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MEASUREMENT OF POLLUTANTS INSIDE VEHICLES OPERATING ON GASOLINE, DIESEL AND NATURAL GAS IN DELHI -AN OVERVIEW

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ABSTRACT

The primary requirement of life is air, water and food. Over the time by anthropogenic activities we have polluted air and water, endangering human health and human life. One of the major anthropogenic activities is travelling, carried out in vehicles such as car, busses, auto rickshaws, and motor bikes. Vehicle burn fuel to propel themselves, generating exhaust emissions. As metro cities have high population density and high per capita income, they have more no of vehicles for transportation. It is also very well know fact that around the world people in metro cities spend more time in vehicle due to considerable time in traffic jam and longer distance of travel. This time may be in public vehicle as well as in private cars. In this research project various analyses carried out regarding for finding the minimum and maximum polluted area in Delhi. Delhi is proper place for this study because number of vehicles registered per year is more than other metro cities. In this study, maximum and minimum polluted time found out in a day at most and least polluted area and then experiments will be carried out for measurement of the pollutants inside the vehicle and effect of outside pollution will be studied inside the vehicle.

KEYWORDS: Pollutants, Exhaust Emission.

INTRODUCTION

Air Pollution is the major problem in metro cities of India. Air Pollution is further divided into two parts one is out door air pollution and another is indoor air pollution. In India lots of study have done on Indoor air pollution but there is a another threat in metro cities which is pollution inside a vehicles. India is a highly populated country and in metro cities per capita income is growing on so every person changing his mode of travel However, in developing countries, the problem of air pollution inside a vehicle far outweighs the ambient air pollution. There are four principal sources of pollutants inside a vehicle:

(I) combustion, (II) Automatic Air Conditioning (III) Air Circulation (IV) Smoking in car.
In a developing country people spend more time in vehicle. This time may be in public vehicle as well as in private cars. The great concern of drivers and passengers stuck in traffic is most likely that they won't to get their destinations on time. Few people however concern about the health effect of the air quality inside their vehicle. If their thought turn to subject at all they are most likely to consider air pollution inside a vehicle. The various reports the air inside a vehicle contains more Carbon mono Oxide, Benzene, Toluene, Nitrogen Oxides and Particulate matters. Pollutants from vehicle exhaust include carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM) such as PM 2.5 and ultrafine particles (UFP), and volatile organic compounds (VOCs). VOCs and semi-volatile organic compounds (SVOCs), such as phthalates poly brominated diphenyl ethers (PBDEs), are sometimes emitted from interior vehicle materials. Sometimes air quality inside a vehicle may be worse than ambient air quality.

The air pollutants accumulate inside a vehicle is due to the gasoline and diesel exhaust. The pollutants inside a vehicle also depend upon the ambient air quality. Commuters inside slow-moving cars are exposed to far higher levels of air pollution in peak traffic times than those using any other form of transport, new research has revealed. Car drivers and passengers face pollution levels inside their vehicles that are two to three times higher than those experienced by pedestrians and cyclists in the open air, the study has found. Comparing all forms of transport, train travelers breathe the cleanest air and pollution levels inside buses are second lowest, despite public transport vehicles such as buses accounting for the bulk of vehicle emission pollution in Australia's major cities. The news

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comes as the NSW Government on 2/09/2008 announced plans for a cycling "blueprint" to promote cycling and improving cycling facilities as part of a balanced transport system.

It is not surprising that air quality in vehicle cabins is usually found to be worse than that typically found in homes or workplaces, especially when so many exhaust pipes are only inches away from adjacent vehicles. Pollutants find their way into the cabin via the ventilation system, also known as the Heating, Ventilation and Air Conditioning (HVAC) system. Independent studies have shown that vehicle cabins commonly show concentrations of toxic gases such as carbon monoxide (CO), hydrocarbons (HC), volatile organic compounds (VOC), and oxides of nitrogen (NO_X) higher than safety limits set by Occupational Safety and Health administration (OSHA) and World Health Organization (WHO).

