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Mapping of Vehicular Emission of Ring Road Kathmandu, Nepal and Its Impact on Human Health

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ABSTRACT
The research is an outline of vehicular emission of Ring Road, Kathmandu, Nepal and it's impact on general public's health. Nepal has ranked 16th position out of 131 countries in terms of worst air quality. Kathmandu has 8 times higher the WHO annual air quality guideline value in $PM_{2.5}$ concentration in 2022.

This research has been conducted using quantitative method, the primary data was recorded by using Open Seneca air quality monitoring device for the real-time measurement of $PM_{2.5}$. Similarly, For PM_{10} the data was collected by recording the vehicle passing through the selected sites and emission was calculated using Dhakal (2003) emission factor. The study comprises that particle pollution is maximum in Shankhapark and minimum in Sinamangal. This study then estimates the emission of $PM_{2.5}$ & and PM_{10} by different vehicles such as: two-wheeler, bus/truck, minibus, taxi/car, jeep/van/microbus. The maximum amount of $PM_{2.5}$ was emitted by gasoline vehicle including two-wheeler, taxi/car and minimum amount by bus/truck, minibus, jeep/van/microbus. Similarly, maximum amount of PM_{10} was emitted by bus/truck, minibus, jeep/van/microbus and minimum by two-wheeler and taxi/car.

It was found that, the particulate matter (PM) doesn't comply with the standard given by NAAQS, WHO and NVMES. The results are higher than that of standard given by NAAQS, WHO and NVMES. The study concludes that increase in particle pollution is caused by increase in different types of vehicles in the city and still using old vehicle for transportation. It also recommends for the use of electric vehicle, better quality fuels (high octane) in fuel station, promotion of public transportation and enforcement of high euro emission standard for the control of vehicular emission.

Keywords: Euro emission standard, gasoline, particle pollution, pollution index, WHO

Introduction

The Kathmandu Valley is the capital city of Nepal and has the largest number of populations. One of the main reasons for the highly polluted state of Kathmandu Valley is the highly dense concentration of people coming from all over the country. Nepal has one of the highest rates of urbanization rates in the world that can steadily keep on increasing in the long run as well (Bakrania, 2015). Most of the development work has been concentrated in the Kathmandu Valley and the subsequent economic activities as well as the consumption of fossil fuel have aggravated the pollution and health-related problems in the city.

Studies have found that the major contributing factors of air pollution in the valley are the vehicles, residential combustion, brick kilns, the manufacturing and construction industries, bio-waste burning, and dust particles (Sarkar et al., 2017; Shakya et al., 2017). Out of them, vehicular emission is the primary contributing factor due to consumption of fossil fuels. The unusually high pollution levels from the vehicles are mainly due to the haphazard traffic system, poor maintenance of the vehicles, and ineffective control of vehicle emissions.

Coarse Dust Particles (PM_{10}) is 2.5 µm to 10 µm in diameter. Sources include crushing or grinding operations and dust stirred up by vehicles on road. The United States Environmental Protect Agency (EPA) has set standard for PM_{10} levels into six categories, based on the 24-hour average concentration of PM_{10} in the air. Fine Particles ($PM_{2.5}$) are 2.5 µm in diameter or smaller and only be seen with and electron microscope. Fine particles are produced from all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning and some industrial burnings.

This research tends to study and analyze the concentration of particulate matter at the different spots of Ring Road, Kathmandu

Objectives of the study:

1. To find out of status of particulate pollution of Ring Road Kathmandu.
2. To study and assess the effect of particulate matter on human health
3. To compare particle pollution levels between heavy traffic area and light traffic area

Research Methodology

The primary traffic count survey was conducted at 21 distinct locations around Kathmandu Valley's ring road for the measurement of PM_{10} while Open Seneca device was used for the real time measurement of $PM_{2.5}$. Traffic count surveys in the actual number of on-road vehicles during peak hours as well as vehicle attrition rates and vehicle movement away from the estimation sites. At the main route, surveys of traffic volumes were conducted.

Utilizing the direct field observation method, data on vehicle emissions were calculated. During peak traffic hours, the vehicle travelling on the various sites of the ring road was counted for around 30 minutes and emission level were measured using Open Seneca ambient air pollution measuring device. For the calculation of PM_{10} emission, the number of vehicles was then counted and divided into 5 separate categories: two-wheelers, buses/trucks, minibuses, taxis/cars, and jeeps/vans and applied Dhakal (2003) emission factor. The number of non-polluting vehicles, such as electric vehicles, clean energy tempos, and bicycles, was also counted but was not taken into account when computing the data. For $PM_{2.5}$ emission, Open Seneca air pollution measuring device was used for the interval of 5 minutes to collect data.

