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ENVIRONMENTAL FACTORS AND CONSTRAINTS IN THE DEVELOPMENT OF THE NEW TERRITORY OF MOSCOW (SO-CALLED «NEW MOSCOW»)

ABSTRACT. The article considers the main trends in the environmental situation in the New Moscow in connection with the acquisition of capital status and rapid population growth. The New Moscow is the territory annexed to Moscow as part of a large-scale project to expand the territory of Moscow at the expense of the Moscow oblast in July 2012. Under the influence of both hereditary and transformational factors, the situation in Moscow new adjoint area is rapidly deteriorating, and for Moscow in the old borders inherited factors are mostly negative for the formation of the environmental situation, and the transformation is in the direction of slow and gradual improvement.

In Moscow new adjoint area the structure of pollution sources is linked to the post-industrial type of cities (heating systems and other non-industrial sources, vehicles), as the most non-industrial part of the Moscow region was chosen to join the capital. The level of pollution is low, but the environmental efficiency is also low and the level of pollution is growing rapidly. The decline in production and structural changes in industry, as well as the growth of the car fleet, the change in traffic conditions along the roads, led to a change in the territorial proportions in atmospheric pollution in Moscow, both in the old and new boundaries, and the scale of housing construction in Moscow new adjoint area led to a pressure on water sources and changing natural landscapes.

KEY WORDS: Air pollution, solid wastes, integrated analysis, environmental conditions, environmental quality, new territory of Moscow, New Moscow, environment of Moscow

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INTRODUCTION

The great urban agglomerations are bound to regions where the anthropogenic influences of recent years combine with one another. Above all this applies to the Moscow capital region, where the impact of the large-scale economy, which attracts investment and labor, intensifies the pressure on the infrastructure from automotive transport, the problems with waste-processing, deforestation, the shrinking of the environmental structure, and the exhaustion of water resources.

Even the growth of the service sector leads only to additional traffic jams, wastes, and noise pollution in the old transport structure.

The regions where the anthropogenic impact shifts in recent years include the largest urban agglomerations, and above all the Moscow metropolitan region, where economies of scale effect, attracting investments and labor, creates an increased load on the infrastructure from motor vehicles, problems of waste disposal, cutting down forests, reduction of the environmental framework, depletion of water resources. Even the increase in service functions on the old transport basis only leads to an increase in traffic congestion, emissions and noise pressure.

Current studies of the topic

The New Moscow is the territory annexed to Moscow as part of a large-scale project to expand the territory of Moscow at the expense of the Moscow oblast in July 2012. It is an area where the environmental situation is rapidly changing under the influence of a number of factors, including as a result of the acquisition of the capital status. Capital cities in countries with economies in transition have become the main beneficiaries of changes in the economic system, post-industrial growth (Brade and Rudolph 2004; Golubchikov and Makhrova 2013). In the post-Soviet period, the capitals and their suburbs became the main centers for the attraction of migration throughout the post-Soviet space (Nefedova et al. 2016)

Capital cities, as a rule, are the poles of the transformation of the environmental situation: they create the majority of innovations provoking new environmental conflicts and create technologies aimed at reducing the anthropogenic impact on the environment of cities, they concentrate an increasing proportion of the population, but do not show growth reduction, which is caused by the restructuring of sources of anthropogenic impact, the introduction of environmental technologies and development programs (Koldobskaya 2014).

Capitals have a number of features compared to other cities, due to the ongoing large-scale process of urban transformation (new construction, reconstruction), spatial expansion and the presence of agglomeration. The concentration of administrative, political, cultural functions causes the decline of the role of industry as an economic basis and source of anthropogenic impact, and higher requirements for environmental quality - the availability of environmental policy and a master plan for the formation of green wedges and green frame, the creation of environmental infrastructure of the city.

The peculiarities of the environmental situation, typical for the capital cities are:

- an increased level of motorization and the predominant role of mobile sources in pollution is several times higher than from stationary ones (Bityukova and Argenbright 2002; Bityukova and Sokolova 2008);
- the predominant role of the electric power industry in the structure of pollution from stationary sources, which is typical for the postindustrial period and as a result the simplification of the pollution structure ones (Bityukova and Saulskaya 2017, Lokoschenko and Trifanova 2017);
- high level of gross and per capita volume of solid waste with prevalence of household waste;
- the formation of a vast belt of multifunctional country cottages and cottage settlements, both urban and rural housing, used all the year round (Brade 2014);
- clear functional zoning, including delimited residential and industrial areas. For capitals is characterized by the complexity of the functional and territorial structures, infrastructure systems (in the first place - transport).