Typical vehicle emission pollutants include carbon monoxide, nitrogen dioxide, volatile organic compounds such as benzene and toluene, and tiny smog particles less than 2.5 microns in diameter. Exposure to these pollutants has been linked to diseases and adverse outcomes such as cancer, asthma, emphysema, leukemia, reduced fertility and low birth-weight. Air pollution from vehicles can harm human health whether it is vehicle exhaust that enters a vehicle from outside or pollutants off-gassing inside the vehicle. Health effects from vehicle pollution can include respiratory and cardiovascular diseases, as well as increased risk of cancer.

POLLUTION INSIDE A VEHICLE WITH ITS HEALTH EFFECTS

Particulate Matter

Particulate matter (PM) pollution consists of solids and liquid droplets of up to 10 micrometers in diameter suspended in the air. Large, dark PM may include smoke and soot from incomplete combustion, though PM may also include dust. These “coarse” particles along with smaller ones are known as PM10. So-called “fine” PM measures less than 2.5 micrometers in diameter and can include particles so small that they may only be seen using an electron microscope. These are known as PM2.5. Even the largest PM particles are very small—the width of a human hair averages about 70 micrometers. Diesel vehicles are a major source of both coarse and fine PM pollution.

Particulate matter is arguably the most dangerous component of automobile exhaust. Particles are small enough to infiltrate nasal, sinus, and bronchial passages where they can accumulate and calcify. Fine PM can penetrate the deepest portions of the lungs and the very smallest particles can be absorbed into the bloodstream. In the nose, throat, and lungs, particulates act as extreme irritants. Exposure to even low levels of PM can cause nasal congestion, sinusitis, throat irritation, coughing, wheezing, shortness of breath, and chest discomfort. Medical studies have associated expo-sure to elevated PM10 levels with the aggravation of existing respiratory conditions, including asthma, and more serious medical problems. Several studies have linked exposure to elevated PM2.5 levels to increased hospital admissions.

PM10 and PM2.5 include inhalable particles that are small enough to penetrate the thoracic region of the respiratory system. The health effects of inhalable PM are well documented.

They are due to exposure over both the short term (hours, days) and long term (months, Years) and include:
• Respiratory and cardiovascular morbidity, such as aggravation of asthma, respiratory symptoms and an increase in hospital admissions
• Mortality from cardiovascular and respiratory diseases and from lung cancer.
There is good evidence of the effects of short-term exposure to PM10 on respiratory health, But for mortality, and especially as a consequence of long-term exposure, PM2.5 is a stronger risk factor than the coarse part of PM10 (particles in the 2.5–10 μm range). Long-term exposure to PM2.5 is associated with an increase in the long-term risk of cardiopulmonary.

Volatile Organic Compounds (VOCs)

VOC presence inside a new vehicle is mostly connected with interior emissions from materials used to equip the passenger compartment. The concentration of observed VOCs depends mostly on interior temperature, humidity, ventilation, age, and the general condition of the vehicle Moreover, interior trim (leather or fabric) significantly affects VOC levels inside a vehicle.

VOC levels of new cars are significantly higher than recommended levels for today's indoor environment. Sources of these VOCs are the materials inside. A look inside the passenger compartment shows significant presence of

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plastics, woods, leathers, and textiles, and many of these have been installed with glues and sealants. The materials off-gas and this effect can be exacerbated by heat.

A report identified the concentration of TVOCs inside a new vehicle was about 5,000 µg/m3, the main group of pollutants being alkanes, with decane at the highest concentration level (345 µg/m3), along with aromatic compounds, with m,p-xylene at the highest concentration (approximately 350 µg/m3). The total number of compounds identified in that study was 82.

