In the quarter century since fiscal 1970, air pollution generated by motor vehicles has not improved sufficiently, and the state is severe, particularly in major cities. This is caused directly by the increasing volume of motor vehicle traffic that is, in turn, a result of the fact that contemporary socio-economic systems and lifestyles depend largely on the use of the motor vehicle. Social cost of air pollution must be internalized to solve the air pollution problem and the total volume of motor vehicle emission must be reduced and controlled to meet environmental quality standards, not just regulated on a vehicle-by-vehicle basis. This will require a review of the prevailing vehicle-dependent socio-economic systems and lifestyles, and necessitate that we look at a set of drastic measures which strike at the fundamentals of our vehicle usage.

Key Words: Motor vehicle traffic, Air pollution, Environmental quality standards, Total emission, Social cost

In Japan, the impact of air and water pollution worsened with the rapid economic growth of the 1960s, leading to a dangerous situation that posed a risk to public health. As a result, the Diet convened a session to deal with pollution in 1970 and introduced anti-pollution legislation. In 1971, the Environment Agency was established and regulations governing factory emissions and motor vehicle exhausts were gradually reinforced.

In the quarter century since then, the once critical situation has been relieved, but there has been no sufficient improvement in air pollution associated with nitrogen oxides and other pollutants in large cities and along major arterial roads; further efforts are needed. This paper analyzes the factors, background and direction of strategies related to this problem and attempts to aid in the study of motor vehicle traffic patterns to prevent air pollution. The views expressed in this paper are not the official views of the Environment Agency.

Environmental quality standards are set in accordance with the Basic Environment Law as standards which are desirable to be maintained on the basis of protecting human health and preserving the living environment. The level of attainment state of environmental quality standards for nitrogen dioxide, suspended particulate matter, photochemical oxidants and carbon monoxide, all particularly related to motor vehicles, were compiled by the Environment Agency in fiscal 1998 after measurements were taken by regional public organizations all over the nation.

Nitrogen oxide

Figure 1 shows the level of attainment of environmental quality standards for nitrogen dioxide. Of the 1,466 general air pollution monitoring stations (hereafter referred to as “general stations”) around the country, 1,382, or 94.3%, reported that environmental quality standards were met. Of the 392 roadside air pollution monitoring stations (hereafter referred to as “roadside stations”) set up along side roads around the country, 267, or 68.1%, reported that environmental quality standards were met.

In large cities covered under the Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides from Automobiles in Specified Areas, 238, or 74.1%, of the 321 general stations and 61, or 35.7%, of the 171 roadside stations reported that environmental quality standards were met. The attainment ratio near
roads is particularly low compared to general stations. Furthermore, general stations are in locations which suffer very little direct impact from traffic exhaust, but even their ratio of attainment of environmental quality standards was low in large cities, and nitrogen oxide emissions from motor vehicle were distributed beyond the vicinity of the roads and polluted a wide area.

The upper limit set by the environmental quality standards is 0.06ppm, 98% of the daily average over 1 year. In contrast to this, some roadside stations in large cities reported concentrations in excess of 0.08ppm while general stations reporting concentrations in excess of 0.07ppm were also focused in large cities.

Suspended particulate matter

Figure 2 shows the level of attainment of environmental quality standards for suspended particulate matter. Of the 1,529 general stations nationwide, 1,030, or 67.4%, met environmental quality standards. Of the 269 roadside stations nationwide, 96, or 35.7%, met environmental quality standards.

In large cities covered under the Law concerning Special Measures for Total Emission Reduction of Nitrogen Oxides from Automobiles in Specified Areas, 109, or 33.7%, of the 323 general stations and 17, or 12.4%, of the 137 roadside stations reported that environmental quality standards were met.

The attainment ratio near roads compared to general stations is particularly low. Furthermore, the low attainment ratio in large cities for both roadside stations and general stations is similar to the situation reported for nitrogen dioxide, but pollution by suspended particulate matter is more widespread.

The environmental quality standards, 0.10mg/m³, exclude 2% from the daily average over 1 year. In contrast, some roadside stations in large cities reported concentrations in excess of 0.16mg/m³ while several general stations also reported concentrations in excess of 0.14mg/m³.
Photochemical oxidants

Of the 1,185 general stations and roadside stations nationwide, only 7 met environmental quality standards with a daytime value of no more than 0.06ppm per hour. Warnings are issued when readings are consistently 0.12ppm or above, and such warnings were issued on a total of 100 days in 19 prefectures and major metropolitan areas throughout Japan. Some of these warnings were also issued in outlying regions surrounding major metropolitan areas, indicating the extent of the widespread pollution.

