6.6 Transportation

6.6.1 Overview

The biggest air pollution source in the transportation sector is the motor vehicles. Among pollution caused by auto exhaust, that caused by CO was revealed from the beginning, but CO pollution has been kept below the environmental quality standards through various measures regulating the emission of exhaust gas. The motor vehicles, at present, is considered to be the biggest source of NO_2 and suspended particulate matters pollution, and the strengthening of measures against them is in demand.

6.6.2 The present situation of the motor vehicles as a facility of transportation

From the mid-1960's, motorization advanced rapidly in Japan, and the motor vehicles, whose position is rising, is becoming a major source of increasing amounts of air pollution, noise and vibration. When looking at the freight volume by transportation, motor vehicles are accounting for a steadily increasing amount year-by-year, rising from 15% in 1960, to 39% in 1972 and to 51% in 1993. Also, although the transportation of travelers has been dull recently, the ratio occupied by the motor vehicles is increasing yearly, with the ratio growing from 23% in 1960 to 51% in 1972 and to 60% in 1993.

Next, when looking at vehicle use, we see remarkable development with number of motor vehicles in operation 810,000 units in 1965 growing to 2,910,000 (3.59 times) in 1975, 4,820,000 (5.95 times) in 1985 and 6,810,000 (8.4 times) in 1994. The increased growth in passenger cars of many variations has been phenomenal. Also, the total distance traveled by vehicles is increasing in accordance with the growing number of vehicles as in 1994 it was 2.86 times that of 1971.

6.6.3 The present situation of the motor vehicles as a pollution source

(1) Pollutant emissions from motor vehicles

The motor vehicles, as a pollution source, is separated into gasoline engines and diesel engines, but there are differences in these two engine types as shown in Table 6.6.1, creating different characteristics of the exhaust gases and different countermeasures against the different emissions.

The discharge of pollutants from gasoline-engine vehicles is roughly from three areas as shown in Fig.6.6.1. Exhaust emission is what after the gasoline is burned in the engine, is discharged from the muffler in the form of CO_2, NOx and H_2O as the products of complete combustion, and CO and HC as the products of incomplete combustion. Next is blow-by gas which leaks into the crankcase through a gap between the piston and cylinder wall and contains unburned fuel, mostly HC. Also, there is the evaporative emission. Because gasoline is a highly volatile fuel, it evaporates from the fuel supply equipment such as the fuel tank and the carburetor, polluting the atmosphere.

Table 6.6.1 Differences between gasoline engines and diesel engines

Category	Gasoline engine	Diesel engine
Fuel & characteristics	Gasoline High volatility	Light oil Volatility is low, but percentage of sulfur is high
Ignition & burning method	It mixes air with the vaporized fuel, (mixed air) beforehand, then the mixture is compressed and ignited by an electric spark.	Fuel is jetted into a chamber where air has been heat insulation adiabatic compressed to a high temperature to ignite and burn the fuel.
Burning characteristic	The mixing is continually adjusted so the fuel burns completely and the ratio of fuel and air does not change.	The air is always constant. As for the fuel, it fluctuates according to the output, big changes in the ratio of air and fuel.

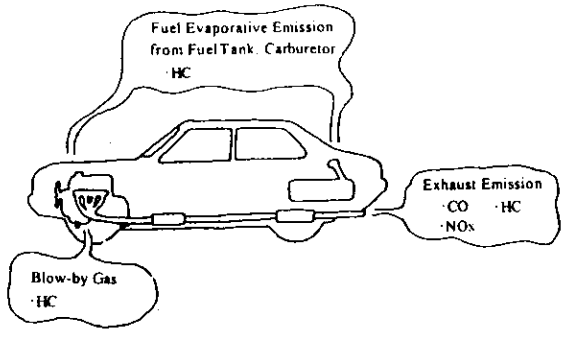

Fig.6.6.1 Emissions from Gasoline-fueled Vehicles

The pollutants discharged from diesel powered vehicles are shown in Fig.6.6.2. Because diesel fuel's volatility is lower than gasoline's, pollution of the air from emission evaporation after the fuel is burned is remarkably low. Also, as only air is pushed into the piston ring part in the early stages of burning, blow-by gas emissions are low resulting in a remarkably low concentration of HC. Therefore, most of the emissions from diesel engines that pollute the air are discharges from the exhaust. As shown in Table 6.6.1, with the diesel engine, an air-excess condition in burning occurs mostly and there is little discharge of CO and HC. However, on the other side is much NOx emission, and, also, black smoke and particulate matter cannot be avoided because of the partial lack of oxygen in the latter part of the burn period. Moreover, because there is a higher percentage of sulfur in diesel fuel than in gasoline, SO_2 is discharged, too.