Volatile organic compounds (VOCs), also known as aromatic hydrocarbons, comprise a class of pollutants released during the combustion or evaporation of solvents, paints, glues, and fossil fuels. The exhaust of gasoline and diesel automobiles contains significant concentrations of about two dozen VOCs, the most important of which are benzene, 1, 3-butadiene, m&p xylenes (typically measured together),xylene,ethylbenzene, toluene, and formaldehyde. These chemicals have the potential to do serious harm to the environment and human health. VOCs serve as ingredients in the chemical reactions that form ground-level ozone, better known as smog. The EPA has designated many VOCs, including those typically found in auto pollution, as air toxics or hazardous air pollutants (HAPs), which are known or suspected to cause serious health hazards. Both benzene and 1.3-butadiene are known carcinogens, and other VOCs, including formaldehyde, are suspected carcinogens

It is difficult to directly link exposure to in-car VOCs to any individual cancer case. However, the carcinogenic effects of VOCs are associated with individuals' cumulative exposures. With people spending increasing amounts of time driving or riding in automobiles, elevated in-car levels of carcinogenic .VOCs contribute a growing portion of many individuals' cumulative exposure human carcinogen by all routes of exposure," and multiple studies have linked inhaled benzene to the development of leukemia. Additional studies suggest that benzene exposure may induce changes in chromosomes, blood cells, and bone marrow cells, though these results are not regarded as conclusive. Most of the studies on benzene carcinogenicity have looked at the occupational exposure of adults. The leukemia risk of children exposed to benzene is likely much higher than that of adults, even at lower levels of exposure. Because of its status as a known carcinogen,the World Health Organization has set the acceptable human expo-sure level for benzene at zero.

Low-level exposure to the majority of VOC air pollutants, including benzene, 1,3-butadiene, ethyl benzene, formaldehyde, and xylenes, can irritate the eyes, nose, throat, and lungs. Short-term exposure to benzene may result in drowsiness, dizziness, or headaches. Toluene acts on the central nervous system and can cause short-term fatigue, sleepiness, headaches, and nausea.

Carbon Mono Oxide (CO)
Carbon monoxide (CO), a very simple molecule consisting of a single carbon atom and a single oxygen atom, primarily enters the air we breathe as a gaseous byproduct of the incomplete combustion of hydrocarbon fuels, such as gasoline and diesel. A newer model, properly maintained car emits about 420 pounds of CO each year, while a newer model, properly maintained SUV emits about 547 pounds over the same period. Older vehicles and those with malfunctioning emissions-control systems can create much more CO.A cold engine, whether or not it is properly maintained, emits significantly more CO than a warm one. Therefore, CO emissions and concentrations in urban and roadside air are often much higher during the winter months than in the summer. Nationwide, the exhaust from cars and trucks accounts for about 60% of the CO released into the air. In major urban areas, motor vehicles are responsible for up to 95% of CO emissions. CO disperses quickly in the air, so moderate and high levels of the gas are usually detected only in areas with significant motor vehicle traffic or within enclosed spaces where it may accumulate.

CO is highly toxic and potentially deadly to humans and other animals. Each year, more than 10,000 people in the United States seek medical attention or are incapacitated for at least one day due to CO poisoning. Incidents in which people commit suicide by intentionally exposing them-selves to CO in car exhaust have received significant coverage in the media and popular culture and number about 1,500 cases each year; it is less well known that an additional 1,500 people die from unintentional automobile-related CO poisoning annually. A study by the National Highway Traffic Safety Administration found that in 1993 nearly one-third of the accidental CO poisonings that resulted in fatalities and were caused by automobile exhaust involved drivers or passengers in moving vehicles.3 Between 1977 and 1988, more than 1,100 people in the United States died due to accidental exposure to CO while they were driving or riding in moving vehicles.

