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Transportation Sector in Kathmandu Valley: Responsible for Significant Amount of Carbon Dioxide Emission & Correlation to Chronic Obstructive Pulmonary Disease (COPD)

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Abstract
For both developing and developed countries, air pollution is one of the primary causes of death. Air pollution was the second leading cause of mortality in one of the Kathmandu Valley's main hospitals in 2011, and the third leading cause in the United States. One of the key factors was the use of fossil fuels for transportation. Vehicle registration in the 665-sq.km Kathmandu Valley climbed from 45,871 in 1990/1991 to 570,145 in 2010/2011, a 12-fold increase in 20 years. Various government divisions provided statistics on car registration and the number of COPD patients. A survey of Kathmandu Valley residents was also used to acquire data on average daily commute distance and fuel mileage. The amount of carbon dioxide (CO_2) emissions by transportation sector is calculated in this article, and a link between CO_2 emissions and COPD patients is established. CO_2 emissions were found to be extremely high, according to the findings.

Keywords
fuel consumption, carbon dioxide emission, health impact, Chronic Obstructive Pulmonary Disease, Kathmandu Valley

1. Introduction

Air pollution is one of the most serious environmental problems, affecting people, animals, agriculture, cities, forests, and aquatic ecosystem. Air pollution is increasing day by day in the world as the result of carbon dioxide (CO_2) emission from anthropogenic activities. According to National Institute of Environmental Health Sciences (NIEHS), air pollution is defined as mixture of fine particles created by the combustion of fossil fuels, which directly or indirectly causes harm to human health. Carbon Oxides (CO_X), Nitrogen Oxides (NO_X), Sulphur Dioxide (SO_2), Volatile Organic Compounds (VOC_S), and Particulate Matter (PM) are the five traditional air pollutants.

Transportation sector is major for emitting carbon dioxide (CO_2) gases in the Kathmandu Valley. Emission of CO_2 have local, regional and global effects. Local effects refer to the quality of ambient air within a few kilometers' radius. Regional effects refer to pollutants such as acid rain, photochemical reactions, and water quality degradation. Global effects refer to ozone layer depletion and global warming induced by greenhouse gas emissions.

The three proposed initiatives to reduce air pollution in the Kathmandu Valley: improving vehicle speed, promoting public transportation, and introducing electric vehicles, which might reduce public transportation energy demand by more than 60% The NIH (National Institutes of Health) defines COPD as "a progressive disease that makes it hard to breathe". COPD includes emphysema, chronic bronchitis, and asthma. In Nepal, COPD data from one of the oldest hospitals, Bir Hospital, showed that COPD was the second highest cause of morbidity in 2009/2010.

2. Research Objectives

The general objective of the study is to estimate the amount of carbon dioxide emission from transportation sector in Kathmandu Valley.

The specific objectives of the study are as follows:

- To calculate the fuel usage and asses the quantity emission of CO_2 gas.
- To figure out if there's a link between CO_2 emissions and COPD patients

3. Methods and Materials

were the type of gasoline used, the annual miles of the vehicle, and the average vehicle mileage. The following steps were taken to compute CO_2 emissions:

- The Department of Transport Management in Kathmandu provided the vehicle registration data, which was divided into three categories: heavy vehicles, light vehicles, and motorized two-wheelers.
- A survey of valley inhabitants was done to ascertain vehicle mileage and vehicle travel mile per day for the three categories of vehicles.
- CO_2 emission data from the US EPA (Environmental Protection Agency) was used in this study. The EPA estimates that diesel emits 2.66 kg/L (22.2 lbs/gallon) and gasoline emits 2.33 kg/L (19.4 lbs/gallon) CO_2 [21, 22].

3.1 Collection and analysis of data

The Kathmandu Valley's motor vehicle statistics was gathered from the Kathmandu DMV (Department of Transport). The vehicle data was collected between 1991 and 2020. Vehicles increased in number from 34,099 in 1990/91 to 14,12,800 in 2019/20. Motorized two-wheelers were the most common vehicle type in the valley.

A survey of drivers was used to acquire data on vehicle trip mile per day and vehicle miles. Drivers were given two questions: how long they drive on average per day and how many kilometers their vehicle can travel on a liter of fuel. The amount of fuel consumption by heavy (diesel vehicles), light (petrol vehicles), and motorized two-wheelers were calculated separately

The total calculated amount of CO_2 emission was shown in figure based on the fuel use. The CO_2 emissions were found to be growing exponentially. The total calculated amount of CO_2 emission was shown in Fig. 2 based on the fuel use. The CO_2 emissions were found to be growing exponentially.

