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Estimation of Vehicular Emissions of Major Districts in Kerala

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Abstract--- *Air pollution is of great importance in the current world and it is a major factor affecting the health of the population. It is a major contributor in global warming too. Air pollution occurs due to many factors such as pollutants from industrial and personal use. Among personal use, vehicular transportation contributes the foremost part in air pollution. The main objective of the current study is to have an understanding of the average amount of pollutants released into the atmosphere by different vehicular categories per day in the year 2018. Carbon Dioxide (CO_2), Carbon Monoxide (CO), Nitrogen Oxide (NO_x), Sulphur Dioxide (SO_2), Hydrocarbons (HC), Methane (CH_4), Particulate Matter (PM) are the major contributors, among the pollutants released into the atmosphere. This study shows the major vehicle categories that produce the most amount of pollution. The amount of pollutants released into the atmosphere in different districts varies. This study shows the category wise pollution released into the atmosphere in major cities of Kerala*

Keywords--- *Vehicular Emission, Air Pollution, Pollutants.*

I. INTRODUCTION

A human being can survive three weeks without food, three days without water but without air, a person can only live about 3 minutes. Air is an important and vital component, any pollution or slight changes in air can cause a series of effects on human living conditions, ranging from asthmas to other diseases affecting the health of both young and old generations. The main source of pollution is from the vehicle and industrial discharges into the air. The major car pollutants are carbon monoxide, hydrocarbons, nitrous oxides, carbon dioxide and particulates. The only way to have a healthy air quality index in the surrounding is to decrease the emissions from vehicles and industries. According to the study conducted by Central Pollution Board (CPCB, 2010), in cities such as Delhi, Kanpur, Bangalore, Pune, Chennai and Mumbai, 70% of ambient air pollution is through the transport sector. [1]

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A lot of work is undertaken in the field of calculating AQI (Air Quality Index) and emission factors of an area [2]. The emissions of different pollutants in gram per kilometer can be calculated for different areas and the amount of emission of these pollutants in these areas can also be determined [3],[4] and [5]

II. MATERIALS AND METHODS

This work is about finding the average amount of pollutants released per day into the air by different vehicular categories. Three major districts in Kerala, Thiruvananthapuram, Thrissur, Ernakulam were considered, and the number of registered vehicles in those areas up to the year 2018 were found [6] and the amount of pollutants released per day from different vehicle categories was determined. This shows the maximum amount of pollutants in kilogram released into the atmosphere per day.

A. Estimation of vehicle emissions in Kerala

Data about the newly registered motor vehicle and the total number of registered vehicles in different districts were obtained from the website of Kerala State Council for Science, Technology and Environment till the year 2018 [7].

This data is useful in finding out the average vehicular emissions in Kerala. The vehicular emission is calculated based on the emission factor wherein different vehicles and emission factor for gases like carbon dioxide, carbon monoxide, nitrogen oxides, methane, sulphur dioxide, hydrocarbons, and particulate matter can be considered.

Particulate matter is the sum of all solid and liquid particles suspended in air many of which are hazardous. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets.

B. Analysis of vehicular emission

The type of pollutants emitted by vehicles is different due to different categories of vehicles used, different engine types, fuel used, condition of the vehicle, situations in which the vehicle is running etc.

The equation used for finding the average vehicular emission is:

$$\text{Vehicular emission} = \text{no. of vehicle} \times \text{emission factor} \times \text{distance} \quad (1)$$

The Average annual miles travelled by major vehicle categories is obtained from the website of U.S department of energy [8]. From this, the average vehicular distance travelled in a day in terms of kilometer is obtained using the equation:

$$\text{Average distance per day(km)} = \text{Average distance in miles per year}/365 \times 1.60934 \quad (2)$$

A computer program is generated which takes input of different parameters such as CO_2, NO_x, HC etc. It calculates the average distance travelled per day (in km) and then estimates the vehicular emission using above equation within a time complexity of O(n) using linear approach.

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Fig. 1: Screenshot of Program Output

Table 1: Emission Factor of Vehicles (g/km)

Emission Factor	CO_2	CO	NO_X	CH_4	SO_2	HC	PM
Trucks & Lorries	515.2	3.6	6.3	0.09	1.4	0.3	0.87
Light Motor Vehicles (Goods)	515.2	5.1	1.3	0.09	1.4	0.2	0.14
Buses	515.2	3.6	12	0.09	1.4	0.6	0.9
Taxis	208.3	0.9	0.5	0.01	10.3	0.07	0.13
Two wheelers	26.6	2.2	0.19	0.2	0.013	0.05	1.42
Cars	223.6	1.98	0.2	0.2	0.05	0.03	0.25
Omni buses	515.2	3.6	12	0.09	1.4	0.6	0.9
Tractors	515.2	3.6	6.3	0.09	1.4	0.3	0.87
Light Motor Vehicles (Passengers)	60.3	5.1	1.28	0.2	0.03	0.2	0.14
Auto Rickshaw (Passenger)	62.41	1.37	0.2	0.2	0.03	2.53	0.045
Auto Rickshaw (Goods)	131.6	0.41	0.51	0.09	1.4	0.14	0.091
Other vehicles not covered	343.9	3.9	3.9	0.1	1.9	0.2	0.5

III. Result And Discussions

A computer program was made using python programming language which was able to calculate vehicular emission precisely across all parameters and the code was validated using the results obtained from the theoretical calculations as shown in Fig.2 and Fig.3.

