4 Compliance of Vehicular Emission Norms in Kanpur City, India

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Abstract

Due to the rising urbanisation, there are significantly more motor vehicles on the road, which has caused a huge increase in vehicle emissions. This study intends to determine the percentage of monitored automobiles in Kanpur, India, that abide by Bharat Stage-IV and VI (BS-IV and VI) emission criteria. For a four-month period in 2018, the transport department's pollution under control (PUC) certificate at a gasoline station was utilized for collecting secondary data on the tail pipe emissions of four and two-wheeled vehicles. Data from 204 automobiles was taken into account. The results revealed that, even though BS-IV norms had been in force since 2010, the PUC certificate given by the transportation department had taken the BS-III emission limitations into account, failing just 2 petrol fuelled four-wheeler vehicles. Almost all motor cars complied with BS-III emission standards, while just around 9% of four-wheelers failed the BS - IV test limits. Furthermore, it was discovered that 18.51 percent of two-wheelers failed to fulfil the BS-VI emission standards for the selected pollutants (combined CO and HC). To assess the harm to human health posed by these tail pipe emissions, more investigation is needed.

Keywords

Air Pollution; Bharat Stage – IV and VI; Emission Norms

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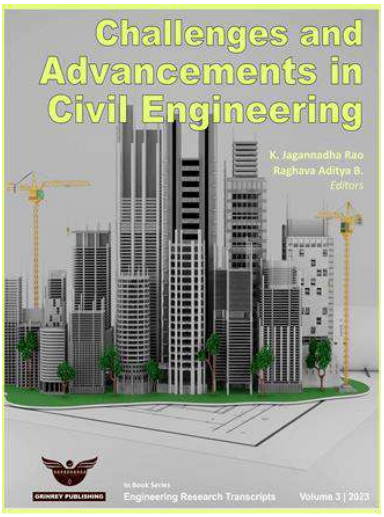

1. Introduction

The number of automobiles using the roads has increased significantly due to the growth in the urban population and the improvement in living standards. With average particulate matter concentrations 10 times higher than WHO limits, India is currently the fifth most polluted nation in the world [1]. In addition to negatively affecting human health, air pollution also negatively affects the nation's economy. A loss of $95 billion, or roughly 3% of the nation's GDP, happened in 2019 as a result of air pollution, and around 1.6 million fatalities per year are attributed to exposure to air pollutants [2] and [3]. Motorised vehicles are always needed for both private and public transportation as cities grow in size and population. Every year, some 25 million new cars are added to the country's roadways [4] [5]. This together with current vehicles make up a sizable source of air pollution. Around 22% of the world's greenhouse gas emissions are attributable to the transport sector alone, with road transport alone responsible for 70% of those emissions [6].

Automobiles are one of the main sources of air pollution because of the toxic exhaust fumes they produce. Spark ignition (SI) engines contribute to more oxides of carbon (CO and CO_2), hydrocarbons (HC), particulates (PM), and oxides of nitrogen (NO_x) than compression ignition (CI) engines. Diesel engines release relatively high levels of nitrogen dioxide (NO_2), but direct injection petrol engines emit very little of it [7].

The government has implemented a number of measures and programmes designed to improve air quality. Air Quality management includes monitoring the quality of the air. The National Air Monitoring Programme (NAMP) was established with the objectives of assessing the current condition and trends of air quality as well as managing and regulating pollution from industries and other sources. The pollution under control (PUC) programme was further established in India so as to regulate and manage automobile emissions. This programme attempts to maintain vehicle emissions below a predetermined threshold established up in accordance with Bharat Stage (BS) guidelines.

