] Throughout the past century, the Earth's surface temperature has increased by about 0.74°C. If carbon emissions are not effectively controlled, temperatures are expected to rise by an extra 3.4°C by the end of this century [2]. The Earth's biosphere would likely suffer from a temperature increase on this scale. This could result in an increase in the level of sea, as well as cardio-respiratory problems, severe storms, floods, and forest fires. According to the most comprehensive scientific evidence, humans must reduce total carbon

dioxide (CO_2) emissions by no less than 80% by 2050 if current trends continue. Yet, daily emissions continue to rise [3]. There are various industry that are responsible for the increase in concentration of greenhouse gases. Among them, transportation ranks third position with the contribution of 16.2% in the emission of carbon dioxide gas by direct or indirect form. Similarly in the context of Nepal, the most promising sector in the development of country is transport. The transport sector contributes to other industries also like tourism. Nepal is a nation that imports fossil fuels from other countries, and the dependency on fossil fuels has been a source of concern for the world community in terms of energy security, particularly for emerging nations that export relatively little energy. The fluctuation in the price of fossil energy and Natural gas has made countries like Nepal more economically vulnerable. Countries, that are developing quickly are coming under more and more attention as a result of ongoing global worries about climate change caused by greenhouse gas emissions.[4] Many studies have been conducted to estimate and forecast the emission loads from the road transportation industry. Shrestha et. al, reported about the second reason behind the death of people at hospital inside the valley of Kathmandu due to the air pollution. It was found that the increase in the patients of COPD i.e., chronic obstructive pulmonary disease was the main impact of air pollution. An investigation was done to correlate the emission of carbon dioxide by transport sector with the number of patients of COPD inside the valley by gathering the data of vehicle registered to the date inside valley and the data of relative patients from different government sections. The result showed that the concentration of emission of carbon dioxide was very high and it was positively correlated with the patients of COPD [5]. Similarly, Paudel et al., presented a report on a comparative analysis between the consumption of fuel by vehicle and the emission of carbon dioxide pre and post COVID pandemic inside the valley of Kathmandu. The emission of carbon dioxide was estimated by the data of sales of fuel updated by NOC according to the guidelines provided by IPCC. From the result, it was found that the 14.9% of total fuel was only consumed by vehicle in KV in FY 2019/20. Further, the result of carbon emission revealed the emission of 914 Mtonnes of carbon dioxide by the sector of transportation in FY 2019/20 [6]. Neupane et al., discussed about the emission of various greenhouse gases by transport sector inside Kathmandu valley. For this, the total number of vehicle registered up to the current period was collected from the department of transport in Nepal. Then, the process of profile of life cycle for vehicle and the function of Weibull distribution were mixed for the estimation of demand energy for vehicle and the emission of CO_2, CO, NO_x, HC, and PM_{10} was done. The results showed the total of 2.7 Mtons of emission of carbon dioxide alone by Kathmandu Valley in 2020. Likewise, the prediction revealed that if the similar trend would be followed than it would reach up to 4.5 and 6.4 Mtons by 2025 and 2030 respectively[7].

This research study will assist in visualizing the total amount of carbon dioxide emitted per year by the transports. This finding will assist to gain the knowledge the content of emission of carbon dioxide from the various types of vehicle which will make contribution in climate change. Various other research estimated the average amount of emission of carbon dioxide gas from transport sector by the fuel consumption neglecting the carbon dioxide emitted during the production of fuel that was consumed. However, this work is centered on the comprehensive estimation of carbon dioxide gas emitted by various types of vehicle and also the emission of carbon dioxide gas in near future on increasing the number of vehicles per year by 2041.

2. Methodology

The present study is centred on estimating the carbon emission on the use of fuel consumption by transport sector passing via BP highway.

2.1 Area of Study

The area of study chosen in this study is BP highway that connects Kathmandu Valley with terai region and this highway is also called Highway of Banepa Bardibas. It honors BP Koirala's name who was a former ruler of Nepal. The highway of Banepa Bardibas is a 158-kilometer (98-mile) route that connects Dhulikhel (30 kilometers eastern of Kathmandu) and Bardibas. It is also referred as the H06 road. The Terai area of Nepal and Kathmandu Valley are connected by this roadway in the quickest possible time. The conducted survey is mixed with transport randomly from inside and outside valley as well from the highway.