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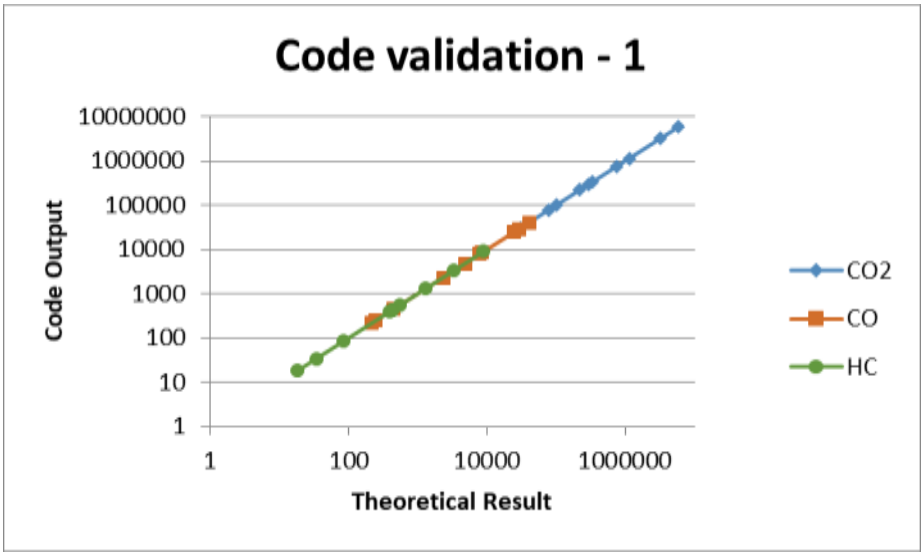

Fig. 2: Validation of Results-1

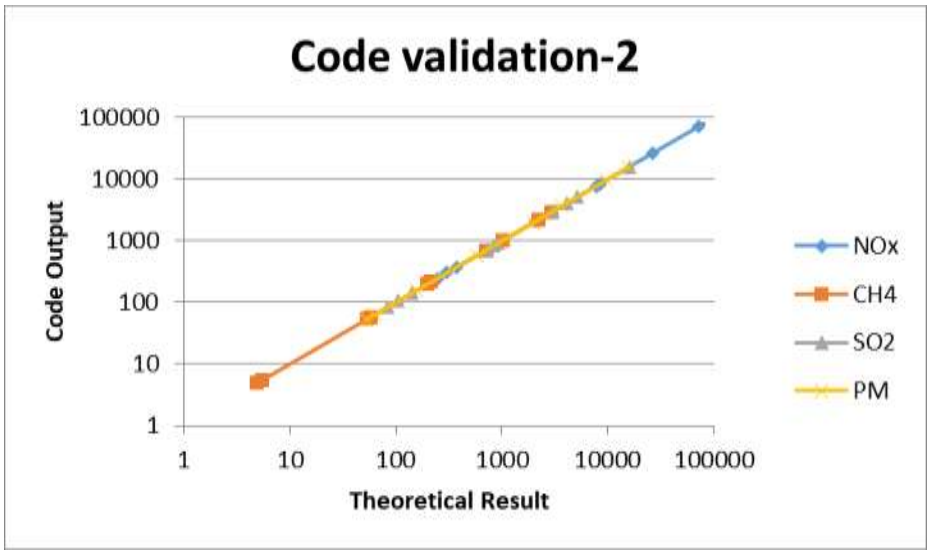

Fig. 3: Validation of Results-2

The data, after analysis was taken into consideration and then used to plot a table that showed the average amount of pollutants released into the atmosphere from different types of vehicles. These data help us to find the average amount of pollutants released into the atmosphere in different districts and used to plot graphs comparing the emission of different classes of vehicles. The values once plotted shows that the most amount of pollution produced is from trucks as they have less mileage and travel great distance when compared to other motor vehicles. This process is continued for the rest of the districts and the values were plotted in graphs accordingly this gave us an over view of the amount of pollution happening in different districts as well as the amount contributed by different vehicular categories.

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A. Analysis of vehicular emission by a single vehicle of different categories

After analysis the data was charted, and calculations were done for emission of one vehicle. The data shows different type of emissions coming from different type of vehicles and this data can be used to identify the major vehicle category which contributes the most in pollution [9].