1.1 History of Emission Norms in India

India adopted the Air (Prevention and Control of Pollution) Act in 1981 to help minimize air pollution. It established the government with the power to regulate vehicle emission standards. The Motor Vehicles Act of 1989 assigned responsibility for creating and implementing vehicle emission standards to the Ministry of Road Transport and Highways (MoRTH) [8]. Following this, idle emission limitations were the first emission rules to be implemented in the nation in 1989. Mass emission restrictions, which went into effect in 1991 for gasoline-powered cars and 1992 for diesel-powered vehicles, swiftly replaced these standards. In April 1995, it became necessary for new petrol-powered passenger automobiles in four major cities—Delhi, Mumbai, Kolkata, and Chennai—to have catalytic converters installed. Beginning in 2000, India began adhering to the Bharat Stage (BS) emission requirements, which were similar to the EURO standards. The nationwide introduction of the Bharat stage I (BS-I) standards, which were comparable to the EURO- 1 standards, took place in 2000. Bharat Stage II regulations implementation began in 2001 and lasted through 2005 in various phases, encompassing various cities in various stages. The implementation schedule for the Bharat Stage requirements was outlined in the auto fuel policy, which was established in 2003. From 2005 to 2010, the BS-III rules were similarly applied in two parts. BS-IV standards were first introduced in a small number of places in 2010, and then they were expanded in 2015 and 2016 before being enforced nationwide in 2017. The BS - VI rules, which were correlated with the EURO - 6 requirements, were enacted and put into national effect in 2020 as a result of the BS - IV standards' delayed enforcement, which caused a discrepancy between them and the EURO emission standards. The criteria for the EURO emission

standards were not used in the creation of the emission limits for two and three-wheeled vehicles and these norms were prepared separately. [7][8][10].

Table 1. The development of India's emission regulations. [9]

Standard	Year	Cities of Implementation
BS – I	2000	Countrywide
BS – II	2001	NCR#, Mumbai, Kolkata, Chennai
BS - II	2003	NCR#, 10 cities$
BS – II	2005	Countrywide
BS – III	2005	NCR#, 10 cities$
BS – III	2010	Nationwide
BS – IV	2010	NCR*, 12 cities^
BS – IV	2014	8 more cities in addition to the existing 12 cities, mainly in Northern India
BS – IV	2017	Countrywide
BS – V	-	Skipped
BS – VI	2020	Nationwide

National Capital Region (NCR i.e., Delhi) is denoted by the sign #, Kanpur, Mumbai, Agra, Bangalore, Kolkata, Hyderabad, Pune, Surat, Chennai and Ahmedabad, are denoted by the symbol $, and Solapur and Lucknow are denoted by the symbol ^.

1.2 India's Current Vehicle Emission Regulation

India now adheres to Bharat Stage-VI emission standards. The limits for emissions of category M and N vehicles (GVW 3.5 Tonnes) that are powered by petrol or diesel are listed in Tables 2 and 3 [11].

In India, a certification programme called Pollution Under Control (PUC) was established in 2005. The PUC certificate requirements were taken from the Bharat Stage standards. Vehicles in India are legally required to get this certification.

Table 2: Four-wheeler category M and N vehicle emissions standards for petrol [11]

Emission Norm	HC	CO	NO_x	PM
BS – IV	0.10	1.0	0.08	None
BS – IV	0.10	1.0	0.06	0.0045

Table 3: Four-wheeler category M and N vehicle emissions standards for diesel [11]

Emission Norm	HC	CO	NO_x	HC + NO_x	PM
BS – IV	None	0.50	0.25	0.30	0.025
BS – IV	None	0.50	0.06	0.170	0.0045

*All values are in gm/km

For gasoline-powered automobiles, idle CO and HC measurements are taken, whereas measures of free-acceleration smoke are taken for diesel-powered vehicles. The PUC program's establishment and administration are shared by both the national and state governments. The Central Ministry of Road Transport and Highways (MoRTH) and the Central Pollution and Control Board (CPCB) are in charge of specifying the testing methodologies, instruments, and emission restrictions. Table 4 illustrates the requirements for two- and four-wheeled vehicles to receive a PUC certificate as stated by the MoRTH [12].

Table 4: Vehicular Emission Standards for obtaining a PUC certificate for petrol powered vehicles [12]

Emission Criteria	Four-Wheeler		Two-Wheeler	
	CO (%)	HC (ppm)	CO (%)	HC (ppm)
BS – IV	0.3	200	3.5	4500
BS – IV	0.3	200	0.5	500

2. Methodology

2.1 Study Area

In the north central area of the country, the city of Kanpur is located on the banks of the river Ganga. It is located in the Indo Gangetic Plain (IGP), which is among the most polluted areas in the globe due to its dense population and geographic conditions. With a population of about 45.81 lakh, Kanpur ranks as India's 12th-largest city [13]. Private motor vehicles, including both two- and four-wheelers, are the primary mode of mobility in the city.