CO_2 is a traditional air pollutant. COPD patient data was studied from 1997/1998 to 2011/2012 to see the effects of CO_2 emissions. The COPD data was gathered from the DHS's annual reports (Department of Health Services) The trend of COPD patients admitted is shown in Figure. It is also increasing exponentially. The exponential Eq. (1) can be used to represent the regression model of the growth in CO_2 emissions over time, where the variable "x" is the number of years since 1990. At a 95% confidence interval, the model was significant:
CO_2 Emission = $87.062 \times e^{0.0981X}$

Table 1: Avg Vehicle distance travel and fuel consumption of Vehicle

Description	Fuel Used	Avg) Vehicle Distance travel (KM)	Avg) Vehicle Mileage (L/km)
Heavy Vehicle	Diesel	70	4.5
Light Vehicle	Petrol	45	10.5
2-wheelers	Petrol	22	32

Table 2: Number of Vehicle registered in the Valley

Year	Heavy	Light	2- Wheelers	Sub Total	% increase
1989/90	5637	9868	18594	34099	
1990/91	6241	11010	22357	39608	16.2%
1991/92	6850	12470	28240	47560	20.1%
1992/93	7557	14270	33103	54930	15.5%
1993/94	10046	16401	40006	66453	21.0%
1994/95	10805	18574	47964	77343	16.4%
1995/96	11618	20701	57796	90115	16.5%
1996/97	13931	22654	67663	104248	15.7%
1997/98	14916	25281	74481	114678	10.0%
1998/99	15899	26940	84003	126842	10.6%
1999/00	17167	29697	94081	140945	11.1%
2000/01	18545	33451	112809	164805	16.9%
2001/02	19994	36543	135344	191881	16.4%
2002/03	21435	39412	154666	215513	12.3%
2003/04	22399	44704	172955	240058	11.4%
2004/05	23661	47911	191941	263513	9.8%
2005/06	25985	51851	212942	290778	10.3%
2006/07	27542	56357	245445	329344	13.3%
2007/08	29781	60441	281839	372061	13.0%
2008/09	32721	65860	323893	422474	13.5%
2009/10	35905	74824	394420	505149	19.6%
2010/11	37868	81694	449512	569074	12.7%
2011/12	39100	89921	494406	623427	9.6%
2012/13	40867	99373	548457	688697	10.5%
2013/14	43207	110957	601951	756115	9.8%
2014/15	46854	123085	657795	827734	9.5%
2015/16	52818	147981	722722	923521	11.6%
2016/17	60258	166077	817473	1043808	13.0%
2017/18	67799	187558	906108	1161465	11.3%
2018/19	75856	210908	998112	1284876	10.6%
2019/20	83737	233475	1095588	1412800	10.0%

3.2 Calculation of energy consumption

To calculate the use of diesel and petrol, we take the survey data.

Fuel consumed per day = N * VC* FD
Where N = number of vehicles
VC = vehicle coefficient
FD = fuel consumed per vehicle

Therefore, we calculate the fuel consumed in a year by multiplying by 365. We keep the units in million liters.

For the emission of CO_2, we use the standard rate given above for the respective fuel.

3.3 COPD Patient Trend

Figure 3 depicts the COPD patient data. According to Figure , the number of COPD patients admitted grew rapidly from 4,136 in 1997/98 to 19,401 in 2012/13 [18]. COPD patients are on the rise in the Kathmandu Valley for a variety of factors, including air pollution, cigarette smoking, chemical exposure, and genetics. Additionally, as a city's population grows, so does the number of COPD patients. A graph was drawn between CO_2 emissions and COPD patient per 1,000 population to evaluate the link between CO_2 emissions and COPD patient admission in hospitals, as shown in Figure.

4. Results and Discussion

This research has a substantial influence on the computation of CO_2 emissions produced by the transportation industry, as well as the impact on the health of Kathmandu Valley inhabitants. The overall number of cars rose by 12 times between 1990/1991 and 2010/2011, according to vehicle registration statistics.

Figure 1 represents trend lines of fuel consumptions by different vehicles in three main categories. The Categories are Heavy vehicles, Light vehicles and motorcycles. In the graph, the x axis represents the timeline (in years) from 1989 to 2020. Similarly, the y-axis shows the fuel consumption in litres in millions. In the figure, we can see that the fuel consumption has increased over the years. The trendline is in increasing trend, therefore, the fuel consumption is likely to increase in the future years as well.