Table 2: Average Pollutants Released Into the Air by One Vehicle Per Day

Vehicle	Distance in 1 year (miles)	Average distance in a day	CO_2(kg)	CO(kg)	NO_X(kg)	CH_4(kg)	SO_2(kg)	HC(kg)	PM(kg)
Trailer	15000	66.135	34.073	0.238	0.416	0.005	0.092	0.019	0.057
Truck	65000	286.58	147.649	1.031	1.805	0.025	0.401	0.085	0.249
Bus	35000	154.317	79.503	0.555	1.851	0.013	0.216	0.092	0.138
Car	10000	44.090	9.858	0.087	0.008	0.008	0.002	0.001	0.011
Taxi	10000	44.090	9.184	0.039	0.022	0.0004	0.454	0.003	0.005
Motorcycle	2500	11.022	0.293	0.024	0.002	0.002	0.0003	0.0005	0.015
Auto	10000	44.090	2.751	0.060	0.008	0.008	0.001	0.111	0.001
Omni buses	13000	57.317	29.529	0.206	0.687	0.005	0.080	0.034	0.051
Auto(g)	10000	44.090	5.802	0.018	0.022	0.003	0.061	0.006	0.004
Others	18944.44	83.526	28.724	0.325	0.325	0.008	0.158	0.016	0.041

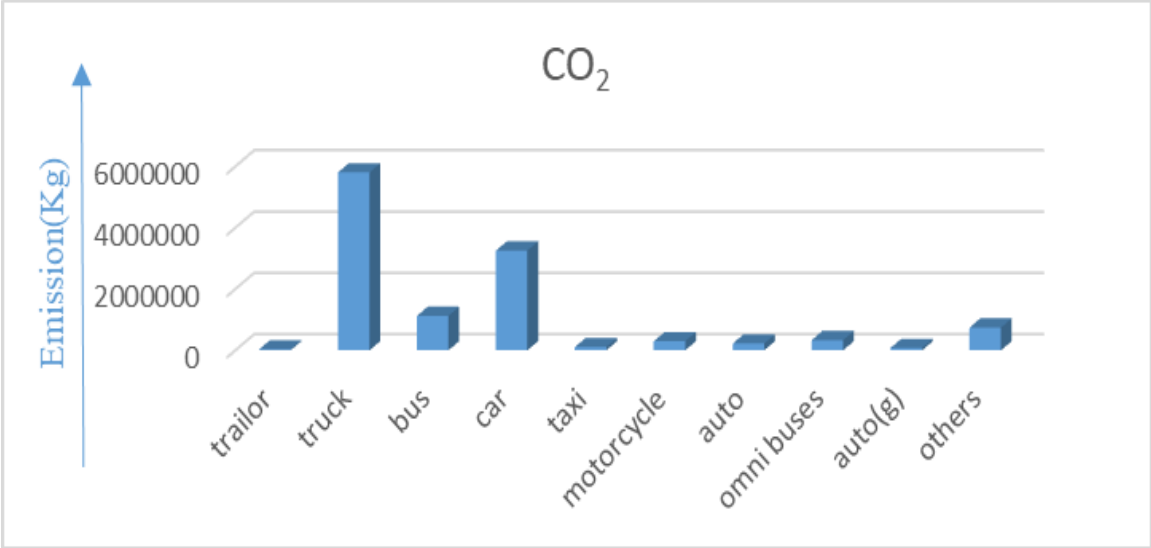

Fig. 4: Amount of co_2 released by different vehicles

From the Fig 4, the amount of CO_2 released into the air is highest from Trucks and is due to the long distance they travel and low Mileage

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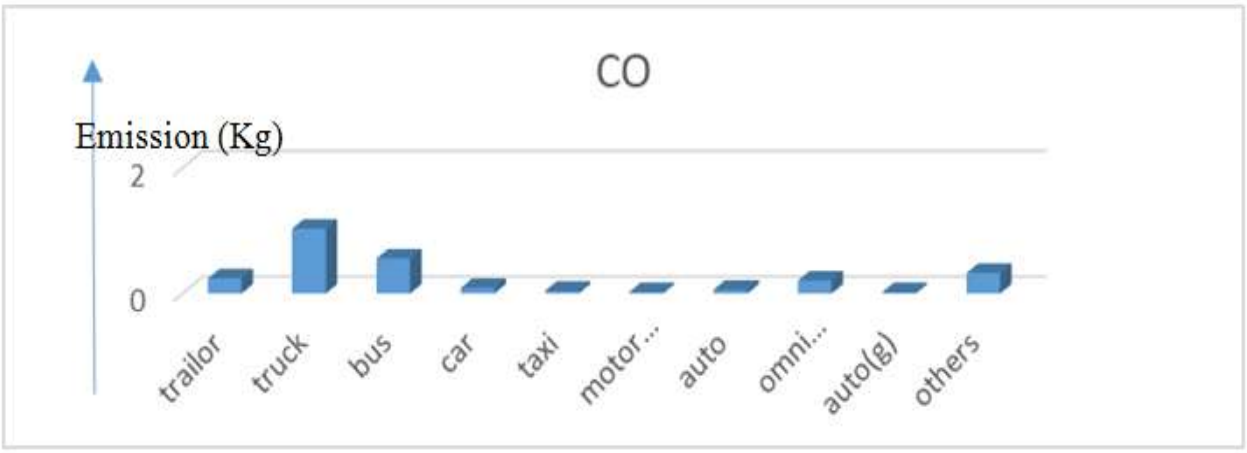