Moscow was the first city in Russia in which environmental problems were explored from the position of their territorial differentiation due to the scale and contrast of the city(Popov et al. 2016). Since it was in the capital that the real estate market began to develop first, then

there were works identifying the role of the environmental factor in the price of residential real estate (Bitykova et al. 2006).

When assessing geoecological features, the city's capital status was not taken into account at all (Ivashkina 2010; Kasimov et al. 2017), exceptions were only works on the formation of the green framework of the capital (Krasnoschekova 2010).

After the accession to the capital of new territories, the peculiarities of their development are considered in numerous articles without taking into account the environmental factor on the one hand, as a result of the established opinion that the environmental situation in New Moscow is a priori better than in the old Moscow (Makhrova and Tkachenko 2013; Kangas 2013; Büdenbender 2017), and on the other hand, because this territory is not considered a full-fledged metropolitan area, where the requirements for the quality of life put forward by the population are higher (Kuricheva 2014; Tishkov 2014). The environmental aspects of the development of the annexed territories are considered as a description of individual problems (Bogdanov 2015), or a complex of measurements (Lurie 2015). But until the issue of assessing the factors and directions of the transformation of the environmental situation of the given territory was considered, is the current state a continuation or a change in the development vector as a result of the acquisition of the capital status.

Therefore, in this paper, New Moscow was considered against the backdrop of the whole metropolitan region, in comparison with the city territory in the old borders and the neighboring districts and cities of the Moscow oblast.

DISCUSSION

The state of the environment in New Moscow directly depends on the amounts of pollution of the air, water, and soil, as well as the level of noise, which have been changing in recent years due to large-scale housing construction. Moscow and Moscow region form a powerful region, the level of environmental tension in which increases throughout the post-Soviet period. Compared to 1990, Moscow decreased its waste emissions, water use, and sewage discharge twice as rapidly as the countrywide average, while the pace of Moscow Oblast' matched the Russian average. Moscow Oblast' is one of five Russian regions (along with the Khanty-Mansiysk Autonomous Okrug — the leading oil producing region—and the small republics of the northern Caucasus) characterized by growth in sewage emissions. In recent years measurable, if not highly significant, decreases in Moscow's output of pollution have occurred, while the share contributed by the capital region has increased, as is shown in Table 1.

The accession of new territories to Moscow was largely explained by the desire to provide a new quality of solving environmental problems. In 2011 the capital's authorities explained the choice of the land which became Troitskii and Novomoskovskii Administrative Okrugs as having the optimal location for the fulfillment of Moscow's capital functions on the basis of city-building, transportation, and environmental factors, as well as the low level of urbanization (at the time of annexation the population consisted of 250000 residents and the amount of developed space amounted to 12 million square meters). In the early stages the environmental factor was a motivation for development of the territory, but the situation is changing rapidly. Although New Moscow is called the "green lungs" of the capital, there are a number of unhealthy spots where either existing sanitary-hygienic norms are being violated at present or a negative scenario is unfolding. However, it turned out that there are negative trends for these regions, primarily due to the increased impact of road transport and the scale of housing construction.

The goal of the present research is to analyze the transformation and territorial differentiation of environmental stress within New Moscow as compared with Old Moscow and the neighboring territories of Moscow Oblast'.

Table 1. Shares of the basic indicators of environmental pollution in Russia contributed by Moscow and Moscow Oblast' (%) (Report on the state... 2017; Environmental protection... 2016; Data base of indicators... 2000-2017)

Indicator	Region	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Volume of emissions into the atmosphere	1	2,8	2,7	2,5	3,0	3,1	2,9	2,9	2,8	2,9	3,1	3,2	3,2
	2	6,0	1,3	1,2	1,3	1,3	1,4	1,3	1,3	1,4	1,5	1,6	1,8
Fresh water use	1	4,4	4,5	4,5	4,3	4,5	6,5	6,3	6,0	5,6	6,0	6,1	4,9
	2	4,3	4,1	3,8	1,9	1,8	0,9	0,9	2,5	2,4	2,4	2,3	1,0
Volume of waste water	1	14,6	14,1	13,5	13,3	13,6	13,4	13,3	13,7	14,1	13,4	13,1	12,9
	2	11,1	10,6	10,1	9,84	10,1	5,5	5,7	5,9	6,2	5,8	5,7	5,6
Wastes from production and onsumption	1	3,6	3,5	3,5	3,4	3,6	7,9	7,6	7,8	7,8	7,6	7,5	7,2
	2	0,30	0,19	0,13	0,13	0,10	0,18	0,10	0,10	0,12	0,19	0,11	0,09
Share of GDP in prices 2005r.	1	3,9	4,2	4,6	4,9	4,7	4,9	4,8	4,7	4,7	4,6	4,9	
	2	19,1	19,5	20,1	23,5	19,6	19,0	18,9	19,2	19,3	19,9	19,5	