2.2 Methods

On the basis of the collected data, the content of carbon emissions from the sector of transportation were estimated in the present study. The vehicles travelling from the valley of Kathmandu, near Khurkot and Banepa were gathered from the JICA source for the projection of carbon emission in near future [8]. The value of average kilometer travelled by vehicle is used in the estimation of carbon dioxide gas emission by different vehicles. The equation for the average yearly VKT, energy demand and emission factor was taken as reference from the article [9]. The value of average annual VKT which was estimated in the current scenario is shown in Figure 1.

Types of Vehicle	Fuel Types	CO_2
Minibus	Diesel	3.4
Bus	Diesel	3.4
Car/Van	Petro	3.9
Pickup	Diesel	3.4
Truck/Mini Truck	Diesel	3.4
Motorbikes	Petrol	3.7
LDV	Diesel	3.4
HDV	Diesel	3.4

Figure 1: Average annual VKT travelled by vehicle

2.3 Average Fuel Consumption

The average amount of fuel used by a vehicle per km is known as its average fuel consumption. To calculate the energy requirements for each type of vehicle, an average fuel consumption must be used.The fuel consumption of the vehicles in this groups was taken into consideration because they were grouped together in this study as similar types of fuel-consuming vehicles. Data about typical fuel use were derived from the article which is shown in Figure 2 [10].

2.4 Emission Estimation

2.4.1 Energy Demand

The given equation can be utilized for the estimation of energy demand by each type of vehicles [7]:

$EDi,t = Ni \times VKTi,t \times Fi,t$ (1)

where,

EDi,t = energy demand of vehicle in L after time t,

Vehicle Types	Types of Fossil Fuel	Fuel economy (l/km)
Bus	Diesel	0.28
Minibus	Diesel	0.25
Pickup	Diesel	0.15
Car/Jeep/Van	Gasoline	0.07
Tractor	Diesel	0.16
Motorbikes	Gasoline	0.02
LDV	Diesel	0.25
HDV	Diesel	0.16

Figure 2: Average fuel consumption by various types of vehicle

Ni = total count of eaxh type of vehicle,

VKTi,t = average kilometre travelled by vehicle annually,

Fi,t = average fuel efficiency of vehicle in L/km.

Further, the determination of emission load generated by various vehicles can be estimated by following equation [9]:

$Ej,i = EDi,t \times EFj,i$ (2)

where Ej,i = total load of emission of j type gas by i vehicle type,

EDi,t = energy demand by vehicle (i) after time t(years),

EFj,i = emission factor for various typegases (j), represented by Kg/L for each type of vehicle (i).

The amount of energy a vehicle uses determines the emissions it produces. Only one category of emission factors for each type of vehicle were studied. For each variety of emission factor, each vehicle category has a unique emission factor value. The data retrieved from the literature is presented in Figure 3.

Types of Vehicle	Fuel Types	CO_2
Minibus	Diesel	3.4
Bus	Diesel	3.4
Car/Van	Petro	3.9
Pickup	Diesel	3.4
Truck/Mini Truck	Diesel	3.4
Motorbikes	Petrol	3.7
LDV	Diesel	3.4
HDV	Diesel	3.4

Figure 3: Emission factors based on vehicle categories

2.5 Assumption of Alternative Scenarios

The emission of carbon dioxide varied depending on various factors such as the rate of fuel consumption, VKT, and the enhanced technology emitting level. In contrast, the methods which are utilized for the determination of carbon dioxide emission are assumed to remain constant. Thus, the various scenarios are developed on the basis of static nature for the reduction of emission load of carbon dioxide. As the instability in political conditions as well as polluted situation, the introduction of conventional fuel-based vehicles would be not effective. Thus, alternative scenarios are considered for the improvement in procedures and strategy which are: decrement in mini as well as micro-buses by 30% (scenario 1), 50% decrease in personal mode of transport (scenario 2) replacement of 75% of traditional transport by EVs (scenario 3), and the combined scenario of all (scenario 4) for the effective outcome.

3. Results and Discussions

3.1 Trend of energy demand by vehicle: Case study

The result shown in Figure 4 revealed the trend of energy demand by the vehicle travelling inside and outside valley from the near locations of BP highway. The outcomes showed that the maximum demand of energy was in the case of micro-bus which were 1.2 ML/year. However, the value of energy demand is found to be minimum for vans/cars about 0.05 ML per year. Similarly, the energy demand in the case of motorbike are also low as compared to others i.e., 0.07ML/year. Moreover, the demand of energy is found to be higher in the case of micro-buses that might be due to the travelling large number of micro-bus from Kathmandu Valley towards Kavre district, terai region via BP highway and vice-versa.