Fig 5: Amount of co released by different vehicles

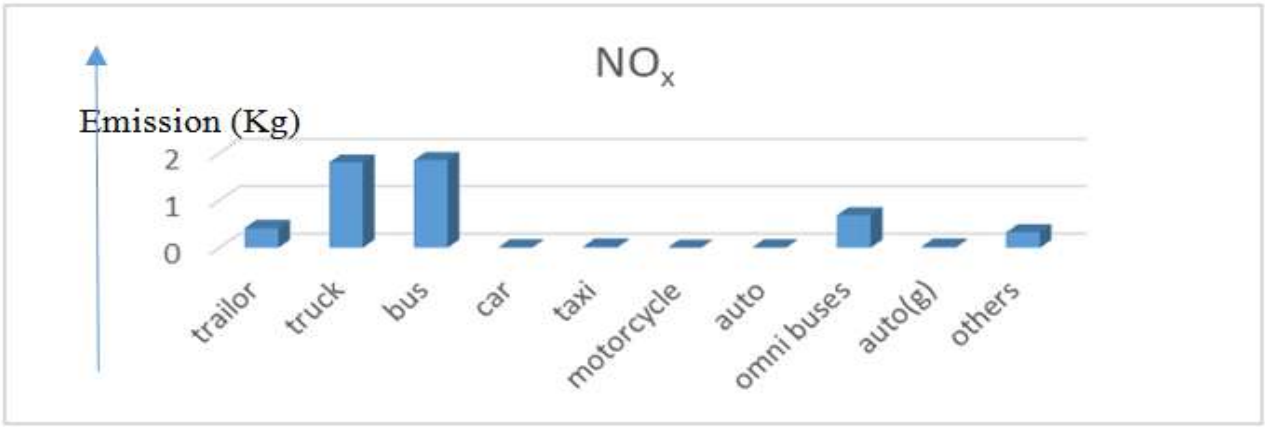

Fig. 6: Amount of NO_x released by different vehicles

From Fig 6, the amount of NO_x released into the air is highest from Buses this is due to the use of diesel engines in heavy duty conditions.

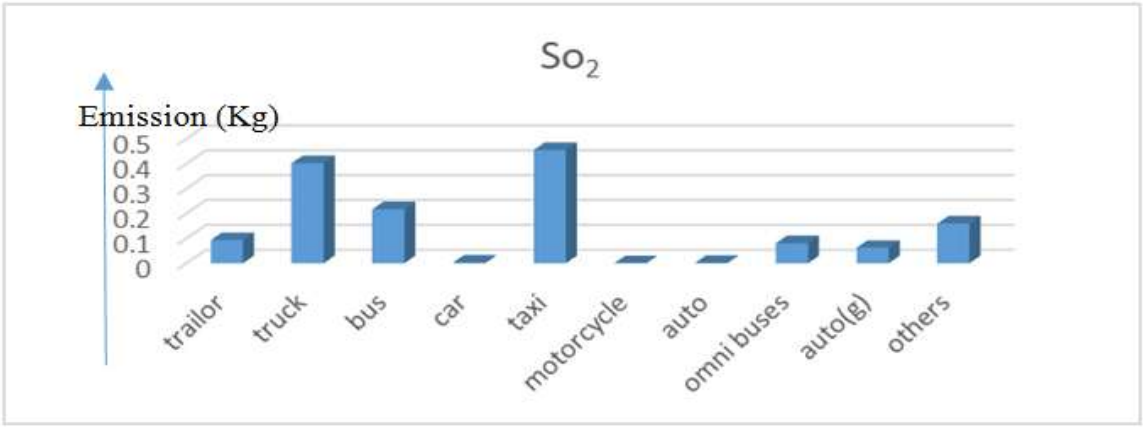

Fig. 7: Amount of SO_2 released by different vehicles

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From Fig 7., the amount of SO_2 released into the atmosphere is the highest from taxis this is due to the high SO_2 emission factor in taxis. This may be due the use of diesel engines. The different type of vehicles and the impact they have on emission of different type of pollutants varies. After analysis of the vehicle vice emission of different pollutants different districts were considered and calculations on vehicle vice emission of that region was done.