2.2 Data Collection

The Kumar et al. (2018) study provided the secondary data that was utilized in this investigation. At the IOCL gas station on Benajhabar Road in Kanpur, emission data from 130 two-wheelers and 74 four-wheelers consisting of CO concentrations in percentage by volume and HC concentrations in parts per million were measured and recorded from January to April 2018. This information was gathered for automobiles that came at the gas station to get their PUC certificates. The emissions from the vehicle's tailpipes were monitored for pollution while they were idling. The constant volume sampling (CVS) method with continuous dilution was adopted for measuring the exhaust emissions. Non – Dispersive Infrared (NDIR) absorption analyzers were used to measure the CO emissions while Flame Ionization (FID) analyzers were adopted for HC measurement. Only gasoline-powered automobiles were used to assess the standards' compliance.

2.3 Computational Work

Simple analysis was performed on the received vehicular emission data for 130 two-wheelers and 74 four-wheelers, which included evaluating whether the data collected complied with both the PUC certificate

standards as well as BS-IV (2010) and BS-VI (2020) criteria. Correlation between the CO and HC measurements for all the vehicles and the correlation between the vehicle age and the pollutants considered was also calculated to determine whether the pollutants (CO and HC) emitted from the vehicles depend on each other and to also find out whether the age of the vehicles plays any role in the amount of pollutants emitted.

3. Results and Discussions

The findings of the vehicles compliance with the emission standards are shown in Table 5. It displays the quantity of automobiles that don't meet the different emission standards. The 130 two-wheelers that were tested all passed the BS-IV and the PUC emission standards, which suggests that the PUC and BS-IV standards that were in place at the time were not very strict. If BS-VI requirements are used, it is found that up to 81 and 29 motor vehicles, respectively, do not meet the emission norms for CO and HC. Additionally, out of 130 motorbikes, a total of 25 weren't compliant with both the CO and HC emission standards. In the case of four wheelers, 26 automobiles did not meet the CO limits, 3 cars did not meet the HC requirements, and 2 cars did not meet the PUC rules for both CO and HC. When the BS-IV rules were used, a total of 7 automobiles failed both test parameters, whereas 37 vehicles failed the CO limits and 8 vehicles failed the HC norms. Because four-wheelers are subject to the same BS-IV and BS-VI requirements for CO and HC, the number of failed vehicles remains constant.

For two-wheelers, the average CO and HC emissions are 0.84% and 390.02ppm, respectively, while for four-wheelers, the averages are 0.45% and 87.68 ppm, respectively. Weak correlation ($0.20 < r < 0.40$) was found between the age of the vehicle and the pollutants emitted from the vehicles. This was observed for both two and four wheelers, with a slightly better correlation observed for four wheeled vehicles. This represents that although there exists a association between the vehicle age and the emissions, there are other factors which also contribute to the amount of pollutants emitted. When observing the dependence of CO and HC on each other, moderate correlation ($0.40 < r < 0.60$) was found for two wheelers whereas weak correlation was found for four wheelers. This shows that for two wheelers the failure of emissions is concurrent whereas for four wheelers it occurs in different stages, implying that two wheelers pose a greater potential for pollution when compared to four wheelers. The correlation values are represented in table 6.

According to the data, a sizable fraction of both two-wheeler and four-wheeler vehicles do not adhere either to the CO emission standards, or the HC rules. Four-wheeled vehicles have a failure rate for CO emissions that is five times higher than that of the emission standards, while for two-wheeled vehicles, the failure rate for CO emissions is three times higher than the emission guidelines. This might be because of the result of inadequate fuel combustion in the engine, poor vehicle maintenance, or an engine with a richer fuel to air mixture. The percentage of automobiles failing both the independent and combined emission tests is shown in Figure 1 and 2.

Table 5: The total number of vehicles not complying with the emission standards

Emission Rules	Four-Wheeler (out of 74)			Two-Wheeler (out of 130)		
	Total	CO	HC	Total	CO	HC
As per PUC	2	26	3	0	0	0
BS – IV	7	37	8	0	0	0
BS – VI	7	37	8	25	81	29

Table 6: Coefficient of Correlation of CO and HC emissions with vehicle age and with each other

Type of Vehicle	Vehicle Age		With each other
	With CO	With HC	
Two-Wheeler	0.192	0.162	0.401
Four-Wheeler	0.217	0.250	0.320