Carbon monoxide

Environmental quality standards of no more than 10ppm on a daily average of hourly values were met at all of the 145 general stations and 327 roadside stations nationwide.

3.1 Factors

Stronger controls on vehicle emissions and environmental concentration trends

Controls on motor vehicle emissions have gradually been stepped up in a bid to cut exhaust emissions on a per-car basis to halt air pollution by motor vehicles. Elements subject to these controls are carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter and black smoke. Different criteria have been established on the basis of vehicle use (passenger or freight), fuel type (gasoline or diesel) and gross weight of vehicle. Figure 3 shows the history of reinforcement of emission controls relating to nitrogen oxides in passenger vehicles and diesel trucks. Levels prescribed by controls today are just 3.2% of what they were in 1973 for passenger vehicles, and just 33% of the 1974 level for diesel trucks.

Despite these reinforced controls, the results of controls on vehicle emissions, with the exception of carbon monoxide, have not been satisfactory in terms of attaining environmental quality standards. Figure 4 shows the simple averages for annual mean values of nitrogen dioxide at all monitoring stations nationwide. Concentrations equivalent to the upper limits of the environmental quality standards averaged 0.03ppm for the year. These figures peaked around fiscal 1970 and reinforced controls on vehicle emissions associated with fixed sources saw rapid decline from escalating pollution.
through the 1970s. Environmental concentrations also declined through 1985 as a result of emission controls and the introduction of total volume controls for fixed sources. However, as improvements in environmental concentrations did not satisfy environmental quality standards, the benefits of controls on vehicle emissions were gradually eroded. Since the latter half of the 1980s, these standards have hardly been met and concentrations have remained unchanged.

Increased automobile traffic

One of the reasons for serious motor vehicle pollution of the atmosphere, despite reinforced controls on vehicle emissions, is the growing volume of traffic. Substantial controls governing nitrogen oxide emissions from motor vehicles have been introduced since fiscal 1973, but the increasing volume of traffic gradually eroded the benefits. Figure 5 shows the course of traffic volume over time. Motor vehicles in Japan traveled a total of 615.1 billion kilometers in fiscal 1998. Of this distance, trucks traveled 182.5 billion kilometers and passenger vehicles (excluding mini-sized motor vehicles) traveled 432.6 billion kilometers. This provides a significant growth figure of 272 based on the index score of 100 for fiscal 1970.

In major cities, increased traffic density brings about widespread pollution and traffic congestion causes higher levels of emission.

Conversion to diesel, larger trucks

The standards for nitrogen oxide control values are higher in diesel vehicles than gasoline vehicles for passenger vehicles, light-duty trucks and medium-duty trucks, and conversion from gasoline to diesel vehicles brought about an increase in nitrogen oxide emissions.

Figure 6 shows the increasing number of diesel vehicles among the total number of ordinary-sized trucks and small-sized trucks in operation. This Figure was 925,000 out of 5,426,000 (17.0%) in fiscal 1970 but rose to 6,485,000 out of 8,553,000 (75.8%) in fiscal 1997. The ratio of diesel passenger vehicles to total passenger vehicles was 10,000 out of 6,777,000 (0.1%) in fiscal 1970 but increased to 5,004,000 out of 41,283,000 (12.1%) in fiscal 1997.

The tendency towards larger trucks also eroded the benefits of emission controls. Figure 7 shows the trend towards larger trucks on the road. The number of small-sized trucks has declined in recent years while the number of ordinary-sized trucks has continued to grow. Of the 5,437,000 trucks owned in fiscal 1970, 814,000 (17.6%) were ordinary-sized trucks. In fiscal 1997, the number of trucks owned stood at 8,565,000, of which 2,656,000 (31.0%) were ordinary-sized trucks.