The rapid and multidirectional development of the territory of New Moscow after 2013 led to the formation of areas with different trends in the transformation of the environmental situation. The changing environmental situation in New Moscow is the result both of transformational factors, which are connected with the change in the territory's status and massive residential construction, and path-dependencies, which determine the level of infrastructure development and the development of the territory.

Pollution of the atmosphere from stationary sources

In the post-Soviet period industrial production in Moscow contracted significantly more rapidly than in Russian Federation as a whole. Simultaneously, the industrial sector's impact on the environmental situation in the city also decreased. The volume of wastes in Moscow decreased to one-fourth the level of 1990, while it was merely halved in the country as a whole. The share of pollutants emitted to the atmosphere from stationary sources decreased to 6%, which was facilitated not only by explosive pace of automobilization, but also by the decline of industrial production (Report on the state… 2016). However, the rate of decline in emissions from stationary sources is gradually slowing, and this is occurring against a background of continuing contraction of industrial production (considered without taking into account the extractive sector in order to avoid statistical distortion due to the location of juridical addresses of major companies in the capital); therefore, emissions from certain stationary sources are increasing.

The change in the sectoral structure of Moscow's air pollution in the post-Soviet period is explained by a growing degree of localization: 14 of the city's enterprises produced 78% of the city's total pollution from stationary sources in the 1990s, and their share rose to 80-85% in the 2005-2016 period (calculations based on data (Report on the state… 2016).

In recent years the thirteen working power stations and their boiler houses have accounted for 50-65% the volume

of polluted emissions and the refinery has accounted for 20-30%. Moscow has done the most in all of Russia to decrease the volume of emissions from the energy sector, specifically by changing the fuel structure to use natural gas – now 96.7% of the total fuel used—and by reconstructing the stations. The level of power consumption by Moscow's industries is among the lowest among Russian regions; however, since 2005 it has had a strong tendency to grow (Basic Indicators… 2017).

Also above the Russian average has been the rate of decrease in emissions from the oil refinery, which is located in the southeastern region of Old Moscow. The refinery lowered its gross pollution by a factor of 2.2 in the 1992-2000 period after reconstruction and changes in the technological process. The share of machine-building in polluting Moscow's air is down to 2-3 percent. There is no pollution today from the metallurgical complex because of the closing of the metallurgical plant in Moscow's eastern region that had been in operation since 1883.On the other hand, pollution has risen by a factor of six coming from stationary sources of the transportation complex and other forms of economic activity, such as the start-up of garbage-incineration plants and non-industrial pollution sources which previously were not monitored (Fig. 1). The two percent share of the remaining sectors is accounted for by the production of food products and construction materials (calculations based on Data base Regions of Russia… 2016).

There is no power station complex in New Moscow, but there are boiler houses which use 4.4% of the natural gas consumed by the city and account for 4.5% of the emissions into the atmosphere. Moscow new adjoint area's share of polluted emissions is gradually increasing (Report on the state… 2017).

A transition in the composition of emissions into the atmosphere from stationary sources has been caused by changes in the industrial sectors. Nearly half the emissions consist of NOx while CO accounts for 15%, thanks to the dominance of natural gas in the power sector; the refinery largely accounts for the 16% share of SO2 and 11% share of volatile organic compounds. The structure of emissions in the administrative districts varies little from the average values for the city except