3.2 Estimation of Carbon Dioxide Emission load by Road Transport Sector

The largest contributor to GHG emissions is the use of fossil fuels for energy production. The transportation industry is the one that relies on fossil fuels the most. So, it is indisputable that one of the main contributors to CO_2 emissions is the transportation sector.

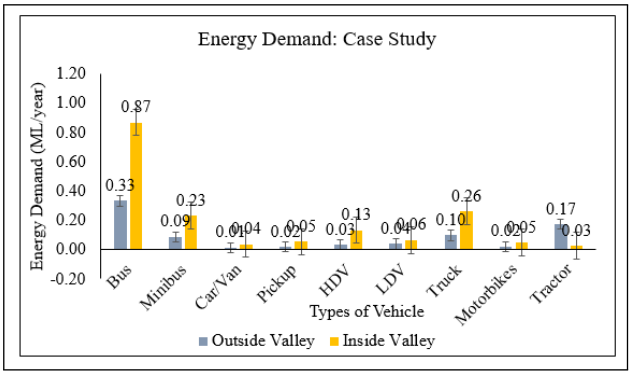

Figure 4: Trend of Energy demand by vehicle from case study

3.3 Total Carbon dioxide gas emission by vehicle: case study

The result of total carbon dioxide gas emission by vehicle accounted in case study is shown in Figure 5. As shown in plot, the total emission of carbon dioxide gas was higher in the case of micro-bus which is 4551.12 ton/year including both outside and inside valley. Similarly, the minimum emission by diesel based vehicles is found to be 99.55 tons/year which was by tractor outside the valley whereas pick-up showed minimum emission only about 59 tons/year inside the valley. Next in the case of motorbike, the quantity of carbon dioxide gas emitted in a year is 258.82 tons/year. The result from case study indicated that the carbon emission depends upon the average annual VKT, and fuel economy.

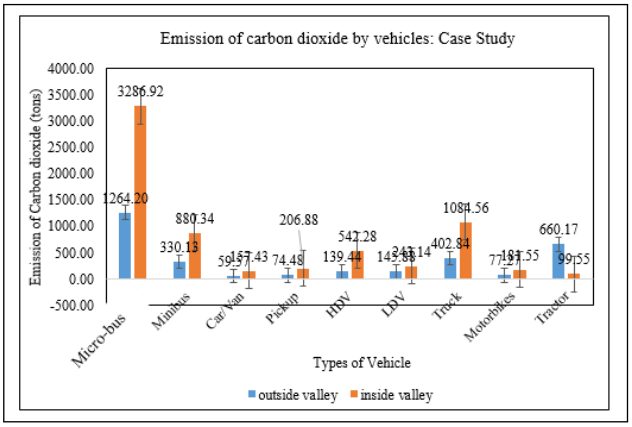

Figure 5: Total Emission of carbon dioxide by vehicle travelling via BP highway: Case study

3.4 Impact of Carbon Dioxide Emission on Temperature

The analysis based on effect of emission of CO_2 on atmospheric temperature was determined by using Pearson's correlation. For this, the temperature data at Mangaltar station together with the vehicles passing via that route was noted down starting from 14_{th} January 2023 to next 14 days. The outcome of the effect on temperature due to the CO_2 gas emitted by vehicles is shown in Figure 6:

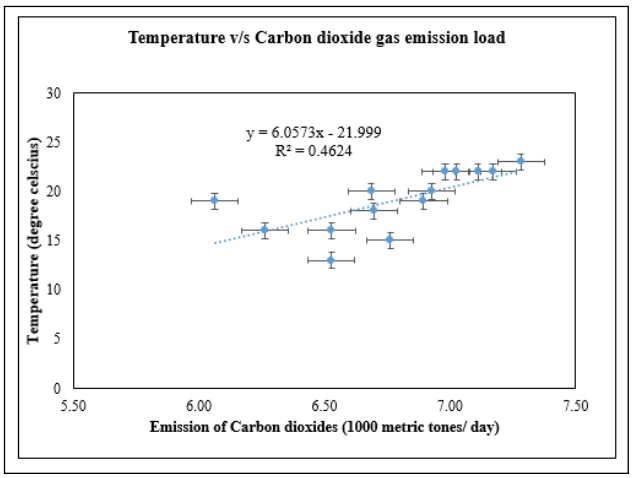

Figure 6: Effect of emission of carbon dioxide gas on temperature: Mangaltar

As shown in figure, it can be ascribed that the gas i.e., carbon dioxide emitted from vehicles is favourably correlated with the slight increase in atmospheric temperature. The level of significance is observed to be about 0.01 which is lower than 0.05. This depicts that the correlation between emission load and temperature is significant nevertheless the value of R_2 is only about 0.46. Thus, it indicates that the increment in emission of green house gases can also be the cause on the gradual increase in atmospheric temperature and becoming one of the main reason behind global warming [11].