For the measurement of $PM_{2.5}$, the recorded data was averaged and reading was calculated. For PM_{10}, the acquired data was examined using Dhakal (2003) emission factor. The number of vehicles was counted, and an estimation of their exhaust emissions was made. The fuel consumption of the various types of automobiles was assessed together with the exhaust emissions of the various vehicles. The exhaust emission by vehicles type (j) for pollutant (i) in terms of time (t) is given by

P(i)=Nj(t) * fuel consumption * EFij(t)
Nj(t) = Number of vehicles in operation of type (j) in time (t)
EF(j) = Emission factor by pollutants type (i) of vehicular (j) in time (t)
Exhaust Emission = Number of Vehicle X Fuel Consumption X Emission factor
Total fuel usage = Fuel consumption X Number of vehicles

Table I. Dhakal (2003), vehicle emission factor table

S.N.	Vehicles	Emission Factor						Fuel Consumption
		CO	HC	NO_x	SO_2	PM_{10}	CO_2	
1	Two-Wheeler	126.30	69.94	11.30	1.50	4.30	3984.8	0.0179
2	Bus/Truck	24	11.10	35.61	4.92	11.70	3440	0.48
3	Minibus	24.80	10.40	11.20	4.92	8.10	3440	0.42
4	Taxi/Car	261.93	87.98	17.11	1.50	2.27	3984.8	0.091
5	Jeep/Van	24.80	10.40	11.20	4.92	7.20	3440	0.132

APPROACH I: The information derived from the pollution emission factors of various vehicles was then compared to the standard emission factor data made available by NVMES, 2069. Next, the locations with the worst pollution were found. The impact of the contaminants on human health was examined under NAAQS guideline value.

Table II. NAAQS, 2012 Average concentration for different parameters

Parameters	Time (Weight Average)	Concentration (Max.)
TSP	Annual	-
	24-hrs	230
PM_{10}	Annual	-
	24-hrs	120
$PM_{2.5}$	Annual	-
	24-hrs	40
SO_2	Annual	50
	24-hrs	70
NO_2	Annual	40
	24-hrs	80
CO	8-hrs	10,000
LEAD	Annual	0.5
BENZENE	Annual	5
OZONE$_{(O3)}$	8-hrs	157

For light duty diesel vehicles (LDDV) (<2.5 tons), upper permissible values (g/kWh) for passenger car are 0.64 for CO, 0.56 for ($HC+NO_x$) and 0.5 PM. Similarly, for LDDV (>2.5 and <3.5 tons), the permissible limit values (g/kWh) are 0.64-0.8 for CO, 0.65-0.86 for ($HC+NO_x$), 0.5-0.78 for NO_x and 0.05-0.1 PM. For diesel vehicles (>3.5 tons), the upper permissible limit values (g/kWh) are 2.1 for CO, 0.66 for HC, 0.5 for NO_x and 0.10-0.13 for PM. (MOEST, 2012)
(Source: *National Ambient Air Quality Standard, 2012*)

Literature Review:

The World Health Organization (WHO) estimates that 92% of the world's population breathes air that contains more particulate matter (PM) than is recommended. Southeast Asia, East Asia, and South Asia are the most polluted continents. Every day, millions of individuals in these areas are exposed to hazardous amounts of PM. (World Health, 2021).

Particulate contaminants include contaminants such as smog, soot, tobacco smoke, oil smoke, fly ash, and cement dust. Biological Contaminants are microorganisms (bacteria, viruses, fungi, mold, and bacterial spores), cat allergens, house dust and allergens, and pollen. Types of Dust include suspended atmospheric dust, settling dust, and heavy dust. Another fact is that due to their small size, PM_{10} and $PM_{2.5}$ particles have extended half-lives in the atmosphere, allowing for their long-lasting suspension as well as their transfer and spread to far-off locations where people and the environment may be exposed to the same level of pollution (Wilson & Suh, 1997). They have the power to harm forests and crops, alter the nitrogen balance in aquatic ecosystems, and acidify bodies of water. $PM_{2.5}$ are having more severe health consequences because to their minute size. The production of "haze" in various urban locations is mostly due to the aforementioned fine particles (Heal et al., 2012; Kan et al., 2012; Pena & Rollins, 2017).

The ever-growing demand for urban services and deteriorating urban environment in the context of limited capacities and resources pose a serious challenge for the country. Rapid urban growth in Nepalese cities has prompted concerns over the degradation of environmental and ecological health. Air pollution is caused by particulate matter (PM_{10}, $PM_{2.5}$) and other organic agents emitted by congested road traffic systems, as well as other reasons. Dust, particles, and aerosols all contribute to air pollution, which disrupts the dynamic atmospheric balance.(Dhakal, 2003)

Polluting substances have detrimental effects on both human health and the environment. Due to the large number of automobiles on the roads today, transportation is a significant contributor to air pollution in many nations. Because more people can now buy bikes and cars due to rising purchasing power, this is terrible for the environment. Rising urbanization has resulted in an alarming increase in vehicular pollution. Urban air pollution from vehicles, especially in large cities, has become a significant issue. The symptoms of vehicular pollution, such as coughing, headaches, nausea, and eye irritation, have started to become more noticeable. Smog has a murky appearance because to these soot, metal, and pollen particles. The greatest serious hazard to human health from vehicular pollution is posed by tiny particles because they can get deep inside the lungs.(Alam, 2020)

Numerous studies have shown that source conditions as well as several meteorological parameters, such as wind speed, wind direction, solar radiation, relative humidity, rainfall, etc., have an impact on the concentration of $PM_{2.5}$ and PM_{10} in ambient air. SPM concentrations on the roadway are primarily impacted by mechanical turbulence caused by moving vehicles and wind, as well as thermal turbulence caused by hot vehicle exhaust gas. These variables outweigh the emission factors of individual automobiles. Compared to $PM_{2.5}$, which has a significantly longer residence time and is seen as a regional or even trans-boundary issue, PM_{10} is seen as more of a local and urban scale issue. Around the world, PM_{10} mean concentrations were typically between 10 and 80 $\mu g/m^3$. At isolated locations with no nearby sources, 10 to 20 $\mu g/m^3$ are discovered. In metropolitan regions, levels typically range from 60 to 220 $\mu g/m^3$, while in severely polluted places, they may even reach 2,000 $\mu g/m^3$. Heavy pollution was discovered at locations with significant traffic density and nearby local sources in excess of 50 $\mu g/m^3$.(Shandilya et al., 2007)