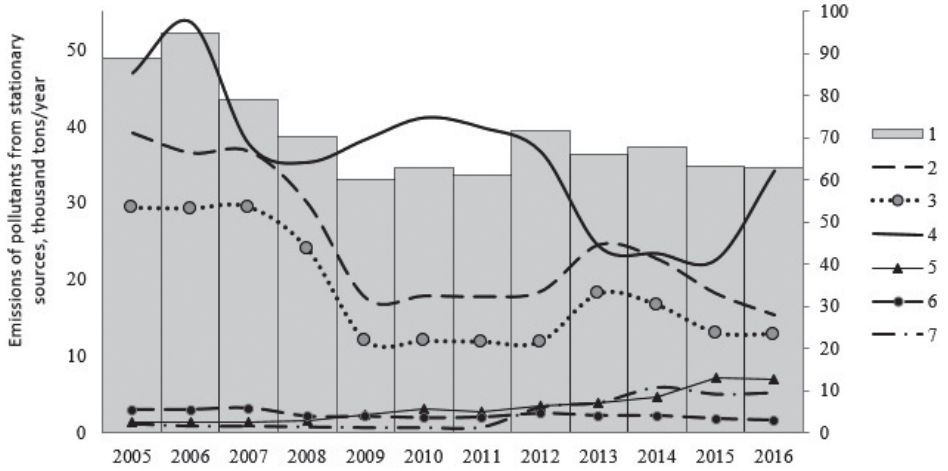

Fig. 1. Total emissions of the most prevalent polluted substances in Moscow's air from stationary sources that contribute more than 1% of the total volume, classed by type of economic activity: 1—Total (right-hand scale); 2—manufacturing; 3—petroleum products; 4—production and distribution of electricity, natural gas, and water; 5—other types of economic activity; 6—production of means of transportation and equipment; 7—transportation and communications

in the southeast, where the share of SO2 rises to 60% in Kapotnya district and to 52% for the whole of the Yugo-Vostochnyi Administrative Okrug, due to impact of the petroleum refinery (Fig. 2) (Report on the state… 2017).

In the 1990-1995 period the decrease in the volume pollutants affected all the ingredients, but after the transition to natural gas beginning in 1995 mainly NOx has accounted for the decrease in emissions. In the 2005-2015 period the emission of solid substances has been curtailed to a great extent (by 59%); sulphur dioxide emission has been halved; volatile organic compounds have decreased by sixty-seven percent. The volume of hydrocarbon emissions is increasing as a consequence of a decrease, from 56% to 40% in the portion of air pollutants that have been retained or rendered harmless by the gas-emission purification installations (calculations based on data (Data base of indicators… 2016).To achieve further reduction in the volume of emissions will be technologically complicated and expensive. In New Moscow the portion of the retained or cleansed emissions is significantly lower and in the majority of the municipalities it does not exceed 1%, with the exception of the urban district of Sherbinka (calculations based on database "Regions of Russia", 2016)

New Moscow is characterized by a low level of pollution; the volume of emissions in the territory constitutes 10-13% of Moscow's total (calculations based on data database "Regions of Russia", 2000-2016). Moscow new adjoint area's percentage share has risen somewhat because in most of Old Moscow's okrugs emissions have declined more rapidly than in the new territories, where they sometimes are growing. The main increase comes from settlements that located along Kaluzhkoe highway, New Moscow's central axis, connected with the presence of gas-pipeline infrastructure (gas-compressor station, which burns natural gas for its operation) leading to Old Moscow. The second important source of pollution is a legacy from the previous period; most of the boilers are antiquated and use fuel oil, and consequently sulphur dioxide makes up a large portion of their emissions This is a low, but «non-capital» type of pollution, because in the post-industrial period, in the territory of old Moscow, the main sources of pollution are gas-fired power plants.

New Moscow's portion of air pollution, fuel consumption, and emissions from heating systems is 2-2.5 times higher than its share of population. This is the consequence both of the technical obsolescence of suburban boilers and the lower population density, with its spread-out infrastructure, and lower environmental efficiency. However, at the same time the low-density distribution of pollution sources allows for the ventilation of the territory. As a result, according to the monitors, the average concentrations of pollutants registered in Moscow new adjoint area's territories are 10-40% lower than the average concentrations over an analogous period in functionally similar zones in Old Moscow (Report on the state… 2017).

Air pollution from automotive transportation

The main determinant of the state of Moscow's environment is automotive transportation (93.4% of the emissions into the atmosphere).The volume of emissions from automotive transportation in the 200-2016 period rose just by 15% (979 200 tonnes in 2016). Today 10% of Russia's automotive fleet is concentrated in Moscow. The maximum annual growth in the number of automobiles (19.1%) was observed at the beginning of the nineties; thereafter the situation stabilized somewhat until a turning point was reached in 1996, when the growth rate began to decline. In recent years, the annual average growth rate of the city's automobile fleet has declined to a 5%, which indicates market saturation (Database "Regions of Russia" 2016).