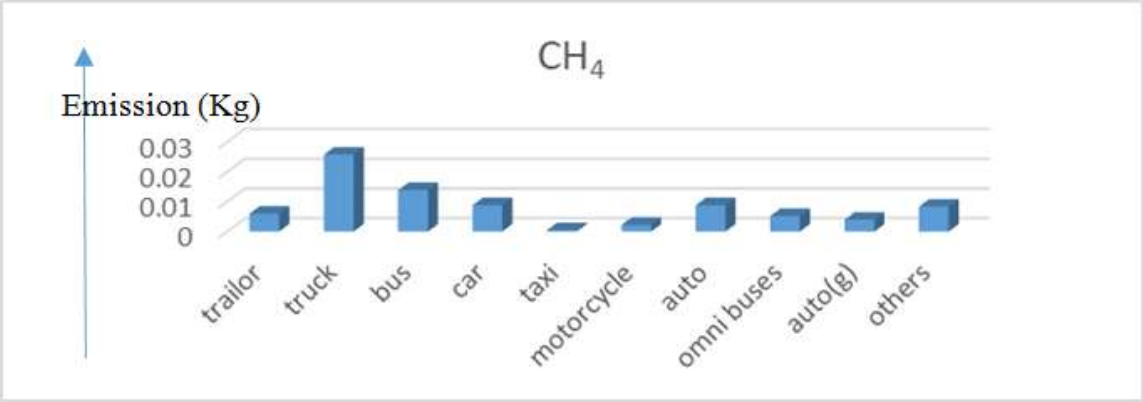

Fig. 8: Amount of CH_4 released by different vehicles

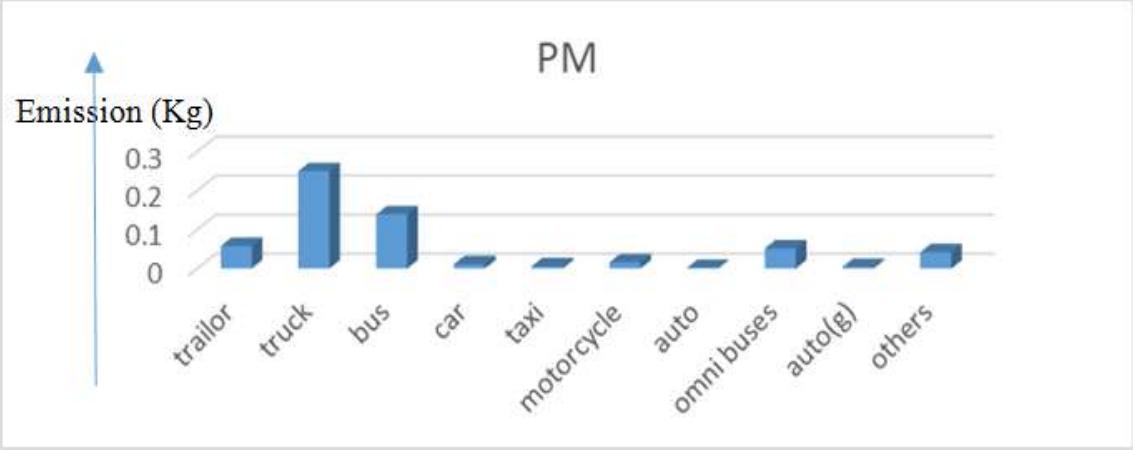

Fig. 9: Amount of PM released by different vehicles

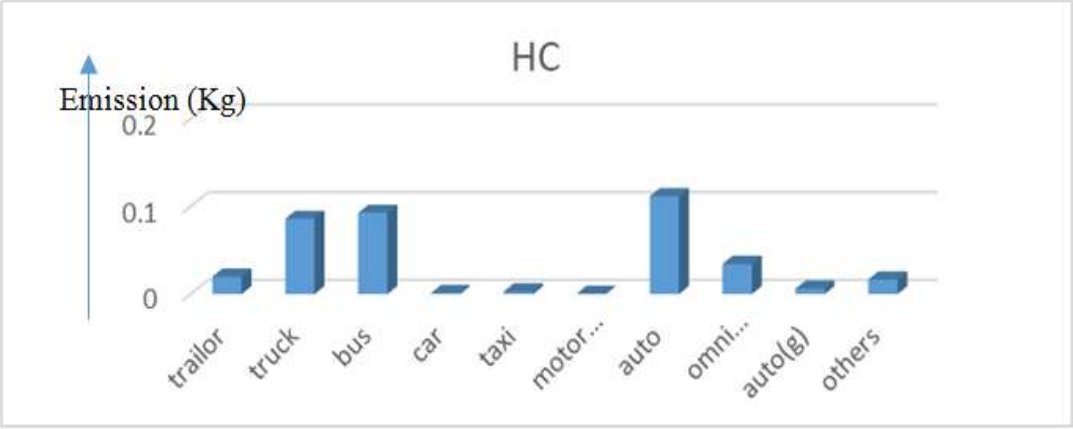

Fig. 10: Amount of HC released by different vehicles

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B. Analysis of vehicular emission by total number of vehicles in major cities

Table 3: Amount of Pollutants Released by Vehicles IN Thiruvananthapuram District

Vehicle	Distance in 1 year(miles)	Average distance(miles)	Total number of vehicles	CO_2(kg)	CO(kg)	NO_X(kg)	CH_4(kg)	SO_2(kg)	HC(kg)	PM(kg)
Trailer	15000	66.1356164	908	30939.11618	216.189	378.33158	5.405	84.074	18.016	52.246
Truck	65000	286.587671	39301	5802935.632	40548.463	70959.811	1013.712	15768.847	3379.039	9799.212
Bus	35000	154.316438	14136	1123894.062	7853.297	26177.657	196.332	3054.060	1308.883	1963.324
Car	10000	44.090411	329784	3251294.593	28790.534	2908.1347	2908.135	727.034	436.220	3635.168
Taxi	10000	44.090411	11149	102395.3245	442.419	245.7881	4.916	5063.235	34.410	63.905
Motorcycle	2500	11.0226027	998005	292623.5695	24201.949	2090.1684	2200.177	143.012	550.044	15621.258
Auto	10000	44.090411	79687	219278.7774	4813.522	702.70398	702.704	105.406	8889.205	158.108
Omni buses	13000	57.3175342	11238	331866.3171	2318.942	7729.8055	57.974	901.811	386.490	579.735
Auto(g)	10000	44.090411	13454	78066.05872	243.215	302.53564	53.389	830.490	83.049	53.982
Others	18944	83.5268341	25752	739741.2772	8389.040	8389.0404	215.104	4086.968	430.207	1075.518