In two intensive campaigns between December 2012 and February analyzed PM_{10} filter samples. They found that motor vehicles (31%), soil dust (26%), biomass/garbage burning (23%), and brick kilns (15%) were the local primary sources of 95% of the average PM10 concentration, while secondary sources accounted for the remaining 5%.(Kim et al., 2015)

According to a MOPE/ESPS research, between 1993 and 2001, PM_{10} emissions from automobiles grew more than four times, and today, vehicle exhaust accounts for 42% of all PM_{10} emissions in the Valley. About 25% of the vehicles tested for emissions while in use failed to fulfill the limits, according to the results. By preventing "gross polluters" like these from operating in Kathmandu, we can significantly improve the city's air quality.

Every year, air pollution causes 42,100 deaths in Nepal, of which 19% occur in children under the age of five and roughly 27% in adults over the age of 70. The typical Nepali's life expectancy is decreased by 4.1 years as a result. According to data on Nepal's leading causes of mortality, the top five killers are COPD (66%) (ischemic heart disease: 34%), stroke (37%), lower respiratory infections (47%) and neonatal fatalities (22%), all of which are significantly influenced by air pollution. When breathed in, pollutants like PM2.5 (particles less than 2.5 micron in diameter, or roughly 20 times smaller than human hair), have been shown to penetrate the lungs deeply and even enter the bloodstream through the alveoli.

The development and progression of heart and lung ailments are directly correlated with the size of particle pollution. Smaller particles are more likely to enter the lower respiratory tract, where they can worsen heart and lung conditions. Furthermore, a large body of research has shown that exposure to fine particle pollution, which includes cardiac dysrhythmia, nonfatal heart attacks, worsened asthma, and impaired lung functioning, results in premature death in those with heart and/or lung problems. The severity of the illnesses caused by particle pollution will depend on the level of exposure. The most common clinical symptoms of respiratory disease brought on by air pollution include wheezing, coughing, dry mouth, and limitations in activities owing to breathing issues (Bentayeb et al., 2013;Guillam et al., 2013).

Findings

1.1 Number of vehicles

By counting the number of vehicles operating at peak office hour intervals, the number of vehicles at various locations near the ring road of the Kathmandu Valley was calculated in between 9:45 to 10:15. The five different vehicle types were classified as follows: two-wheeler, bus/truck, minibus, taxi/car, and jeep/van. The figure below displays the number of cars operating at the various locations. Chapagaun Dobato has the fewest amount of vehicle operating throughout the time period, whereas Kalanki area has the most. Since Kalanki is the main entry and outgoing point of capital city, we can observe significant amounts of Vehicles running at peak hour. It is due to the number of people living in outskirt of ring road and long route vehicle. Most people use this motorway to travel outside of the Kathmandu valley. Chapagaun Dobato has least number of vehicles during the peak hour. It is the small commercial area, so the number of vehicles is also the few in that area. Koteshwor, Balkhu, Satdobato and Gwarko also witnessed the highest number of vehicles during the peak hour. It is because the large number of people travels via this route.

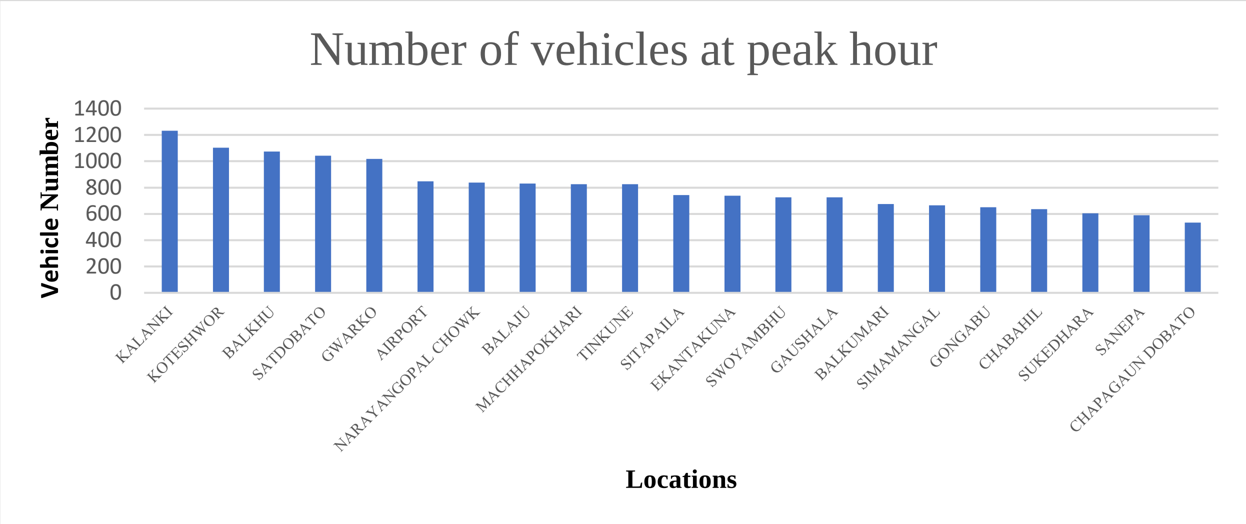

Fig.I. Number of vehicles running at different sites on peak hour

1.2 Vehicular Emission

Using Dhakal (2003) emission factor method and Open Seneca air pollution monitoring device, concentration of particulate matter (PM) of 21 different sites were obtained for the period of half an hour. For PM_{10}, direct vehicle count method is used and Dhakal (2003) emission factor was applied whereas for $PM_{2.5}$, Open Seneca air pollution measuring device was used.