Note: Mini-sized motor vehicles excluded.
Source: Land Transportation Statistics Survey, Ministry of Transport

Source: Land Transportation Statistics Survey, Ministry of Transport
3.2 Background

Volume of motor vehicle traffic, Real GDP, Number of vehicles owned

Figure 8 shows the relationship between growth in traffic volume and growth in real GDP and number of vehicles owned. GDP for fiscal 1997 was ¥488 trillion, for fiscal 1970 ¥190 trillion, at market prices in calendar year of 1990. Using 100 as a base index for fiscal 1970, a score of 1997 is 256, almost the same as the score of 272 for growth in motor vehicle traffic volume over the same period. The number of vehicles owned in fiscal 1970 was 18.92 million and 72.86 million in fiscal 1997. Using 100 as the base index for fiscal 1970, growth was significant at 385.

The rising popularity of motoring could not be stemmed in the quarter century since fiscal 1970 and because of the close relationship between the production, ownership and use of motor vehicles and economic activity and lifestyles in the community, it is reasonable to believe that this precipitated an increase in traffic volume bringing about air pollution. Of the 72.86 million vehicles owned in fiscal 1997, 48.43 million were private passenger vehicles (including mini-sized vehicles). This means 1.05 private passenger vehicles for each household and demonstrates that ownership and use of motor vehicles are commonplace in the community.

Note: Volume transported by motor vehicle excludes mini-sized motor vehicles.

Volume transported by motor vehicle

Motor vehicle traffic is responsible for transporting goods and people. Figure 9 compares real GDP and the volume transported by motor vehicle.

Domestic goods carried by motor vehicles amounted to 135.9 billion metric ton-kilometers in fiscal 1970 and 304.2 billion metric ton-kilometers in fiscal 1997. Based on an index score of 100 for fiscal 1970, this is a score of 224. The number of passengers carried by motor vehicle was 284.2 billion people-kilometers in 1970 and 724.3 billion people-kilometers in 1997, a score of 255.

The Real GDP growth score in this period was 256, demonstrating a close correlation with growth in goods and people carried by motor vehicle.

In conjunction with growth in volume transported by motor vehicle, motor vehicle’s share of transportation relative to other modes also increased. Freight figures for fiscal 1997 show that motor vehicles transported 90.8% on a metric ton base and 53.8% on a metric ton-kilometer base. Passenger figures for the same year show that motor vehicles transported 73.5% on a per person base and 66.6% on a person-kilometer base. Transport logistics for both freight and passengers relies heavily on the motor vehicle.

4.1 Environmental quality standards and reducing total emission

In terms of preserving the environment, motor vehicle transportation should be used within the limits established by environmental quality standards. If these standards for air pollution are exceeded in areas adjoining arterial roads, restricting the volume of traffic on the roads in question to within the limits established by the standards is the viable course of action. However, because motor vehicle traffic is concentrated in large cities while pollution is widespread, restrictions on traffic volume on the roads in question may not always bring about satisfactory improvements in environmental concentrations at those locations. If that volume of traffic is diverted to other roads by those restrictions, the location of the motor vehicle emission may simply move elsewhere. Therefore, it is necessary in large cities to reduce total emission levels for the entire area to levels that meet environmental quality standards.

In economic terms, the social cost of pollution from motor vehicles is not being borne by vehicular transport itself, which brings over-use of motor vehicles and increase of external diseconomy. The social cost could be internalized, and motor vehicle traffic restricted, by calculating the social cost of pollution and imposing the share of that cost through user-paid taxes, etc. Calculating the social cost presents some difficulties in practical terms, but if the social cost of air pollution from motor vehicles is viewed as a result of pollution in excess of environmental quality standards, the social cost can be internalized by reducing the total emission in line with environmental quality standards.

Figure 10 shows the ratio of nitrogen oxides (nitrogen oxide and nitrogen dioxide) in large cities by source. More than half of this type of emission is from motor vehicles. Yet the contribution of the motor vehicle to environmental concentrations on roadsides is much higher. Restrictions on total nitrogen oxide levels from factories and workplaces have been in place since fiscal 1985. To meet environmental quality standards, targets must be set for total nitrogen oxides emitted from motor vehicles, and emissions must be reduced and sustained at levels below those targets.
4.2 Methods of reducing total emission

Under the Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides from Automobiles in Specified Areas, regional authorities designate total emission reduction programs and set targets for the reduction of total nitrogen oxides emission in prescribed areas. To reduce those levels, they also promote policies for individual vehicles, restrictions on vehicle types, low-emission vehicles and transport policies for goods and people. Newly introduced regulations on vehicle types stipulate the mandatory conversion from small diesel trucks to gasoline trucks.