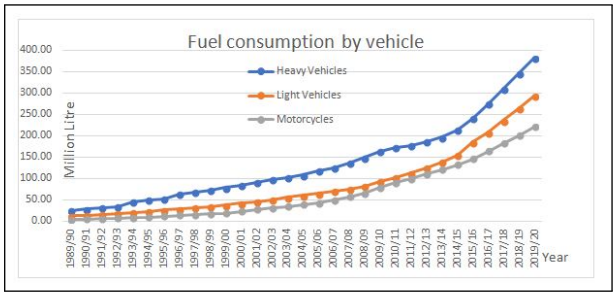

Figure 1: Fuel Consumption by different types of vehicles

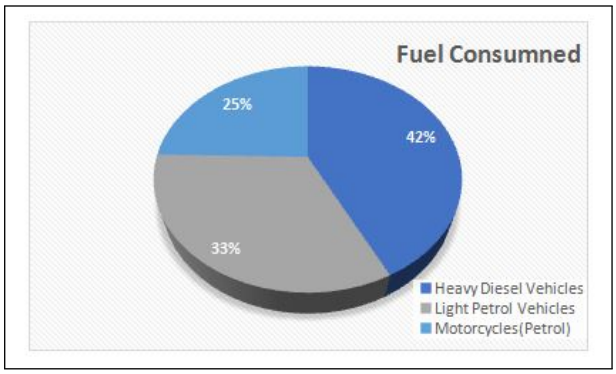

Figure 2: Fuel Consumption by different types of vehicles

Figure 2 represents pie chart of different types of fuel consumed by different vehicles in three main categories. The Categories are Heavy diesel vehicles, Light petrol vehicles and motorcycles (petrol). In the chart, we can see that diesel in heavy vehicles is 42% of the overall fuel consumed and is the most consumed fuel. This is followed by light petrol vehicles at 33%. The least consumed is petrol by motorcycles which is 25%. The statistics show that there are huge numbers of motorcycles in the valley, since they consume 25% of the petrol even though they have significantly higher mileage than light petrol vehicles.

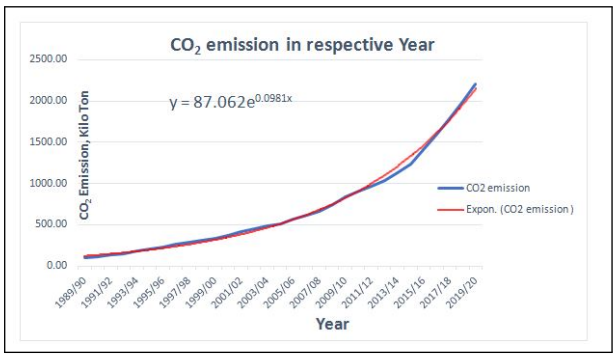

Figure 3: Graph showing the CO_2 emission per year

Figure 3 shows the graph ofCO_2 emission per year, from the year 1989 to 2020. The blue line shows the emission in kilo ton. The x – axis shows the years 1989 to 2020, whereas the y-axis represents CO_2 emission in Kilo ton. The orange line shows the rate of increment in the emission, which is represented by the formula $y = 87.062e^{0}.0981x$. y can be used to make projections for the future years as well. In the formulae, we can make projection of future emissions by replacing the value of x with the year we want to project for. In the graph, we can see that the emission has increased significantly over the years. There is a huge increase in emission from the year to 1989 to 2020 which projects an alarming trend.

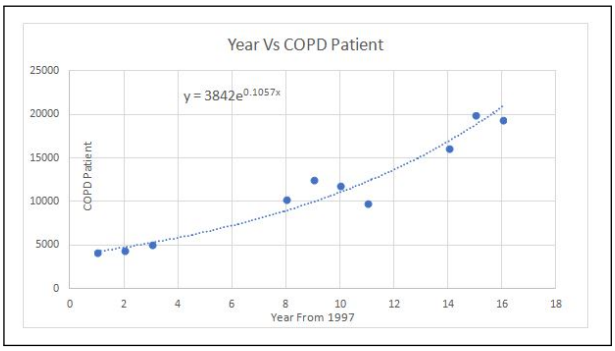

Figure 4: Trend of COPD Patient in Kathmandu Valley

Figure 4 shows the graph of COPD patients in Kathmandu per year, from the year 1997. The x – axis represents the year starting from 1997, whereas the y-axis shows the number of COPD patients. In the graph, we can see that the number of patients have increased over the years. The number has significantly increased over the years