3.5 Forecast of Demand of Energy by Vehicles and Emission load: BP highway

The rate of private as well as public based vehicles travelling via BP highway is increasing at various rate that is about 2.5 & 9% respectively [8]. This will also lead to the linear increment in the demand of energy by various vehicles per year. Thus, the energy demand and emission of CO_2 by vehicles in next 20 years is predicted on the basis of their growth rate which are shown in Figure 7 and 8 respectively. As shown in Figure 7, it illustrates that the highest requirement for the energy demand id by micro-buses and it will be keep increasing by 2041 A.D. However, the other vehicles like large bus, tractor, and HDV require lower amount of fuel which are travelling via BP highway. Next, Figure 8 ascribes that there is linear relation between the increase in number of vehicles and emission of carbon dioxide via these vehicles. As shown in Figure 8, emission of carbon dioxide stood at 42695.126 tons/year in 2021, while it is predicted that it will reach up to 46727.317 tons/year by 2041. Further, the R^2 is also relatively high and equal to 98%. This indicates that there is linear relation and if there would not be any taken any step to prevent the current trend then the emission load would be keep increasing and affecting climate and our environment.

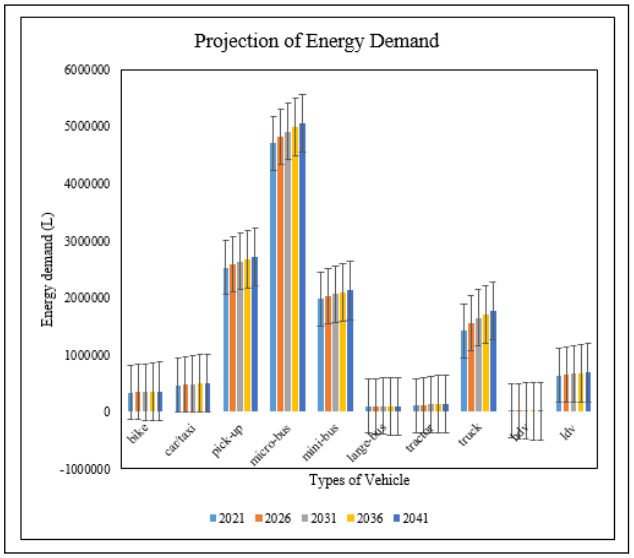

Figure 7: Increment in carbon dioxide gas emission by vehicles passing via BP highway in next 20 years (2021-2041)

3.6 Alternate Cases: Application of EVs

Electric vehicles (EVs) are a type of vehicles that are able to convert fuel into energy without producing carbon dioxide. Compared to fossil fuel-powered automobiles, it exhibits a promising quality. As a result, four distinct scenarios are generated for the reduction of carbon dioxide emissions within 20 years by using EVs instead of traditional transportation vehicles in varying percentages. In comparison to the reference approach (series 1), a study of four different approaches, including the 50% reduction in personal

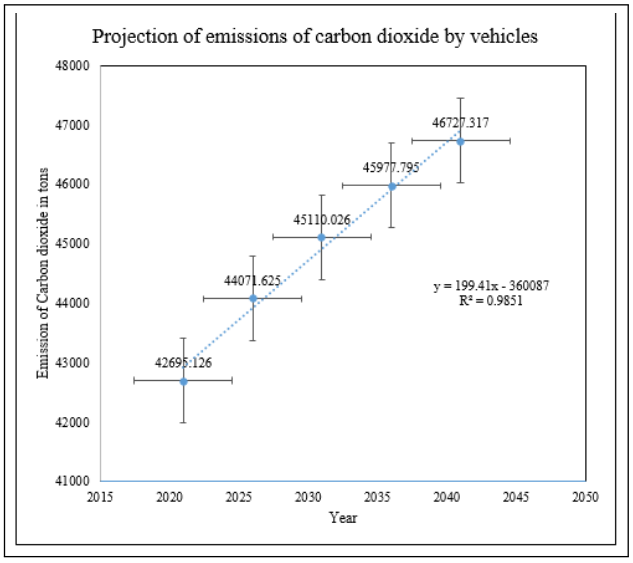

Figure 8: Increment in energy demand by vehicles passing via BP highway in next 20 years (2021-2041)