Table 4: Amount of Pollutants Released by Vehicles in Ernakulam District

Vehicle	Distance in 1 year (miles)	Average distance(mile)	Total number of vehicles	CO_2(kg)	CO(kg)	NO_X(kg)	CH_4(kg)	SO_2(kg)	HC(kg)	PM(kg)
Trailer	15000	66.1356	2292	78097.417	545.712	954.996	13.643	212.221	45.476	131.880
Truck	65000	286.588	74513	11002115.539	76878.137	134536.739	1921.953	29897.053	6406.511	18578.883
Bus	35000	154.316	3973	315876.564	2207.212	7357.373	55.180	858.360	367.869	551.803
Car	10000	44.0904	4E+05	3943544.373	34920.473	3527.321	3527.321	881.830	529.098	4409.151
Taxi	10000	44.0904	22328	205066.177	886.028	492.238	9.845	10140.094	68.913	127.982
Motorcycle	2500	11.0226	1E+06	293208.521	24250.329	2094.347	2204.575	143.297	551.144	15652.485
Auto	10000	44.0904	61079	168074.196	3689.499	538.613	538.613	80.792	6813.455	121.188
Omni buses	13000	57.3175	11387	336266.395	2349.688	7832.292	58.742	913.767	391.615	587.422
Auto(g)	10000	44.0904	17880	103747.668	323.226	402.062	70.952	1103.699	110.370	71.740
Others	18944	83.5268	40787	1171630.455	13286.882	13286.882	340.689	6473.096	681.379	1703.446

Table 5: Amount of Pollutants Released by Vehicles in Thrissur District

Vehicle	Distance in 1 year (miles)	Average distance(miles)	Total number of vehicles	CO_2(kg)	CO(kg)	NO_X(kg)	CH_4(kg)	SO_2(kg)	HC(kg)	PM(kg)
Trailer	15000	66.1356	2347	79971.482	558.807	977.912	13.970	217.314	46.567	135.045
Truck	65000	286.588	41155	6076685.5	42461.312	74307.295	1061.533	16512.732	3538.443	10261.484
Bus	35000	154.316	4256	338376.71	2364.434	7881.445	59.111	919.502	394.072	591.108
Car	10000	44.0904	238621	2352531.3	20831.896	2104.232	2104.232	526.058	315.635	2630.290
Taxi	10000	44.0904	13390	122977.25	531.347	295.193	5.904	6080.968	41.327	76.750
Motorcycle	2500	11.0226	840537	246452.61	20383.299	1760.376	1853.027	120.447	463.257	13156.493
Auto	10000	44.0904	63050	173497.9	3808.558	555.994	555.994	83.399	7033.323	125.099
Omni buses	13000	57.3175	8266	244100.99	1705.675	5685.582	42.642	663.318	284.279	426.419
Auto(g)	10000	44.0904	15840	91910.686	286.348	356.189	62.857	977.773	97.777	63.555
others	18944	83.5268	21215	609413.3	6911.055	6911.055	177.207	3366.924	354.413	886.033

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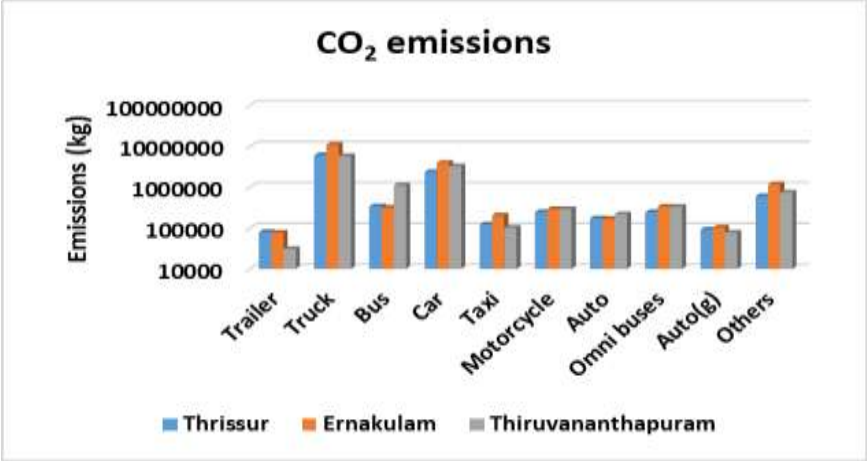