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CODEN: IJESS7

Acute CO poisoning occurs when inhaled CO combines with hemoglobin in the bloodstream, thereby preventing the hemoglobin from supplying oxygen to the brain, heart, and other bodily organs and tissues. Low levels of CO, relative to levels of oxygen, in inhaled air can prove highly toxic because CO binds with hemoglobin some 200 to 230 times more readily than oxygen and, on top of that, CO can alter hemoglobin so that it is no longer able to deliver oxygen to organs and tis-sues. CO has no color, no smell, and no taste. Moderate exposure may produce flu-like symptoms–headaches, dizziness, and weakness in healthy people. Therefore, many people who suffer non-fatal CO poisoning probably remain un-aware that they have been exposed to the gas. It is likely that the majority of cases of acute poisoning go untreated and unreported, and the actual number of poisonings certainly exceeds the 10,000 cited above.

The concentrations of carbon monoxide present in vehicles travelling in dense traffic are higher than those generally found at the curbside of busy streets, but less than those immediately outside the vehicles. Variations in vehicle design cause differences in the internal CO levels, and the ratios of measured internal to external average CO concentrations ranged from 0.3-0.8. Absolute CO levels inside the cars ranged from 12-60 ppm when averaged over a 35 km route in London.

The most common symptoms of CO poisoning are headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion. High levels of CO inhalation can cause loss of consciousness and death. Unless suspected, CO poisoning can be difficult to diagnose because the symptoms mimic other illnesses. People who are sleeping or intoxicated can die from CO poisoning before ever experiencing symptoms. Red blood cells pick up CO more quickly than they pick up oxygen. If there is a lot of CO in the air, the body may replace the oxygen in blood with CO. This blocks oxygen from getting into the body, which can damage tissues and result in death.

NO_X

Nitrogen dioxide (NO_2) is the best known of the nitrogen oxides (NOX) and has been listed by the U.S. EPA as a criteria air pollutant under the Clean Air Act. NOX contributes to the formation of ground-level ozone and acid rain. Chemical reactions involving NOX in auto exhaust can lead to the creation of acidic particulate matter.
According to the available literature on vehicular IAQ studies the contaminant concentration buildup within a transit micro environment was observed to be predominantly influenced by the indoor contaminant sources (such as the passenger density, emissions from various indoor components, *etc*.), ventilation settings, and outdoor air quality (affected by the test vehicle and lead vehicular exhaust emissions, and the ambient contaminant background concentrations in relation to different meteorological conditions). There are no in-vehicle sources for NO, and NO2 concentrations; the contaminant buildup within the vehicle compartment is primarily dependent on the ventilation settings and outdoor air quality.

Direct exposure to NO_X can irritate the eyes, nose, throat, and lungs, and can exacerbate respiratory diseases, including asthma and influenza. NO_X exposure can also reduce the capacity of the lungs to resist infectious viruses and bacteria, which could lead to increased incidence of colds, influenza, and pneumonia. Studies have come down with colds and miss days of school

Source of Pollutants inside a vehicle

There are many sources of air pollution inside vehicles. Considering the relatively small size of most interiors, air pollution inside vehicle can become very concentrated. Some of the following pollutants can trigger allergies, sinus trouble, etc.

Exhaust from Other Vehicles

On road, we have noticed an irritating exhaust buildup in the air. Exhaust contains benzene, carbon monoxide and other toxic chemicals. These pollutants are drawn into vehicles, and air inside is about 2 to 10 times more polluted on a congested freeway or major street.

General Air Pollution

Pollution from factories, power plants, fires, etc. drawn into car through ventilation ducts.

Auto Interior Materials

The synthetic materials (plastics etc.) that make up vehicle's interior release toxic chemical gases into the air, and that "new car smell" is actually an initial stronger release of these chemicals. Like carpets, furniture, building materials, etc. in homes and offices, vehicle's plastic dashboard, seats, and carpeting release formaldehyde and

