Assessment of Automobile Transport-related Pollution in Cities at Low Ambient Air Temperatures

Aleksandr S Gavaev* and Sergei A Ertman

Tyumen Industrial University, 72 Melnikaite str., Tyumen, 625000, Russian Federation

E-mail: *Gavaev@list.ru

Abstract. This article covers a number of issues related to identification of environmental pollution with combustion gas emissions from vehicle engines in urban areas at low ambient air temperatures. Ambient air quality in urban living areas depends on elimination of adverse impact of traffic-related pollution on environmental well-being of citizens. This article gives an overview of dependences of the number of vehicles warmed up at night time and in the morning at ambient air temperatures below zero. Massive emissions subject to ambient air temperature for open air car parking have been determined. It has been established that most of car owners violate the Russian Federation legislation in terms of failure to comply with its bylaw, namely the Traffic Regulations. Based on the results of the conducted study, certain measures have been provided to identify law violators and to strengthen control of compliance with the Traffic Regulations. While discussing the study results a suggestion has been formulated that inevitability of punishment will contribute to raising effectiveness of environmental pollution control in large cities. Cultivation of environmental policy and management system should also be kept in line with up-to-date international needs and requirements and enable effectiveness and efficiency of environmental-related activities in the state.

1. Introduction.

Traffic flows are the major source of ground-level air pollution. Existing traffic flow environmental monitoring patterns are based on the use of statistical data on the types of road fuel, vehicle emission classes [1], traffic flow parameters to determine massive combustion gas emissions.

Statistical data show that the amount of pollutant emissions attributable to traffic flows increase every year. In particular, dynamics of air pollutant emissions by road vehicles in Russia over the last 18 years has remained practically at the same level [2].

However, protection of cities' ecological systems and human health is not simply limited to improvement of internal combustion engines (ICE) design for newly manufactured cars to minimize emissions of pollutants in the ground-level air, as stipulated by federal programs.

2. The studied problem.

Air pollution causes significant economic damage as well. Maximum losses are incurred by housing and utilities, agricultural and forest sectors. We have revealed dependence of costs for repair of residential buildings on concentration of pollutants in the air.

Lack of a system approach to management of urban safety and protection against comprehensive toxic effect of traffic emissions. No obvious dependence exists between creation and change of pollution for the above sources and automobile transport parameters. This means that a comprehensive study was required to investigate factors influencing the degree of pollution attributable to automobile transport.

Primary environmental hazard for cities is posed by toxic build-up in the ground-level air made by emissions from ICE combustion gases. Therefore the key objectives for protection of cities against vehicles-related environmental effects include elaboration and implementation of technical and organizational measures for reducing pollutants concentration, and prevention of toxic build-up in the ground-level air in living areas.
Figure 1. Amount of pollutant emissions by years

Public health protection is a systemically most important criterion for environment quality control, and elimination of hazardous and harmful habitat factors impact on human health is a top-priority task for ensuring the ecological well-being of the society.

The need for reduction of traffic pollution in large cities is a pressing environmental and economical issue.

Solution of this problem for traffic pollution reduction through advanced management of traffic flows, technological improvements, fuel emission controls and restrictive measures does play its positive role but still cannot keep up with rapid growth of car-ownership in urban areas [3-5].

At the same time, there are no sufficient studies on specifics of outdoor air formation due to vehicle pollution in large cities, where a relatively small territory is occupied by millions of operating fixed and mobile pollutant sources. A multi-factor nature of processes responsible for public health formation makes it difficult in many ways to assess the public health condition and to identify cause and effect relations between the impact of habitat factors and public health, and raises a question of selecting most informative indicators to reflect the environmental condition and human health [6-7].

3. Problem solution and results.

Theoretical and practical importance of this study lies in improvement and strengthening of scientific credibility of technical approaches to continued development of health risks assessment strategy as a result of vehicle pollution impact.

A unique feature of outdoor air pollution in megacities is a large number of pollutant emission sources on a relatively limited territory.

The principal goal of this study is to identify the hazard the combustion gas poses for the atmosphere when vehicles stay in open air car parks at low ambient air temperatures. In winter, vehicles kept in open air car parks constitute a particular risk to the outdoor air quality, since car warm-up takes much more time, especially at night when engines are warmed-up at idle. As such, the time period selected for our study lasts from 23:00 to 7:00 o’clock.