For PM_{10}

Table below illustrates the share of emission from different categorized vehicle. According to observation, maximum amount of exhaust emission was of two-wheeler, Which contributed about 63.2%. Similarly, Taxi/car has contributed about 11.98%, Bus/Truck has contributed 9.05%, Jeep/Van has contributed 7.95% and Minibus has the lowest exhaust emission of PM_{10} about 7.78%. The main reason behind two-wheeler being the highest emission contributor is the increasing number of two-wheelers inside the valley. After COVID-19, people prefer to travel in bike to protect themselves from crowd. This trend has changed the travelling lifestyle. Another reason is the never-ending traffic congestion of Kathmandu valley. Taxi/Car also contributes the higher number about 11.98% of total emission. It is due to the increasing number of rental taxi and private cars. The lowest contribution is of Minibus that is about 7.78% percent of total emission. After being replaced the old minibus from the routes of Kathmandu we can also witnessed newer version of them. So, emission is comparatively low in that category.

Table III. Share of categorized vehicle emission (PM_{10}) of different sites

Site	PM_{10} Emission ($\mu g/m^3$)				
	Two-wheeler	Bus/Truck	Minibus	Taxi/Car	Jeep/Van
KALANKI	61.6	550.3	289.17	32.2	87.4
KOTESHWOR	52.7	494.2	197.3	40.9	70.3
BALKHU	57.9	365.04	234.7	20.24	98.8
SATDOBATO	55.03	404.35	255.1	21.7	71.3
GWARKO	53.7	421.2	210.9	21.07	77
AIRPORT	39.8	230.2	194	32.2	72.2

NARAYANGOPAL CHOWK	42.1	550.3	166.7	13.8	45.6
BALAJU	38.7	544.7	258.5	20.2	53.2
MACHHAPOKHARI	38.3	539.1	268.7	21.07	48.5
TINKUNE	39.3	426.8	228	19.6	74.1
SITAPAILA	32.8	522.3	255.15	19	53.2
EKANTAKUNA	39.4	247.1	166.7	18.4	42.77
SWOYAMBHU	33.1	454.9	214.3	19.4	56
GAUSHALA	36.8	331.3	207.5	14.3	56.1
BALKUMARI	31.7	365.04	142.9	19.2	60.8
SIMAMANGAL	32.5	241.5	211	16.1	55.1
GONGABU	30	550.3	166.7	13.9	45.6
CHABAHIL	32	303.3	197.3	13.8	45.61
SUKEDHARA	27.5	314.5	166.7	13.8	45.6
SANEPA	24.2	533.5	194	13.8	53.2
CHAPAGAUN DOBATO	24.25	404.35	255.15	12.8	53.2

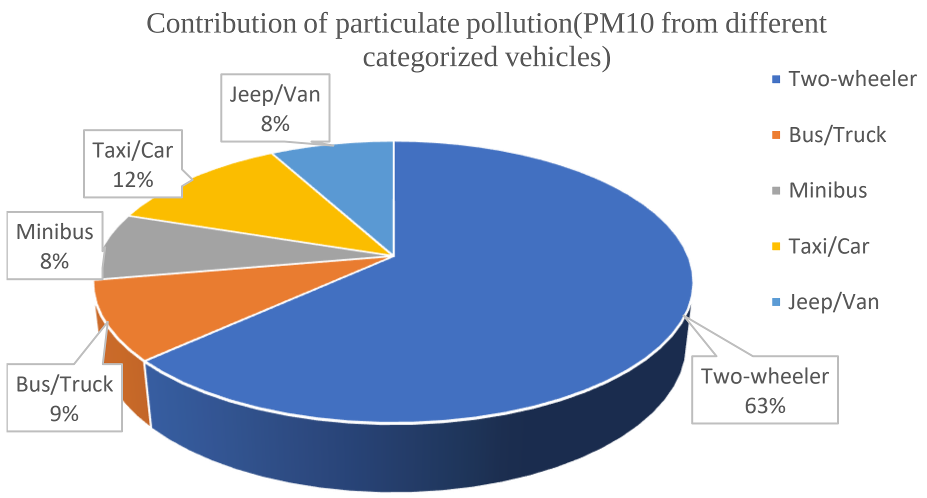

Fig.II. Share of particulate pollution (PM_{10}) from different categorized vehicle

For $PM_{2.5}$

In the peak office hour, Sukedhara recorded the highest $PM_{2.5}$ pollution with the reading of 116.8µg/m^3. Chapagaun Dobato was the least polluted site in the ring road with the contribution of pollution level of 32.3 µg/m^3. Similarly, Narayan Gopal Chowk and Balaju were the top polluted places in Kathmandu ring road with the reading of 113.5 and 111.35 respectively. Ekantakuna, Sanepa and Airport were the least polluted place.