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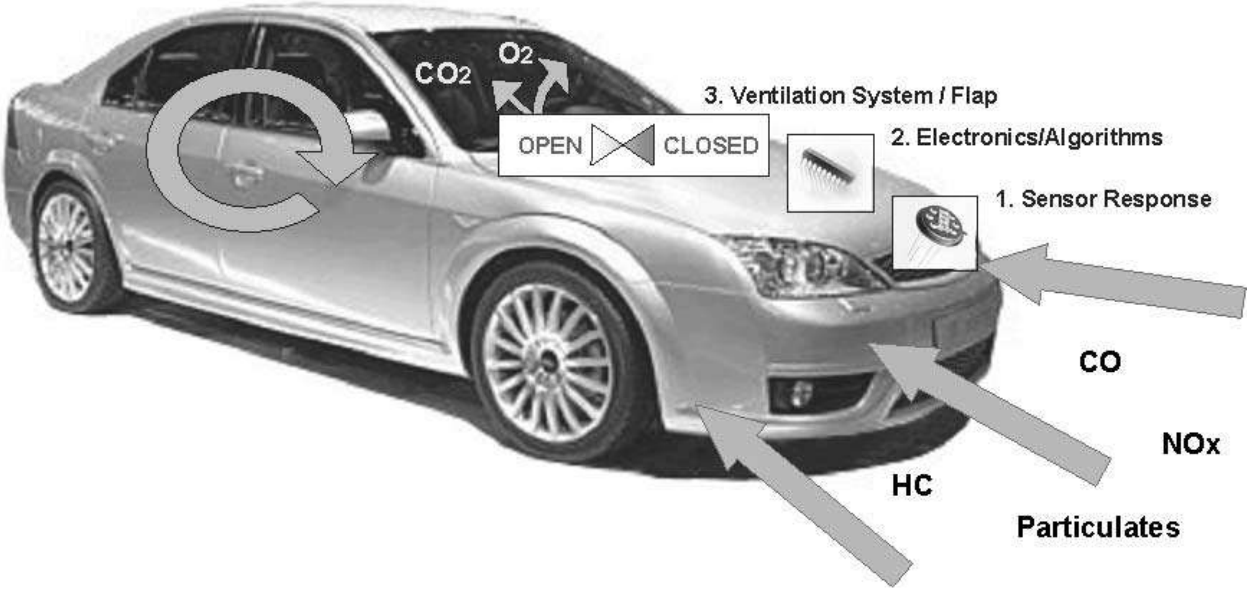
other toxic chemical gases. This is called "out-gassing" and it affects all vehicles. It may be may noticed that a thin film or residue coating the inside of the windshield every week or so, especially during hot summer months, which is the result of chemical out-gassing from the dashboard. Parking your car in the heat, especially in direct sunlight, "bakes" the interior, which increases the problem since heat causes or aggravates chemical gassing? Since most vehicle exteriors consist of painted metal they also absorb and transfer a great amount of heat to the interior. The darker the exterior paint and interior colors, the more heat absorbed from the sun and the higher the interior temperature. In addition, car's windows and windshield act as giant magnifying glasses, further intensifying heat and UV rays onto the dashboard and interior. This is commonly known as the greenhouse effect. As an example, a 79 degrees Fahrenheit outdoor temperature can quickly result in the following temperatures inside your vehicle:

Interior Color	**Potential Temperature**
WHITE	135 degrees Fahrenheit
RED	154 degrees Fahrenheit
BLUE/GREEN	165 degrees Fahrenheit
BLACK	192 degrees Fahrenheit



Food
Spills from trips to fast-food places can leave lingering odors.

Mold
Mold can grow inside your vehicle's AC system and ducts due to condensation and moisture accumulation. Mold can form on carpets, seats, and other materials as a result of a water leak or spill. Mold also causes musty odors, and some species of mold are toxic.

People
Perspiration from trips to the park, gym, beach, soccer practice, etc. can easily be absorbed into seats, causing odors to build-up over time. Cold germs can also linger in vehicles.

Smoking
Cigarette smoke contains thousands of chemicals which penetrate and remain embedded in upholstery, AC systems and ducts for years. Smoke is also a major odor source.