Simultaneous with the increase in automobilization, there has been an intensive renewal of the auto fleet with

Fig. 2. Index of physical volume of air emissions of pollutants from stationary sources, 2008-2016, % (2008 = 100%) Index: 1. More than 500; 2. From 200 to 500; 3. From 105 to 200; 4. From 95 about 105; 5. From 75 to 95, and 6. From 50 to 75; 7. Less than 50; 8. No data

automobiles of higher ecological classes (approximately 2-3% per year) and a decrease in the proportion of freight-hauling trucks (by about 50% between 1991 and 2006), which have helped improve the environmental parameters of automobile transport. This has been connected simultaneously with the growth in the population's purchasing power and the strengthening of environmental regulations concerning fuel and automobiles.

If you look at the dynamics of emissions from vehicles by type of cities, the rise of the early 2000s was characteristic of all types, to the greatest extent for millionaires, the smallest for small cities. The cities of New Moscow (Troitsk, Moscow and Shcherbinka) stand out even against the background of similar cities in terms of population. The increase in emissions from vehicles differs not only from Moscow in the old borders, but also from the cities of the near Moscow region (Fig. 3). It is here that in recent years and there has been the most significant increase in emissions into the atmosphere and, as a result of the increase in the number of cars and as a result of the fact that the transport network can not cope with the flow.

The changes in the structure of the automotive fleet and the improved quality of fuel were induced by the growing environmental consciousness of consumers. The strengthening of the regulations on automobiles and the formation of vertically-integrated companies capable of bring high-quality gasoline to the market led to investments in oil refining for the production of higher quality gasoline. Now that motor fuels have reached the planned level of quality, there are practically no options for further reduction of emissions. The improvement

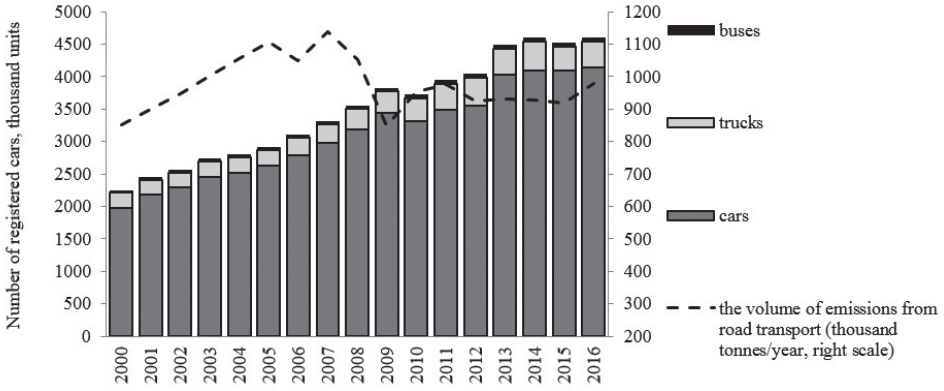

Fig. 3. Dynamics of emissions into the atmosphere from stationary source and automotive transport, 2000-2016 (Report on the state... 2017; Data base of indicators... 2017)

in the quality of gasoline and the change in the composition of the automotive fleet led to reductions in both the gross and relative amount of pollution (the amount of emission per kilometer has been reduced by 75%) from automotive transportation. Consequently, in 2007 the intense growth of the automotive fleet in Moscow ceased to correlate with growth in the volume of pollutants emitted(calculations of the authors of emission volumes along the streets). Calculation of emissions was based on primary information on traffic intensity and flow structure on each street in Moscow in 1990, 1998, 2002 and 2006 and 2016. The measurements were carried out with the help of traffic police cameras (traffic police of Moscow) and provided by the research firm ESPAR-Analytic, supplemented by data from field monitoring studies conducted by the authors and their students. The results of previous studies are published in the article written by Bityukova and Sokolova (2008).