Table IV. Average concentration of $PM_{2.5}$ from different sites

Site	Average $PM_{2.5}$ Concentration (µg/m^3) (Per half an hour)

KOTESHWOR	108.7
BALKUMARI	91.2
GWARKO	84.0
SATDOBATO	89.0
HAPAGAUN DOBATO	32.3
EKANTAKUNA	40.7
SANEPA	41.4
BALKHU	91.7
KALANKI	108.9
SITAPAILA	106.9
SWOYAMBHU	73.5
BALAJU	111.3
MACHHAPOKHARI	107.0
GONGABU	108.5
NARAYANGOPAL CHOWK	113.6
SUKEDHARA	116.8
CHABAHIL	80.3
GAUSHALA	81.8
AIRPORT	46.5
TINKUNE	73.2
SINAMANGAL	61.6

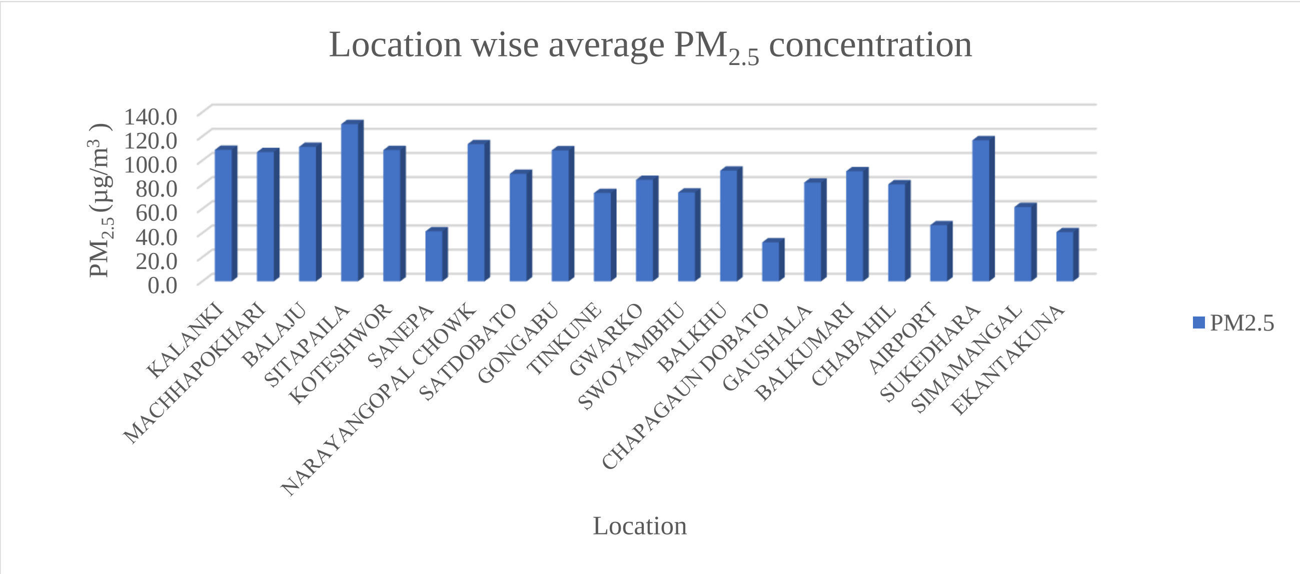

Fig.III. Average concentration of $PM_{2.5}$ per half an hour

1.3 Location wise emission comparison

From the graph below, we can clearly observe that Kalanki witnessed the highest level of particle pollution on an average of 7.3% PM_{10} and 6.2% $PM_{2.5}$ respectively. Koteshwor, Balkhu, Narayan Gopal Chowk, Balaju, Satdobato, Machhapokhari, Gwarko, Sitapaila, and Sukedhara shows the highest level of emission value. Those areas are very harmful for long time exposure. While ChapagaunDobato is the least polluted area on the ring road with the value of 3.1% PM_{10} and 1.8% $PM_{2.5}$. Similar to this, Sanepa, Ekantakuna, Sinamangal and Airport also seems to be lowest polluted area on the ring road. In Sukedhara, level of $PM_{2.5}$ was observed about 6.6% which was the highest while in Kalanki, PM_{10} value was measured about 7.3%.