Fig. 11: Amount of CO_2 released by different vehicles

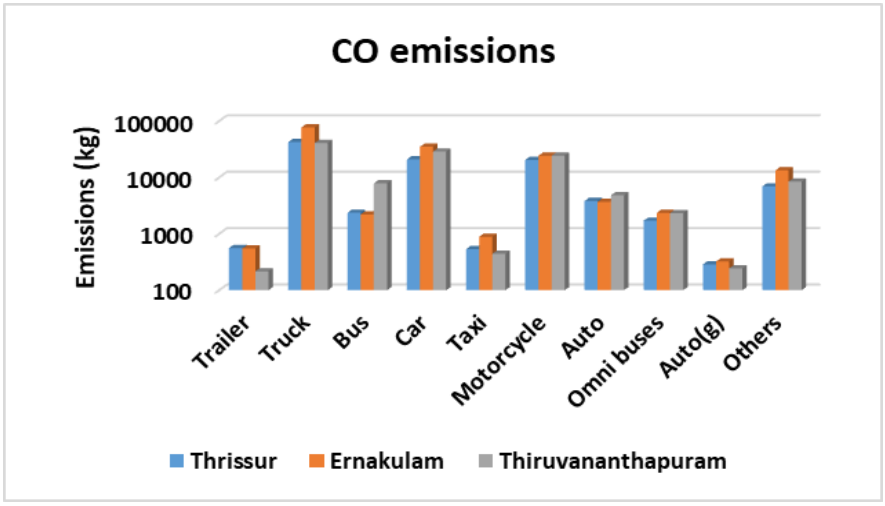

Fig. 12: Amount of CO released by different vehicles

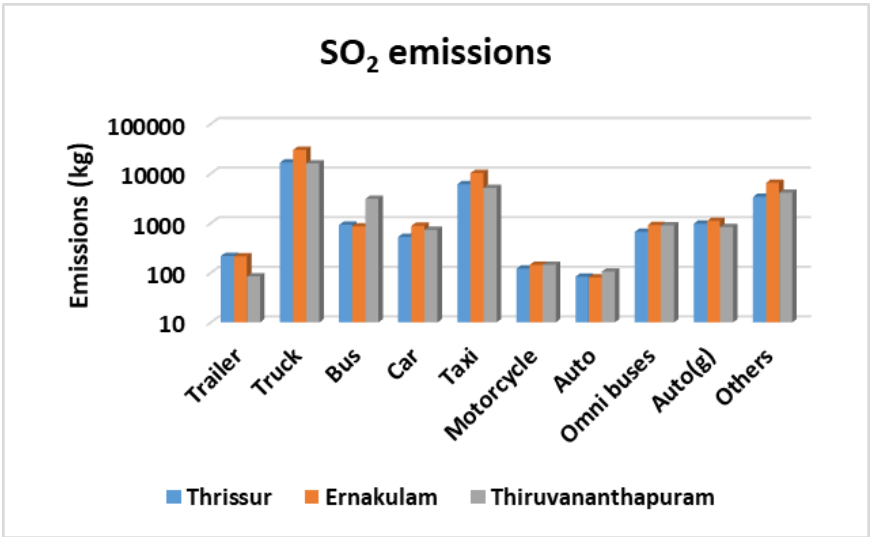

Fig. 13: Amount of SO2 released by different vehicles

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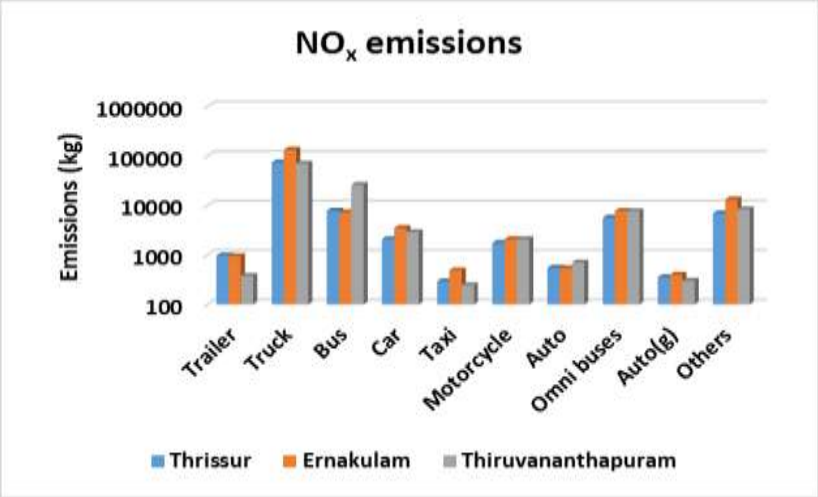