In contrast to industrial emissions, in which case the data are to a significant decree derived from measurements, the volume of emissions from automotive transport is entirely a calculated quantity, based on the results of different studies of the emissions of various types of automobiles having various engine-operation conditions. The complexity of deriving a correct assessment of the volume of emissions from automobile transportation is due to a multitude of factors, effects of which are extremely complicated to take into account. In the current study, based on data about the intensity of mobility, the structure of the traffic flow according to automobile type (load-carrying capacity), engine horsepower, environmental characteristics (taking into account age), and the fuel type, we calculated the annual mileage of automobiles on every arterial road taking into account adjustments for speed of traffic flow, the frequency of "stop-and-go" traffic, and the number of traffic jams. To determine the territorial differentiation of air pollution independently from mileage we calculated the volume and then the density of emissions (tonnes per square kilometer) relative to the size of the source areas of the emissions, which were obtained by the OND-86 method from every source. The OND-86 a long time remained the only document developed and approved by the Main geophysical Observatory named after A.I. Voyeykov of the USSR Goskomgidromet in the prescribed manner, and that this method is the calculation of dispersion of emissions of pollutants from emission sources in the project documentation (Tishchenko 1991).

In Old Moscow the main trend of the last 15 years has been the evening out of environmental pollution due to automobiles, as it shifts from the regions where jobs are concentrated to residential areas. As the projects to expand and reconstruct the road network have been completed, the number of areas with maximum levels of pollution has decreased.

The emissions from automotive transportation is New Moscow constitute 6% of the city's total. This amount is increasing rapidly. Areas in which the volume of emissions exceeds 1500 tonnes per year and the average density exceeds 350-550 tonnes per square kilometer (which is the base level found between the city's center and its outskirts in 2012) are found along MKAD and the main road arteries. The areas which experience rather high densities of automotive emissions in the former cities of Troitsk, Shcherbinka, and Moskovskii are not large (the maximum density of emissions in Kommunarka amounts to 530 tonnes per square kilometer).In contrast to Old Moscow, the source-areas and intensity of automotive pollution can only grow, especially in the zone adjacent to Old Moscow in the near future, thanks to population growth and the insufficient growth of the transport network (calculations based on data (Data base of indicators… 2016).

Automotive transport is also a source of noise pollution. Moreover, the noise level along major highways in recent years is not reduced in contrast to the volume of emissions into the atmosphere. This problem is significantly acute in the Moscow new adjoint area, where sources of noise are numerous construction sites. Expansion of roads involves cutting of trees, which had previously protected the surrounding areas from the noise and dust of the roads. The major source of acoustic and vibration pollution is the airport «Vnukovo», which is on the rise.

Pollution of water resources

On the whole in Moscow the pressure on water resources is diminishing: from 2007 to 2015 a steady downward trend in the volume of sewage (27%) has been observed. However, in New Moscow both water use and sewage are growing, which is largely connected with the construction of individual homes, residential complexes, and settlements (calculations based on data Report on the state… 2017).

Construction near waterways is causing pollution from surface run-off, which despoils natural landscapes. Construction of cottages near waterways is the most pervasive, residential complexes are rarer. In 2016 work began in the water-protection zones of the Pakhra and Desna rivers on the widening of Kaluzhkoe highway and construction of an overpass over it, as well as overpasses over Moscow Oblast's segment of the Central Ring Road. Construction often disturbs the water-protection zones of rivers – even when purification facilities are built the excavated soil is piled up adjacent to the rivers.

Most of the projects and, as a consequence, new potential centers of settlement are located in a ten-kilometer zone from the Moscow Ring Road (Revzin 2015). However,

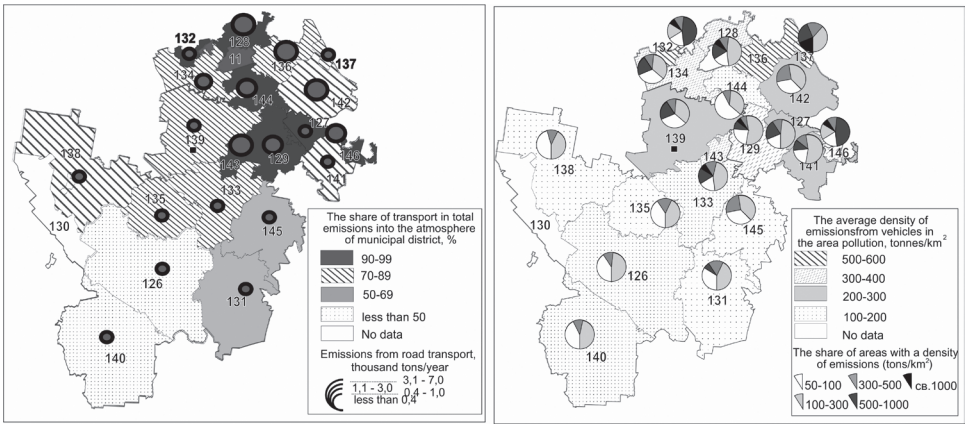

Fig. 4. Automotive emissions into the atmosphere by municipal district in New Moscow, 2016

if a few years ago the intensity of housing construction, like most of the indicators, reflected well the belt structure of the Moscow agglomeration (Brade et al. 2013), was determined by the distance from the Moscow Ring Road, without allocating the sector of New Moscow (Brade et al. 2014), the latest data show a sharp increase in construction in New Moscow.