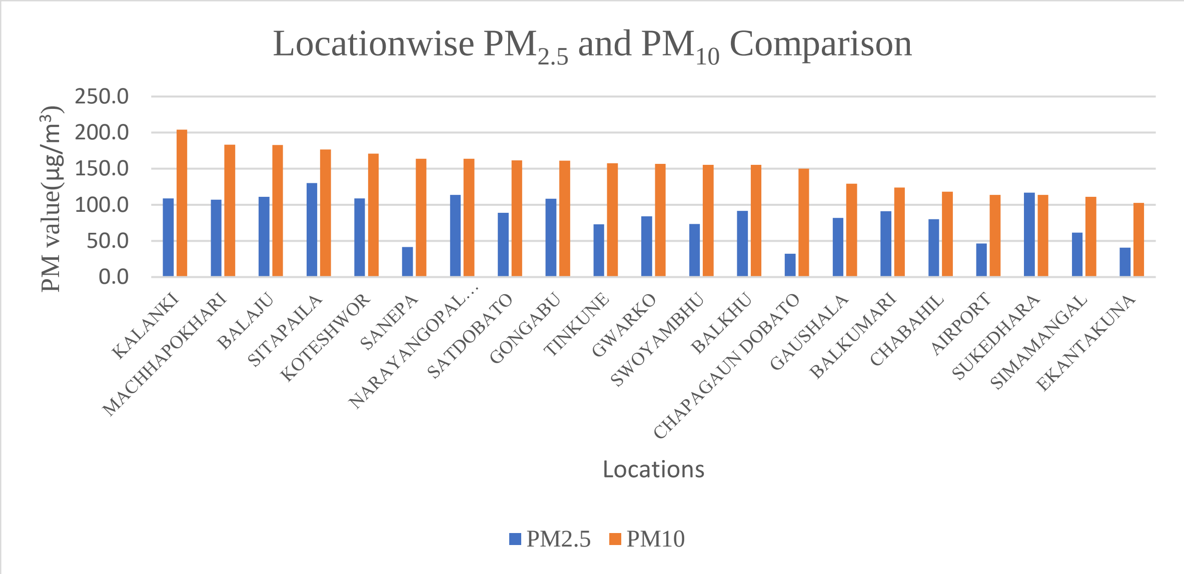

Fig.IV. Location wise average concentration of $PM_{2.5}$ and PM_{10}

1.4 PM comparison of heavy traffic and light traffic area

The $PM_{2.5}$ and PM_{10} values are higher in busy areas than in non-busy areas. This is because busy areas have heavy traffic and commercial activities, which emit pollutants into the air. The highest $PM_{2.5}$ and PM_{10} values were found in Kalanki and Koteshwor, which are two of the busiest areas in Kathmandu. The lowest $PM_{2.5}$ and PM_{10} values were found in Ekantakuna and Sanepa, which are two of the least busy areas in Kathmandu. The $PM_{2.5}$ values are generally higher than the PM_{10} values in both busy and least busy areas. This is because $PM_{2.5}$ is smaller and lighter than PM_{10}, so it can stay suspended in the air for longer periods of time.

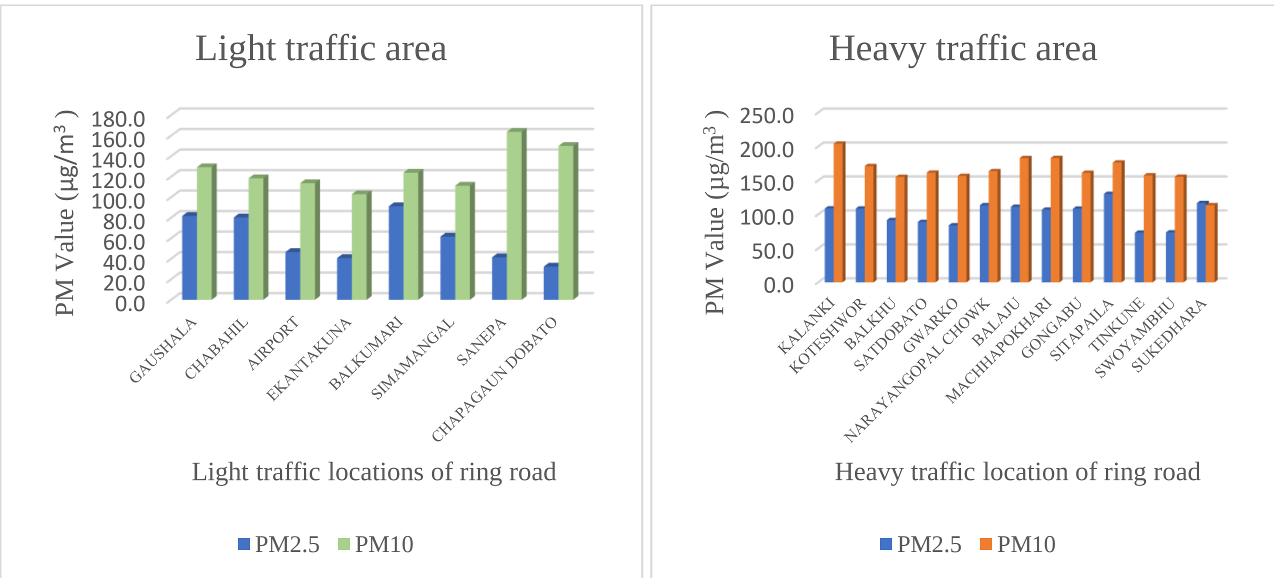

Fig.V. Comparison of $PM_{2.5}$ and PM_{10}on heavy traffic area and light traffic area.

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1.5 Vehicular emission mapping