Fig. 14: Amount of NO_x released by different vehicles

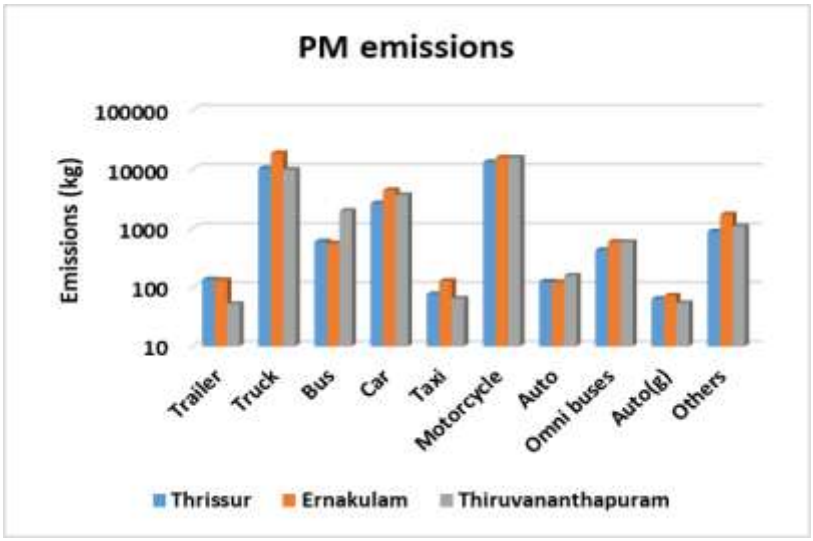

Fig. 15: Amount of PM released by different vehicles

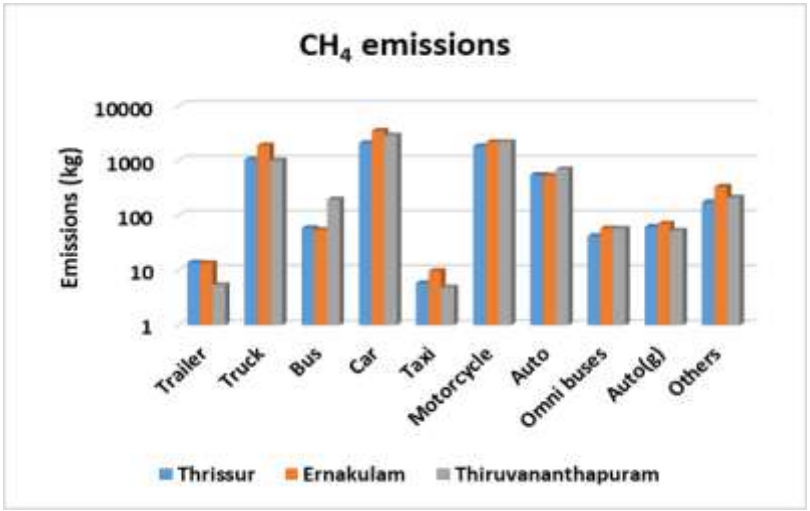

Fig. 16: Amount of CH_4 released by different vehicles

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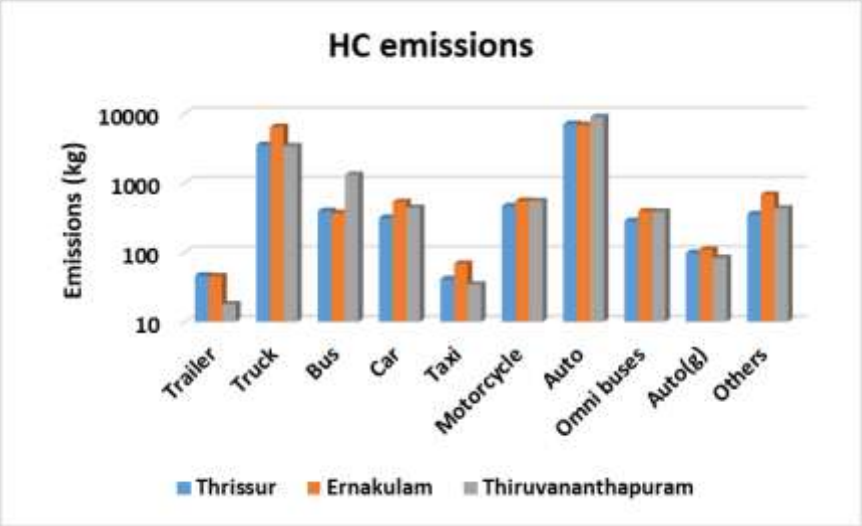

Fig. 17: Amount of HC released by different vehicles

From the graph, it is clear that the amount of CO_2 produced is highest in Ernakulam as there are a greater number of registered trucks in Ernakulam. This trend is also evident in the emission of CO and NO_x as well. In the case of NO_x, the increase is due to the difference in the number of trucks registered in Ernakulam. The most amount of hydrocarbon released is from autos in Thiruvananthapuram. The highest amount of particulate matter released is in Ernakulam and is from trucks followed by motorcycles. The most amount of SO_2 released is also from trucks in Ernakulam. The significant amount of SO_2 emission is also from Ernakulam and is from trucks. The deviation in the values of emission of different pollutants has changed in different districts due to increase in number of vehicles in that area. The number of trucks in Ernakulam is 74513 whereas the number of Auto rickshaws is the highest in Thiruvananthapuram.

As per the data charted, we can understand that the types of pollutants released into the atmosphere varies in different districts due to increase in a certain type of vehicle in that area.

IV. CONCLUSIONS

The study uses data about the number of registered vehicles in different districts and uses it to calculate the amount of pollutants released into the atmosphere. The amount of pollutants released per vehicle is calculated and then the total amount of pollutants, which is produced in a certain district, is calculated.

From the study conducted, we can conclude that the most amount of pollutants released is from Ernakulam (SO_2, CO_2, CO, NO_x, CH_4 and PM), this is due to the enormous amount of traffic and the number of vehicles in Ernakulam. The study also shows that the most emission of HC is at Thiruvananthapuram as the number of auto rickshaws in Thiruvananthapuram is more.

V. MITIGATION MEASURES

As per the data and calculation, we found out that as the number of vehicles increases the amount of pollutants released into the atmosphere also increases, It is also shows that certain types of vehicles specifically have higher

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amount of emission of certain pollutants, so to reduce the amount of certain pollutants in a certain area if we reduce the type of vehicle producing that type of pollutant in a vast amount we can decrease the amount of that type of pollutant. Promotion of eco-friendly measures like carpooling, electric cars and improving the efficiency of the internal combustion engines can help to reduce the emission of the pollutants in cities.

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