vehicles (series2), the 30% replacement of mini/microbuses by EVs (series3), the 75% replacement of vehicles into electric vehicles (series4), and an amalgamation of 2, 3, and 4 (series5), is shown in the figure below. From the given figure, it shows that adopting Approach 2, i.e., reducing private vehicle use by only 50% and using alternative vehicles or public transit, resulted in a decrease in carbon dioxide emissions from 46727.31 tones/year to 46331.78 tones/year by 2041. Additionally, it stated that while fewer private vehicles might be on the road than other kinds of vehicles, accomplishing so might not have the desired effect. In the next case, the vehicles which are most emitting carbon dioxide are replaced by 30% of EVs and it shows the 8.3% of reduction in carbond dioxide emission between 2021 and 2041. In the third scenario, all the traditional automobiles are changed by 75% of EVs for the further emission of carbon dioxide by 2041 as the government of Nepal has created the policies to reach zero emission by 2050 [12]. The third scenario shows the decrement of 74% emission in carbon dioxide from 2021 to 2041. At last, all the three cases are combined to reach the effective reduction in the carbon dioxide gases by transport sector travelling via BP highway. Thus, the fourth scenario i.e., the employment of EVs, decrement in personal modes of transport, and the replacement of vehicles emitting carbon dioxide most depicts that it would be able to reduce the carbon dioxide emission by 90.24% by 2041. Similar outcomes was also found when the various approaches were combined to reduce the carbon dioxide gas emission by 54% like employment of hybrid transport, fuel efficiency enhancement as well as electrification [9]. Further, there is also another report which predicted the decrement of 60% in emission of carbon dioxide on utilization of electric buses, mini and micro-buses [13].

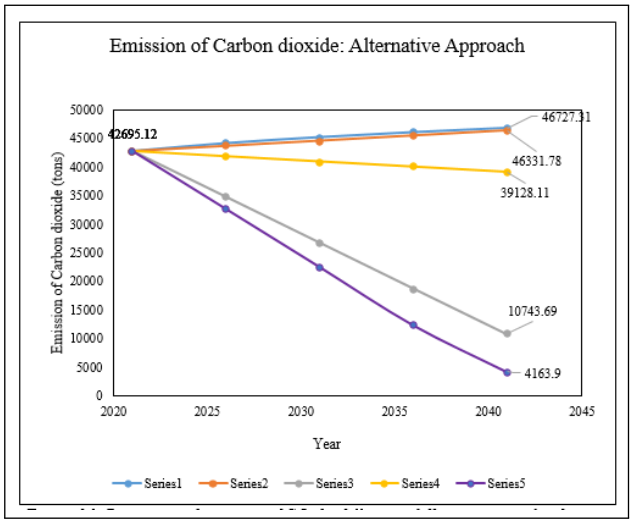

Figure 9: The projections of CO_2 emissions utilizing various strategies including electric vehicles to reduce emissions from the transportation sector

4. Conclusions

The entire emission loads from the road transport sector that use the BP highway were estimated in this paper. The study investigated at the rising trend in the evolution of various vehicle kinds, their energy use, and associated emissions of carbon dioxide from the vehicles driving via BP highway. For this, case study was completed near the valley for observing the average emission of carbon dioxide by transport sector using BP highway. The outcomes of case study indicated that the major source for the carbon dioxide emission were micro-buses which emitted carbon dioxide equivalent to 4551.12 tons/year including inside and outside valley near BP highway. Moreover, the effect of carbon dioxide emission on atmospheric temperature was analyzed on the basis of regression analysis indicating positive correlation along with R_2 equal to 0.462. Similarly, the projections for carbon dioxide emissions showed a value of R square equal to 98%, demonstrating the linear relationship between the emission of carbon dioxide and the annual increase in the number of automobiles. In a similar way the combined effect of all approaches showed that

electrification of the transport sector and a decrease in the overall number of personal automobiles may reduce carbon emissions by 90.24% by the year 2041 A.D. Consequently, it is concluded that if the present trajectory continues, emissions will rise up to 46727 tons/year, but if procedures and regulations are changed, emissions will decrease to zero in the coming years.

Acknowledgments

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