Selected types of open air car parking differ in their technical properties, number of cars being parked, traffic intensity in the morning, types of surrounding buildings, total number of parking places, and number of cars being parked at a time. For the purposes of our investigation we have recorded the
number of cars with their ICEs running, the time spent for the ICEs warm-up and the then ambient air temperature.

All measurements have been done in winter time from December to February, on different days of the week, and monthly air temperature varied from -5°C to -30°C. Number of floors of surrounding houses have also been taken into account. Road surface condition has been determined based on available engineering and technical data.

Our study has demonstrated that cars rotate in a car park throughout the day, and this rotation slows down a little from about 0000 to about 0600 o’clock. For the territories in question, an ‘early peak’ is typical - from 0730 to 1030. ‘Late peak’ falls within the period from 1830 to 2300 o’clock. It was observed that the night and morning hours accounted for the largest number of running car engines. At an average it took from 4 to 15 minutes to warm up a car engine, and 19 minutes in colder days.

Figure 2 Influence of air temperature on the duration of open air parked cars warming-up

According to our study, most vehicles are parked outside because there are too many cars and too little place in cities for indoor parking, and as a result passage ways, grass lawns, playgrounds and yards are packed with cars. Maximum concentration of pollutants in the ambient air is observed in peak traffic hours and in densely built-up areas with blocks of flats and low wind flows. Significant damage to human health is caused by cars because they are located and parked around apartment blocks and in the immediate vicinity of residential buildings, in particular, in well courtyards and directly in front of the windows of apartments.

Our investigation has shown that as the outside air temperature lowers, the number of cars being warmed-up increases, along with the time required for warm-up. The highest peak of parked cars with their engines running was observed at the temperature of -30 °C, and the lowest peak was noted at the temperature of -5 °C.

The results we have received lead us to the following conclusions: the engine starting and the time required for the engine warm-up depend on the ambient air temperature, therefore concentration of pollutants emitted by running engines increases in cold seasons. It takes twice more time to warm up an engine in winter than in warm seasons. As shown in the preceding sub-chapter, engine warm-up takes from 4 to 19 minutes at an average. The diagram below reflects the results of the field observation (Fig. 3).

Ambient air temperature has a particular influence on the engine starting and time required for the engine warm-up, which increases emission of pollutants from running ICEs.

In the course of our study we have derived dependence of massive pollutant emissions (ΣM_i) from fifty vehicles (fig. 4) during their engines warm-up at the outdoor parking. For calculation purposes we have taken into account the number of cars with their engines warming up at the outdoor parking, engine running time and ambient air temperature.
Remote engine start car alarm systems are very popular nowadays. You can start the car without leaving your apartment and let the engine warm-up for a long time until the transmission and interior are fully warmed-up [8].

We have conducted a poll among car owners who have remote engine start systems. According to the poll results, 70% of car owners warm up their cars until the car is fully warm, without leaving their apartments. At an average, the warm-up process takes about 20 minutes (on frosty days from – 20 to 30). As a result, in the morning courtyards by the block of flats turn into sources of increased hazard to citizens. People who live on the ground and first floors suffer extreme discomfort because cold engines after cold starting emit the largest amount of pollutants. Their emissions contain vapors of nitrogen oxides, carbon dioxide, sulphur, cancerogene microparticles and other toxic gases.
4. Discussion of the results.

According to Clause 17.2 of the Traffic Regulations, 'through traffic, driving lessons, parking with engine running, as well as parking of lorries with maximum permitted weight over 3.5 tons are prohibited in living areas, unless in specially designated and properly marked and/or labelled areas'.

A most common violation which remains unpunished is parking of cars with their engines running in a living area for more than 5 minutes. It should also be noted that courtyard territories are equivalent to living areas. The Traffic Regulations explicitly say that parking with engine running is prohibited. Based on a video recording, law enforcement officers are entitled to write out an administrative fine for 1,500 rubles under Article 12.28 of the Administrative Offences Code of the Russian Federation [9-12] (Violation of rules established for transport movement in living areas).

5. Conclusion.

According to the above, it is suggested that respective authorities of the Russian Federation should strengthen monitoring of violations and inevitability of punishment, thus contributing to effective control of environmental pollution in large cities.

Environmental policy and management system development strategy should keep in line with up-to-date international requirements and enable effectiveness and efficiency of environmental-related activities in the state.

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