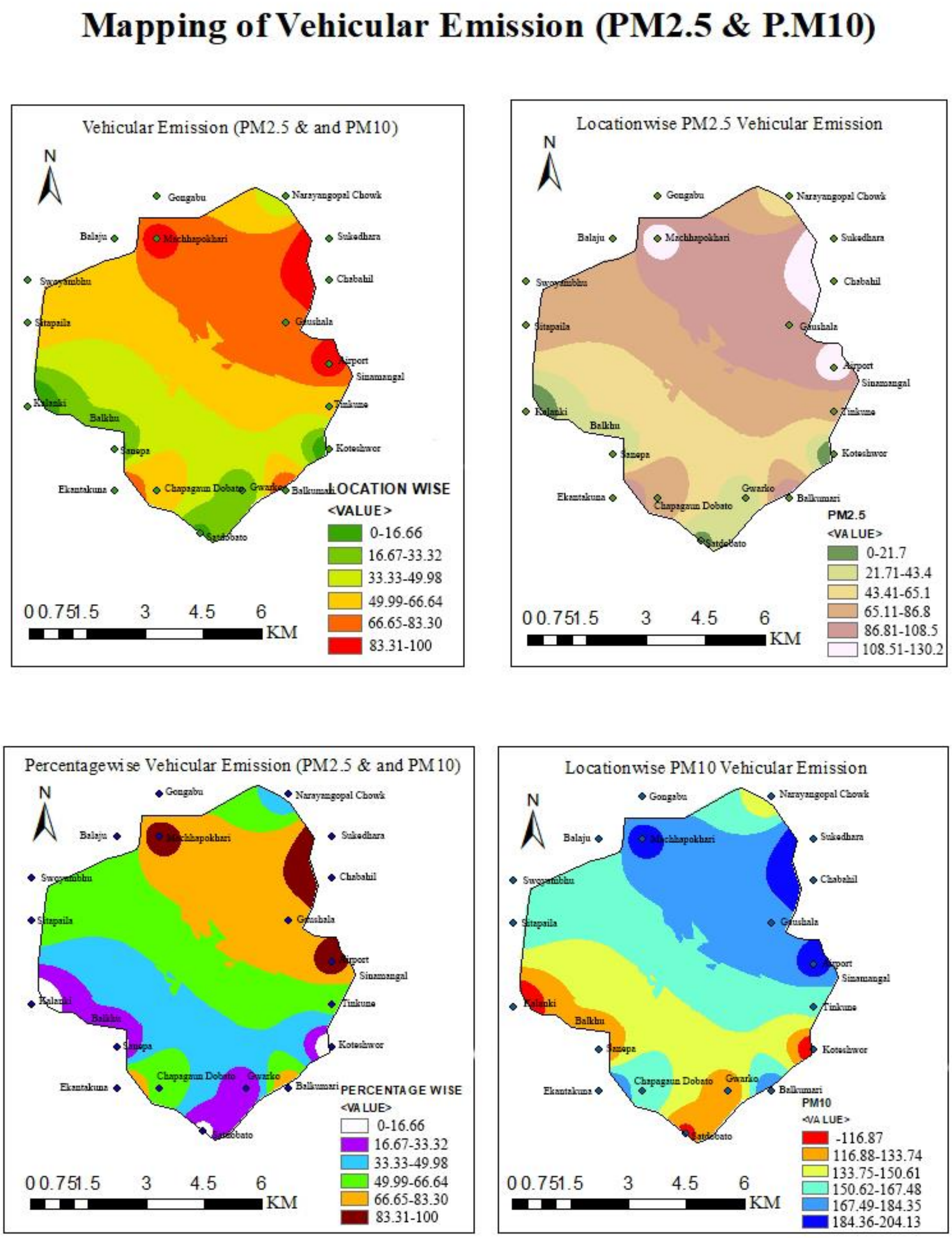

Fig. VI. Mapping of vehicular emission of $PM_{2.5}$ and PM_{10}, Location wise $PM_{2.5}$ Mapping, Percentagewise $PM_{2.5}$ and PM_{10} Mapping, Location wise PM_{10} mapping

Discussion

During the study period $PM_{2.5}$ and PM_{10} concentration around ring road has been observed. While comparing the concentration of $PM_{2.5}$ and PM_{10} between the sampling sites, there is heterogeneity in the observed data. The maximum $PM_{2.5}$ concentration recorded116.7 µg/m^3in Sukedhara followed by 113.6 µg/m^3 in Narayangopal Chowk, 111.3 µg/m^3in Balaju, 108.9 µg/m^3 in Kalanki, 108.7 µg/m^3 in Koteshwor, 108.5 µg/m^3 in Gongabu and 106.9 µg/m^3 in Sitapaila area. Similarly, the minimum $PM_{2.5}$ concentration recorded 32.3µg/m^3 in Chapagaun Dobato, 40.7 µg/m^3 in Ekantakuna, 41.4 µg/m^3 in Sanepa, 46.5 µg/m^3 in Airport and 61.6 µg/m^3 in Sinamangal area. Also, the maximumPM_{10} concentration recorded204.1 µg/m^3in Kalanki, 183.1 µg/m^3 in Machhapokhari and Balaju, 176.5 µg/m^3in Sitapaila, 171.1 µg/m^3in Koteshwor and 163.7 in Sanepa and Narayangopal Chowk respectively. Likewise, the minimum PM_{10} concentration observed 102.9 µg/m^3 in Ekantakuna, 111.215 µg/m^3in Sinamangal, 113.6 15 µg/m^3in Sukedhara, 118.4 15 µg/m^3 in Chabahil, 123.9 15 µg/m^3in Balkumari and 129.2 15 µg/m^3 in Gaushala. (Regmi, Poudyal et al. 2023) conducted a study on the measurement of $PM_{2.5}$ and found the value 127.31 µg/m^3. The research was conducted on winter and summer. Due to rain diffusion in the vertical atmosphere $PM_{2.5}$ values were lower in summer months. (Giri et al., 2008) also conducted research about PM_{10} and observed a daily average of 633 µg/m^3. (Gupta et al. 2023) did a trend analysis on particulate matter and daily average AQI $PM_{2.5}$ values recorded on unhealthy range i.e., 150 µg/m^3 - 200µg/m^3.

The mean $PM_{2.5}$ concentrations for 21 sampling sites revealed that the $PM_{2.5}$ and PM_{10} concentrations in these areas are also above the daily mean exposure threshold value of WHO (15 µg/m^3 for $PM_{2.5}$ and 50 µg/m^3 for PM_{10} and National Ambient Air Quality Standards (35µg/m^3 for $PM_{2.5}$150 µg/$m^3$for PM_{10}).These variations in the concentration of pollutants may have depended on the sources and weather conditions prevailing during the study period. During the observation period, there may be an increment in vehicular movements for a short duration, leading to a higher concentration of $PM_{2.5}$ and PM_{10} for a short period. On the other hand, meteorological factors influence the aggregation, diffusion, and spread of $PM_{2.5}$ (Feng, Gao et al. 2016). However, this study could not predict the impacts of meteorological conditions on the concentrations of $PM_{2.5}$ as it was carried out for a short duration only.