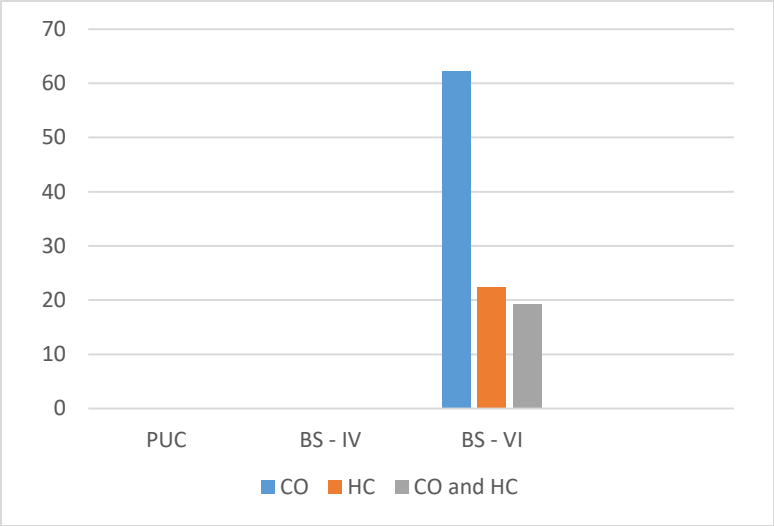

Fig. 1. Bar Chart representing the number of two wheelers failing the emission standards – PUC, BS – IV and BS - VI

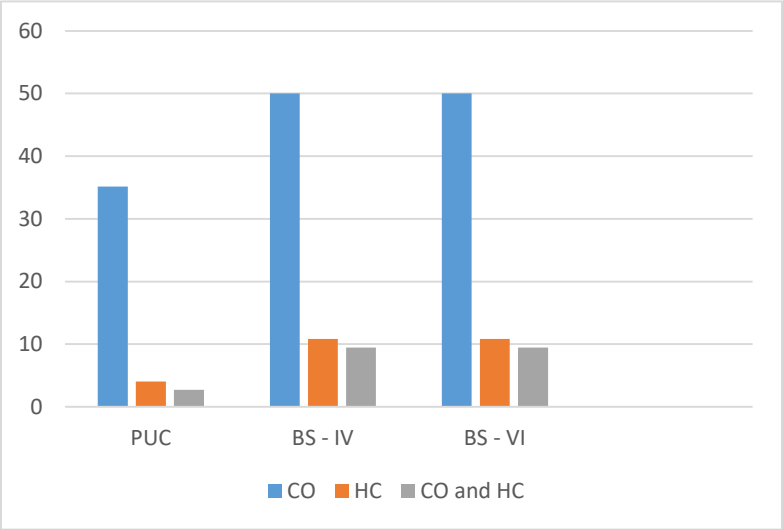

Fig. 2. Bar Chart representing the four wheeled vehicles failing the emission standards – PUC, BS -IV and BS – VI

4. Conclusion

According to the data collected for both two- and four-wheeler vehicles, the majority of two-wheeler motor vehicles meet PUC emission regulations, but when Bharat stage emission rules are applied, roughly 19% of the vehicles fail in the emission limits. Similarly, when PUC rules are used instead of Bharat stage

norms, just 2.5% of four-wheeler vehicles fail, compared to around 9% of cars under Bharat stage criteria. Despite the fact that four-wheelers were subject to BS-IV regulations in 2018, the PUC standards adhered to BS-III standards, which allowed for the certification of more vehicles. Furthermore, it has been discovered that automobiles break CO emission laws more frequently than HC regulations.

Further studies are required to be conducted on a larger sample pool, so as to account for the different vehicle classifications based on the type of fuel and size and mass category, and to also analyse the numerous different pollutants to be monitored. Future studies can also examine how these exhaust emissions affect the health of those who use the roads and work in the auto industry.

Nomenclature

mg	:	Milligram
km	:	Kilometer
ppm	:	Particle per Million
BS	:	*Bharat Stage*
CI	:	*Compression Engine*
CO	:	*Carbon Monoxide*
CPCB	:	*Central Pollution Control Board*
CVS	:	*Constant Volume Sampling*
EURO	:	*European*
FID	:	*Flame Ionization Detector*
GDP	:	*Gross Domestic Product*
GVW	:	*Gross Vehicle Weight*
HC	:	*Hydrocarbon*
IGP	:	*Indo Gangetic Plain*
MoRTH	:	*Central Ministry of Road Transport and Highways*
NAMP	:	*National Air Monitoring Programme*
NDIR	:	*Non-Dispersive Infrared*
NO_x	:	*Oxides of Nitrogen*
NO_2	:	*Nitrogen Oxide*
PM	:	*Particulate Matter*
PUC	:	*Pollution Under Control*
SI	:	*Spark Ignition*

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