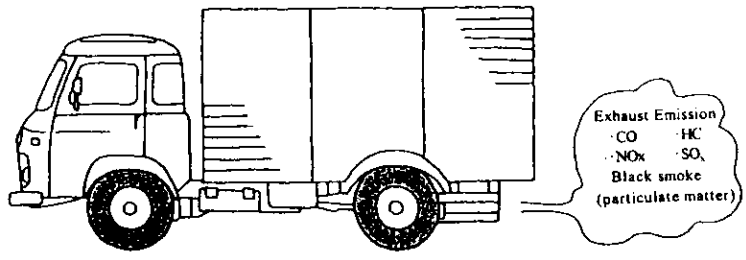

Fig.6.6.2 Pollutant emissions from Diesel-powered Vehicles

(2) Pollutant emission level

The type of vehicle, its weight and running condition, among others, mainly change the pollutant which is discharged from the vehicle. Table 6.6.2 compares the emission level of various pollutants at an average running condition (average speed of 18.2 km/h) in the Tokyo area. Looking at the type of vehicle in Table 6.6.2, the emission volume of each pollutant increases as the size of the vehicle increases. This tendency is conspicuous with NOx and particulate matter (PM). When attempting to see the ratio of NOx emissions, we find that, with a gasoline-engine passenger car at 1, a 10-ton diesel powered truck comes in at 31 and its PM emission is at 55. As for CO, there is originally little emission volume in a diesel vehicle, so that in a 10-ton diesel-powered truck is almost the same as a gasoline passenger car. As for HC, remarkably low emission volume of gasoline-engine passenger cars makes the comparative emission ratio of diesel-powered trucks is, however, almost the same as that of heavy-duty gasoline-fueled vehicles.

Table 6.6.2 Emission level by hazardous substances and by vehicle category (Unit: g/km)

Hazardous substances	Gasoline-fueled passenger cars	Medium-duty gasoline fueled vehicles 750kg	Heavy-duty gasoline fueled vehicles 1 ton van	Diesel- powered trucks			
				2 t	4 t	8 t	10 t
NOx	0.26	0.39	0.96	3.25	3.99	5.13	8.05
		(1.5)	(3.7)	(12.5)	(15.3)	(19.7)	(31.0)
CO	3.99	5.76	15.84	1.63	1.88	2.03	3.56
		(1.4)	(4.0)	(0.4)	(0.5)	(0.5)	(0.9)
HC	0.19	0.20	1.39	0.78	1.12	1.11	1.86
		(1.1)	(7.3)	(4.1)	(5.9)	(5.8)	(9.8)
PM	0.012	0.010	0.022	0.173	0.365	0.505	0.656
		(0.8)	(1.8)	(14.4)	(30.4)	(42.1)	(54.7)

Note: The numbers in the parenthesis are the ratios with 1 standing for gasoline-fueled passenger cars.

(3) The contribution ratio of motor vehicles as a pollution source

Fig.6.6.3 shows the NOx emission per pollution source on a nationwide level. The contribution of motor vehicles accounts for 42%, including both controlled and uncontrolled vehicles. The uncontrolled vehicle is equipped with special characteristics and includes industrial machines (forklifts, etc.), construction machines (hydraulic shovels, bulldozers, wheeled loaders, etc.) and agricultural machines (tractors, combines, etc.). Most NOx emissions occur from these vehicles during their working periods. This pollution source ratio changes somewhat when it occurs in a metropolitan area. The emission rate of NOx per pollution source in metropolitan areas is shown in Fig.6.6.4. The emission rate of motor vehicles exceeds 60% for both controlled and uncontrolled vehicles. Also, the NOx contribution rate according to the category of motor vehicle is shown in Fig.6.6.5, where it can be seen that the emission rate is high for the freight vehicle sector such as ordinary sized trucks next to the uncontrolled vehicle category.

The SOx emission rate for motor vehicles is increasing (55% of all the SOx emission volume is from motor vehicles according to the 1990 emission volume calculation for the Tokyo area) mostly because of the reduction in the emission volume of factories. However, as the percentage of sulfur in light oil has been reduced in recent years, the emission contribution rate seems to be declining.

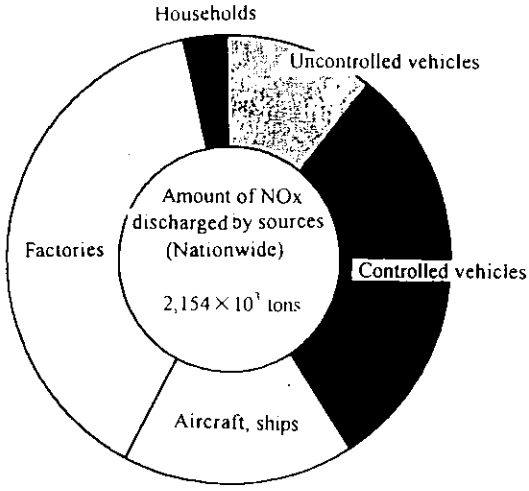

Fig.6.6.3 Contribution to NOx emissions by source (Nationwide)