There are several other viable methods of reducing total emission. Fixed sources such as plants and workplaces are already governed by restrictions on total emissions of sulfur oxides and nitrogen oxides in prescribed locations. Total emission targets are set based on environmental quality standards, and regulations to achieve those targets are applied to plants and workplaces above a given size. Total emissions are reduced effectively through regulatory practices such as these. Under a similar concept, a move is being considered to include emissions from vehicles owned or used by plants and workplaces. In incorporating this, it should be noted that the direct producers of emission are diverse and numerous, and that there will be an inflow of vehicles to the area.

Regulations on motor vehicle emissions have already been imposed on automobile manufacturers, but the increase in traffic due to rising vehicle ownership and the introduction of larger vehicles and diesel engines have helped to erode these regulations. In contrast, electric vehicles and other low-emission vehicles are designed to release far less emission than regulation levels. Therefore, it is feasible that average and total emission levels from vehicles sold by automobile manufacturers will be subject to restrictions. Regulations on average levels for each manufacturer have already been introduced in California and the ratio of low-emission vehicles can be gradually increased by reinforcing the standard values in stages. The total volume of emissions can be cut by increasing the number of such units sold.

The total volume of emission from a vehicle can, in theory, be displayed by: emission units per vehicle (g/km) x traffic volume (km). Therefore it is also feasible to focus on the concentration of traffic rather than the volume of emissions, and introduce controls to reduce the volume of traffic. Regulations using number plates and access restriction using road pricing are being introduced in Singapore and several other regions.

These methods, cited several examples above, relate to protection of health and it is essential to ensure their effectiveness. From that point of view, the use of regulatory methods should be considered. Because the extensive pattern of socio-economic activities are related to the use of the motor vehicle, the social cost of air pollution with vehicle use should be reflected in the market price. This kind of economic methods that make use of market mechanisms and internalize external diseconomies are also effective. Care should also be exercised in relation to policy feasibility, cost effectiveness and compatibility, etc.

4.3 Reducing total emission and converting socio-economic systems and lifestyles

The reason that air pollution from motor vehicles has not improved is that the volume of motor vehicle traffic has increased on a scale large enough to erode reinforced legislation on emissions per vehicle, and that the use of diesel engines has continued to increase as mentioned in Section 3.1. Behind this is the close correlation between the growth in ownership and use of motor vehicles and growth in real GDP as mentioned in Section 3.2. Therefore, cutting the total volume of emissions to a level where environmental quality standards are met, will require a review of the systematic and structural factors that led to greater use of the motor vehicle with economic expansion.

Mass popularization of low-emission vehicles, for example, would be an effective means of reducing the emission units per vehicle but, at present, the prices of these vehicles are high, they have a short range, and there are few fuel facilities for them. However, the price difference emerges not because low-emission vehicles are expensive but because diesel powered vehicles and other large-scale polluting vehicles do not pay the social cost of air pollution by themselves. In both regulatory and economic approaches to reducing the total volume of emissions, or in the mass popularization of low-emission vehicles as a means of achieving this, the social cost to the community of diesel vehicles must be internalized. Increases in the associated cost of vehicle use or the cost of distribution will present an opportunity to review the convenience of the motor vehicle. On the other hand, the installation of fuel facilities for low-emission vehicles needs to be stepped up as part of the social infrastructure.

To improve air pollution from motor vehicles, to-
tal emission volumes must be reduced, but this is tied to a conversion of current socio-economic systems and lifestyles to ones with less impact on the environment. A study is needed to develop a set of drastic policies reaching back to patterns of vehicle use. This type of comprehensive approach can lead to the realization of motor vehicle transport with a lower impact on the environment.

The convenience of the motor vehicle has expanded its use and created a society rich in material possessions but at the same time dependant on the motor vehicle for its economic activities, land use in cities, transport systems and urban lifestyles. This creates the backdrop for growing air pollution from motor vehicles.

To improve the widespread air pollution in the cities, we need to reduce and manage the total volume of emissions from motor vehicles and internalize the social cost. However, this is linked to converting our current social economic systems and lifestyles into ones with less impact on the environment, and will require a review of radical policies reaching back into the patterns of vehicle use.

1. Step by Step Guide to the Automobile NOx Control Law, Edited by the Study Committee on Automobile NOx Control Law (Chuo Houki), October (1994).