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Impact Factor: 4.116
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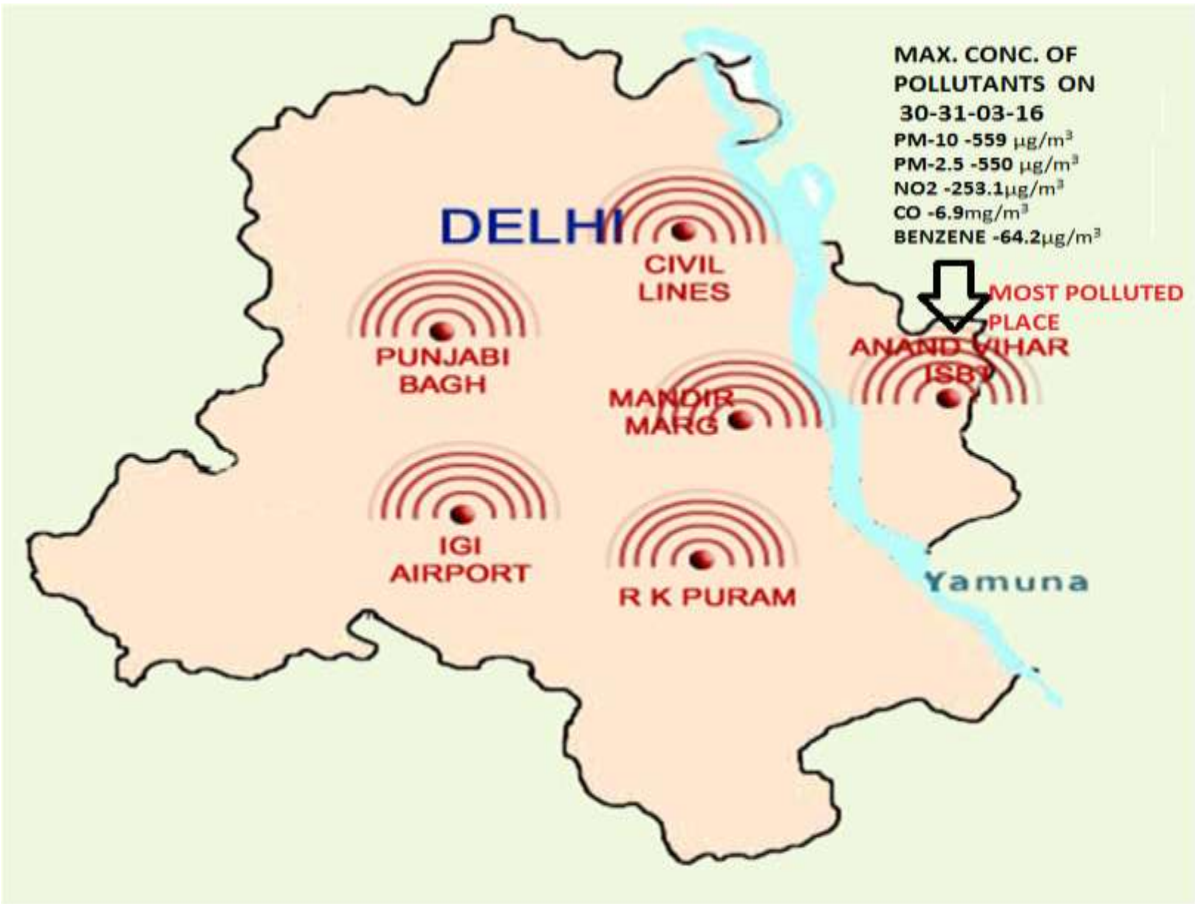
MATERIALS AND METHODS

The vehicles registered in Delhi as compare with other metro cities is very high. The numbers of vehicles registered in Delhi up to March, 2015 are 88.27 lakh where as in Benguluru, Chennai and Mumbai are 55.59 lakh, 44 lakh and 25 lakh respectively. As the vehicle density in Delhi is very high the emissions from these vehicles when integrated gives a poor quality of ambient air.