Kathmandu is exposed to high levels of air pollution, which could have a negative impact on human health. For a long time, it has been believed that air pollution is a silent killer that contributes to a number of infectious and chronic diseases. Around 6.5 million premature deaths are attributed to air pollution worldwide each year, of which 3.5 million are attributable to home pollution and 3 million to ambient pollution. By 2040, it is projected that this number would rise to 7.5 million. (Lancet 2016). $PM_{2.5}$ was the fifth-ranking global mortality risk factor in 2015, accounting for an estimated 76 percent of all deaths worldwide. In Nepal's case the impact on human health is equally severe. By 2030 annual premature deaths in Nepal, due to outdoor air pollution, are expected to be 24,000. (Shindell, Kuylenstierna et al. 2012).

Lung cancer, chronic obstructive pulmonary disease (COPD), ischaemic heart disease (IHD), and strokes are among the most prevalent chronic diseases in Nepal along with respiratory sickness, allergies, and eye infections. According to statistics, non-communicable diseases (NCDs) account for 60% of all fatalities in humans. Cardiovascular illnesses have contributed to the highest number of NCD-related deaths (22%), followed by cancer (8%), chronic respiratory conditions (13%), and other NCDs (14%). Premature mortality from NCDs is 22% (between the ages of 30 and 70) (Cohen, Brauer et al. 2017). 2014). Data from the Global Health Observatory (GHO) for 2012 showed a concerning rate of 9,944 deaths in Nepal due to ambient air pollution, with ischemic heart disease (IHD) accounting for 33.4% of those deaths, followed by stroke (32%), chronic obstructive pulmonary disease (COPD) (17.8%), lung cancer (9.3%), and acute lower respiratory tract infection (ALRTI) (7.4%). In a hospital-based study, the prevalence of NCDs was 31%, with cancer at 5%, COPD at 43%, and cardiovascular disease at 40% (Bhandari, Angdembe et al. 2014). According to a survey conducted among hospitalized patients at multiple hospitals in the Kathmandu Valley, respiratory illnesses are very common. The majority of the illnesses, including a sizable percentage of others, were diseases, with COPD being the most common. According to a district-by-district breakdown, the majority of patients (44.4%) came from Kathmandu. Overall morbidity was 44.4%, with COPD cases having the highest morbidity rate (Karki, Dhakal et al. 2015). According to a 2017 study, there may have been between 2.7 and 3.4 million premature births worldwide in 2010 due to exposure to $PM_{2.5}$. Preterm births account for 14% of all births in Nepal. Air pollution in Kathmandu is becoming a greater occupational concern, particularly for traffic police who are constantly exposed to dusty roads (Aryal Bhandari, Gautam et al. 2015). Due to this pulmonary functions have been significantly worsened in the traffic police working in Kathmandu (Shrestha, Nepal et al. 2015). Workers in Kathmandu's grocery stores and brick kilns face the same airborne occupational dangers, posing a major threat to their health and necessitating immediate protection (Sanjel, Khanal et al. 2016; Sanjel, Khanal et al. 2017).

Conclusion

The weight of air pollution, which annually threatens the lives of thousands of people, has been enormous for Kathmandu's citizens. If prompt preventive action is not done in the upcoming years, the situation will undoubtedly get worse. It is imperative to inform the general public about the negative effects of air pollution and the necessary safety measures to avoid its fatal repercussions. Only when the government takes the initiative to address the issue Kathmandu's air pollution will be solved. After analyzing the observed data of particle pollution, following conclusion are made. They are as follows:

1. Since no-go zone for freight vehicles during peak hours, their contribution could have been increase.
2. This research has shed important light on the mapping of vehicle emissions along Kathmandu's Ring Road and their ensuing effects on human health. The results highlight the critical need for efficient regulations and sustainable transport management to reduce the negative consequences of air pollution in this densely populated area.
3. Particulate matter is just one of the worrying contaminants that the thorough analysis of vehicle emissions and air quality evaluations indicate. In addition to lowering air quality, these pollutants pose serious health concerns to Kathmandu's citizens, especially those who live close to the Ring Road.
4. The study concludes the importance of community awareness and involvement in addressing the challenges posed by vehicular emissions. Public education campaigns can empower individuals to make informed choices that contribute to a cleaner environment and improved overall well-being.
5. In conclusion, the mapping of vehicle emissions along Kathmandu's Ring Road is a useful tool for decision-makers in the fields of public policy, urban planning, transport management and healthcare. It lays the foundation for evidence-based decision-making with the goal of building a sustainable and healthy living environment for Kathmandu's citizens and acts as a model for other urban regions throughout the city dealing with comparable issues.

Recommendation

After research, the following recommendation is made,

1. One of the extremely significant factors is traffic management and road maintenance within the valley, which should be carried out successfully on a regular basis.
2. Promotion of healthy activities like walking, cycling etc.
3. Strong strategies to reduce air pollution. It could be penalty system for threshold emitters and ban on old heavy polluting vehicle.
4. The government should effectively implement an environment-friendly vehicle and transport policy.
5. Implementing stricter emission standards for vehicles, promoting public transportation, and investing in green technologies are crucial steps to alleviate the impact on human health.

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