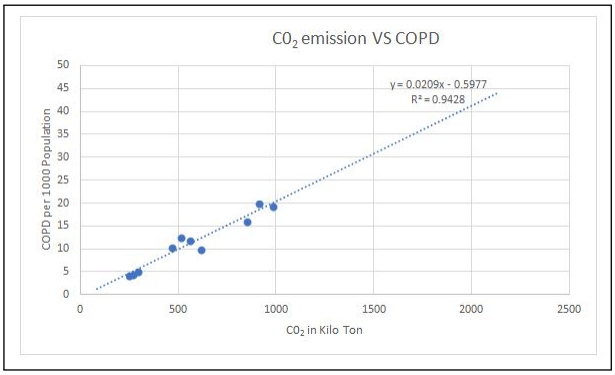

Figure 5: A correlation between COPD patient and CO_2 emission

There is strong positive correlation between CO_2 emission and COPD patient in Kathmandu Valley. Due to excessive air pollution inside Kathmandu valley, we can find the number of COPD patient increased in the hospitals. Figure 5 shows the graph of correlation between OPD patients and CO_2 emissions. The x – axis represents the CO_2 emission in kilo ton, whereas y axis represents COPD per 1000 . The line shown in the graph (y= 0.0209x -0.5977), shows a positive correlation between the two variables. However, the line shown in a uni-variate line.

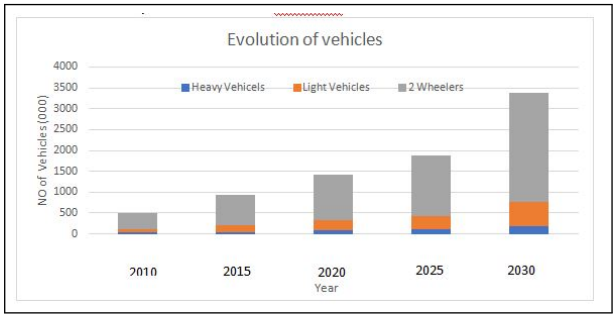

Figure 6: Vehicle fleet (‘000) in Kathmandu Valley

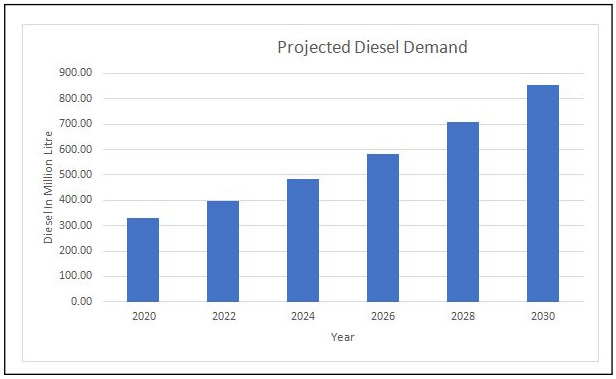

Figure 7: Total Projected Diesel Demand in Kathmandu Valley

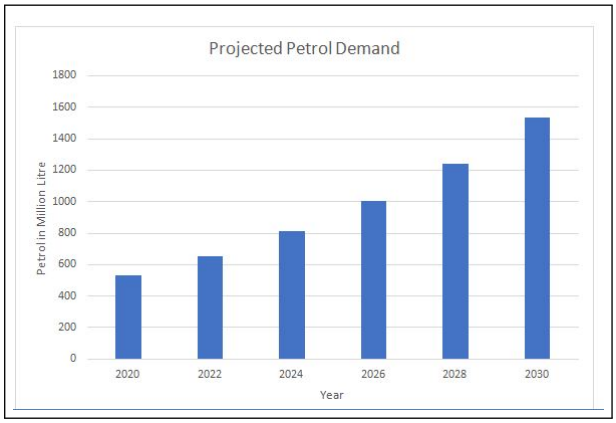

Figure 8: Total Projected Petrol Demand in Kathmandu Valley

Figure 7 shows the bar graph of projected diesel demand in Kathmandu city from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows diesel demand in million litres. While the demand in 2020 was approximately 310 million litres, the demand is projected to significantly increase in the next 10 years. The demand has been projected to increase to up to 850 million litres by 2030. Figure 8 shows the bar graph of projected petrol demand in Kathmandu city from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows petrol demand in million litres. While the demand in 2020 was approximately 550 million litres, the demand is projected to significantly increase in the next 10 years to increase to up to 1550 million litres by 2030.