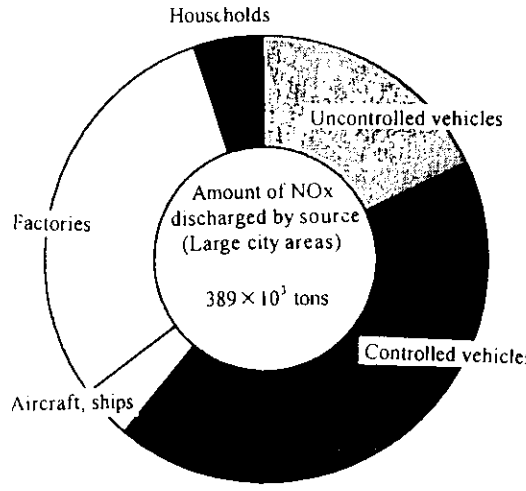

Fig.6.6.4 Contribution to NOx Emissions by Source (Large city areas)

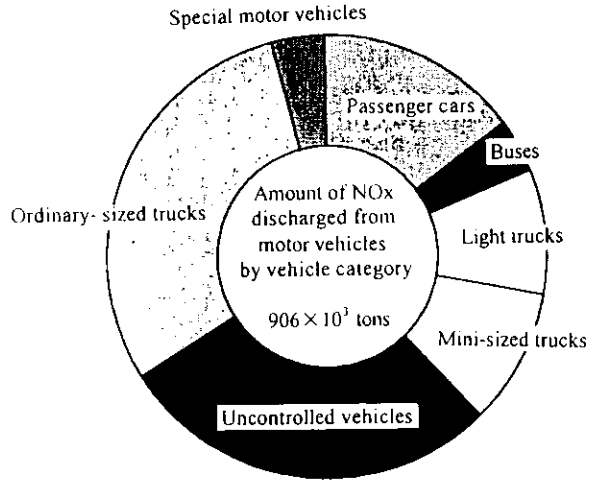

Fig.6.6.5 Contribution to NOx emissions from motor vehiclesby vehicle category (Nationwide)

6.6.4 Other modes of transportation

(1) Aircraft as a pollution source

When treating aircraft exhaust gas as a pollution source on the ground, an altitude of 1,000 meters is set generally for measuring purposes. In dealing with the discharge of exhaust gas for aircraft, this includes the landing, the parking and the reaching of 1,000 meters on takeoff. This mode of landing and take off for aircraft is called the landing/takeoff (LTO) cycle and the mode of operation for this question is classified into approach, idle, take off and climb. Therefore, to calculate the exhaust gas volume from aircraft, the duration should be understood according to each mode and the pollutant emission factor (the pollutant discharge volume per unit of time and engine mode) of the concerned aircraft. The duration according to this mode depends on the airport and aircraft type. However, the domestic research data on the pollutant emission factor in various engine types is scarce and the US's EPA published value for the pollutant emission factor per engine classification is depended upon. When calculating the NOx

emission volume for Haneda Airport using these numerical values, the volume becomes 400 tons annually , accounting for 2.4% of the NOx discharge volume for the whole Tokyo area. Also, as for the average NOx discharge volume per aircraft, it reaches 8.7 kg per 1 LTO cycle, equal to the discharge volume of a 10-ton truck running at an average speed of 18.2 km/h for 1,080 kilometers.

(2) Maritime vessel as a pollution source

When evaluating maritime vessel as a pollution source, it is necessary to examine it by dividing it into the vessel being in motion or being anchored in the harbor. Also, when anchored, the emission source depends on whether the loaded or unloaded. The hazardous substance discharge volume from a vessel can be calculated when the conditions are understood such as the vessel's operational mode observation rate on its sailing route and the longshore craft's ratio of idle time, its boiler and its diesel load factor. As shown in Fig.6.6.4, maritime vessel, along with aircraft, in its role as a NOx pollution source contributes 4% of the whole for the metropolitan area. The personal contribution rate of ships and aircraft depends on the scale of the harbor and the airport, etc. In the NOx emission volume calculation results for 1990 in the Tokyo area, the volume for ships accounts for 2.7% of the whole volume and, in Yokohama, this ratio is 9%.

6.6.5 Indicated problems

There still are many problems in grasping the pollutant emission situation in the transportation sector. First, it is said that large-scale equipment is necessary to grasp the actual state of the pollutant discharge from motor vehicles or vessels and there are few made which have a capacity of measuring exhaust gas. Second, these transportation facilities are the pollution source of hazardous chemical species such as benzene, 1,3 butadiene, aldehyde and benzo(a)pylene. Therefore, grasping the actual state of the discharge is becoming an urgent business.