The pollutants concentration at four major places of Delhi took and it was found that Maximum pollution occurs at **Anand Vihar** and minimum at **Punjabi Bagh.**



The emissions from the vehicles pollute the atmosphere which surrounds us and vehicles are engulfed by polluted air in the atmosphere. Polluted air enters vehicle's cabin and potentially affect the occupants. A lot of studies have shown that air pollution may be even more severe inside a vehicle than outside. The pollution inside a vehicle are confined in a definite and small area so it is more severe than outside pollution. Studies carried out on air quality inside a car have reveal that in-car air pollution levels frequently reach concentrations that may threaten human health. Reports from agencies like (ICTA), reported that the air inside a car typically contains more carbon monoxide, VOCs, particulate matter, and nitrogen oxides than ambient air .In-vehicle pollution is often even worse than pollution in the air at the side of the road.

Hence the objective of this study will be

- To measure concentration of PM, CO, VOC's (HC & Benzene) and NO_X with respect to:

i. Time (At which Pollution is maximum & Minimum)
ii. Different Whether Conditions (Summer, Rainy and Winter)

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In a car with following HVAC Conditions:

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Vehicle	Vent Condition	AC	Fan	Front Window	Rear Window	Air Circulation Type
Car	CLOED	OFF	OFF	CLOSED	CLOSED	AIR RECIRCULATION
	OPEN	OFF	OFF	CLOSED	CLOSED	AIR RECIRCULATION
	OPEN	ON	ON	CLOSED	CLOSED	AIR RECIRCULATION
	OPEN	OFF	OFF	OPEN	CLOSED	AIR RECIRCULATION

Vehicle	Vent Condition	AC	Fan	Front Window	Rear Window	Air Circulation Type
Car	CLOED	OFF	OFF	CLOSED	CLOSED	Fresh Air entrance Mode
	OPEN	OFF	OFF	CLOSED	CLOSED	Fresh Air entrance Mode
	OPEN	ON	ON	CLOSED	CLOSED	Fresh Air entrance Mode
	OPEN	OFF	OFF	OPEN	CLOSED	Fresh Air entrance Mode
	OPEN	OFF	OFF	CLOSED	OPEN	Fresh Air entrance Mode
	CLOSED	OFF	OFF	OPEN	CLOSED	Fresh Air entrance Mode
	CLOSED	OFF	OFF	CLOSED	OPEN	Fresh Air

The vehicles and equipments will be used in this study are :

- Car (Gasoline, diesel and natural gas Operated)
- SUV (Diesel Operated)
- Buses (AC & Non AC)
- Instruments

-Air quality Meters to measure the pollutants and their concentration inside a vehicle cabin with following specifications:

POLLUTANT- CO	
Specification of Instrument	
Range	0-100mg/m^3
Resolution	1mg/m^3
Accuracy	± 2% reading

POLLUTANT- NO2	
Specification of Instrument	
Range	0-500µg/m^3
Resolution	1µg/m^3
Accuracy	± 0.5 PPM of Reading
POLLUTANT- BENZENE	
Specification of Instrument	
Range	0-200µg/m^3
Resolution	1µg/m^3
Accuracy	± 0.5 of Reading

POLLUTANT- PM 2.5	
Specification of Instrument	
Range	0-1000µg/m^3
Resolution	1mg/m^3
Accuracy	± 2% reading

POLLUTANT- PM 10	
Specification of Instrument	
Range	0-1000µg/m^3
Resolution	1mg/m^3
Accuracy	± 0.5µg/m^3 of Reading

RESULTS AND DISCUSSION

By the use of above instruments and materials, pollutants inside a car, buses can be measured and the effect of the outside pollutants inside a vehicle can be studied at most polluted area of the Delhi. From this study we can also found the effect of different HVAC conditions on in vehicle air quality.

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