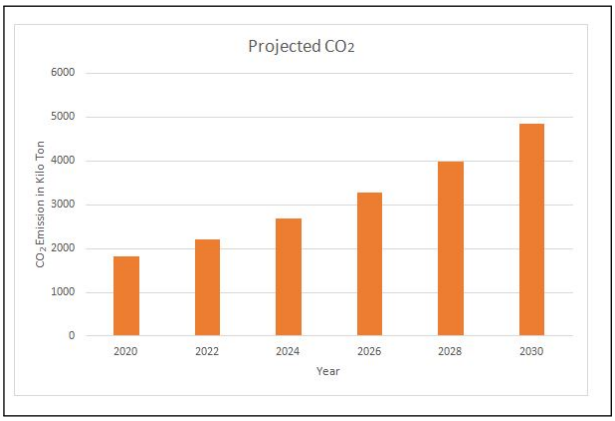

Figure 9: Projected CO_2 in Kathmandu Valley till 2030

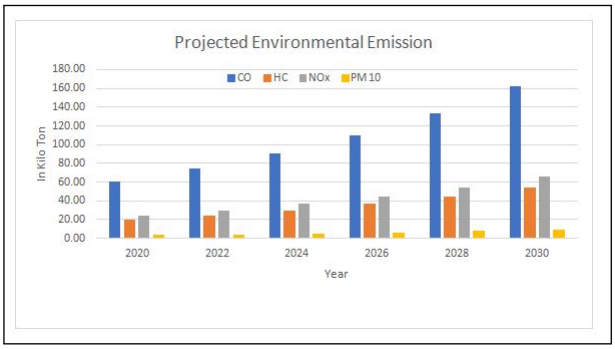

Figure 10: Projected Environmental Emission from fuel in Transportation Sector

Figure 10 shows the bar graph of projected Environmental emission in Kathmandu valley from the year 2020 through 2030. The x – axis represents the year starting from 2020 to 2030, whereas the y-axis shows C0 emission in kilo ton. The bars show the different gases like CO, HC, NOx and PM 10 represented by the colors blue, orange, grey and yellow respectively.

As we can see, the emission of most of the gases is in increasing trend. Comparatively, CO is projected to have the highest increment from 60 kilo ton in 2020 to 161 kilo ton in 2030. Similarly, NOx has the second highest projected increment, from 21 kilo ton in 2020 to 61 kilo ton in 2030. HC is projected to increase from 20 kilo ton in 2020 to approximately 51 kilo ton. The lowest increment is for PM10 which is projected not to increase much in the next 10 years. It has been projected to increase from approximately 3 kilo ton to approximately 9 kilo ton.

This research has a substantial influence on the computation of CO_2 emissions produced by the transportation industry, as well as the impact on the health of Kathmandu Valley inhabitants. The CO_2 emissions calculated for the Kathmandu Valley in 2010/2011 were 1,094 kilotons, approximately 14 times more than in 1990/1991. When comparing the population density of cities, the Kathmandu Valley had a population density of 4,386/km2 in 2009, which was half that of New York City, which had a population density of 10,434.62/km2 [24, 25, 28-31]. Although New York's car emissions were significantly greater than those in the Kathmandu Valley, the trend of CO_2 emissions in New York was dropping every year, but those in the Kathmandu Valley were growing exponentially. The CO_2 emissions calculated for the Kathmandu Valley in 2010/2011 were 1,094 kilotons, approximately 14 times more than in 1990/1991. According to the findings, there was a clear link between rising CO_2 emissions and an increase in the number of COPD patients in hospitals.

5. Conclusion & Recommendation

Every year, many individuals die as a result of air pollution. Air pollution has risen to the top five major causes of death in various countries and towns, including the Kathmandu Valley. From 1990/1991 to 2019/2020, the number of automobiles registered in the Kathmandu Valley increased by more than 19 -fold. As the number of automobiles increased, so did the amount of fossil fuels consumed, and thus the amount of CO_2 emitted. The results demonstrate that CO_2 emissions from transportation in the Kathmandu Valley have been increasing dramatically. From 1997/1998 to 2019/2020, the number of COPD

patients in the Kathmandu Valley was closely associated with CO_2 emissions, according to the findings.

Four recommendations are made in this study to reduce CO_2 emissions in the Kathmandu Valley: (1) The newly implemented policies/standards should be adhered to. enforced successfully [13]; (2) the government should import fuel with lower carbon content; (3) the government should introduce bus rapid transit or metro railway on possible routes [32, 33] and other public transportation modes, such as double decker large buses, street cable cars, and so on; and (4) the government should efficiently expand and improve existing road networks.

According to this analysis, if the sales of these motor vehicles are reduced by 75 percent by an equivalent number of public buses by 2030, a substantial amount of fuel consumption and significant amounts of environmental pollutants can be avoided. As a result, bus utilization for public transit should be encouraged.

The usage of electric motorbikes instead of conventional gasoline motorbikes is another way to reduce future energy consumption and environmental emissions in the Kathmandu valley. Motorbikes are a very convenient mode of transportation in the Kathmandu valley, and their number is growing at an exponential rate every year.

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