Our calculations by the method (Popov and Kuricheva 2015) show that in 2017 the share of new buildings from the number of existing houses in Novaya Moscow in comparison with the Moscow region in the 5-kilometer zone from Moscow ring road is 4.8 times higher, in the zone of 6-10 km - 3.4 times, 11-15 km - 1.3 times, 16-40 km - 2.6 times. In the near future of New Moscow, the number of new buildings exceeds the number of existing houses by 1.5 times.

Increases in run-off from urbanized areas and in the volume of sewage are confirmed by data from monitoring, which registered growth since 2015 in the average annual concentrations of a majority of the analytic indicators in Moscow new adjoint area's waterways. The main source of biogenic pollution of the rivers is untreated and inadequately treated household wastewater and sewage while the suspended solids and metals come from rainwater and snow-melt run-off from asphalt. Therefore, in relatively wet years the concentration of suspended materials and metals increases, while the concentration of biogenic elements (nitrogen and phosphorus groups) diminishes because of dilution. The results of regular observations of water quality in the Pakhra and Desna rivers indicate that they are significantly more polluted than the Moskva river and that the main source of the pollution is found in the upper reaches of the watershed, which includes Moscow Oblast' territory (Environmental program… 2017).

According to the "Mosvodokanal" corporation, a large part of the purification facilities in New Moscow don`t meet current technical and technological standards for water purification and drainage. They require complex reconstruction aimed at boosting productivity. Moreover, the massive scale of current and planned residential construction necessitates the construction of new purification facilities. In this regard, after the rivers leave New Moscow, the concentration of pollutants declines by 10-30%.This indicates that the river-basin landscapes have not yet lost their capacity for self-restoration. Thanks to naturally occurring processes, they can restore the quality of their natural components (Report on the state… 2017).

The processing of solid household wastes

One of the peculiarities found in the interaction of the city with its hinterland is how the system of collection, hauling, and processing of waste operates. Moscow generates household, construction, industrial, and medical waste products; this article considers only the household solid wastes. Already in the early 2000s the quantity of wastes from Moscow located in the landfills and dumps of Moscow Oblast' exceeded the amount of wastes produced in the oblast'.

In 2010 one of Moscow Oblast's environmental problems was the presence of more than 50 landfills, the capacity of which was 80% exhausted, and some 1500 unsanctioned dumps. In Russia officially a landfill (poligon) is a legislatively-determined area for the collection of garbage which is equipped with devices for the collection of soil filtrates and gases from wastes. A garbage dump (svalka) also might be legal, but it is not supplied with special equipment. In reality, what is called a landfill may actually be a dump. Within Old Moscow itself there were four garbage-incineration plants, which burned one-third of Moscow's garbage. About 5% of the household solid wastes are recycled and the rest are buried in Moscow Oblast' (Generation… 2016). Today the situation regarding wastes in Moscow and Moscow Oblast' is changing, but not for the better. Old Moscow alone annually produces about 25 million tonnes of wastes from

production and consumption (household, industrial, construction, etc.), while the new territories account for about an additional 90 000 tonnes. Every year this figure increases by three percent (Gunko et al. 2016).

Troitskii and Novomoskovskii administrative okrugs currently are relatively minor producers of household solid waste, but in ten years they will catch up with Old Moscow's districts. It is especially important to consider the rapid pace of residential construction in New Moscow new adjoint area. Moreover, now there is the question of where to take the construction waste that will be generated by the destruction of buildings in Moscow in accordance with the "renovatsiya" program, which will demolish low-quality five-story buildings. It is possible that this waste will end up in New Moscow.

In July 2011 authorities in Moscow and Moscow Oblast' signed an agreement concerning production and consumption wastes which considered setting up inter-regional complexes to recycle wastes. Since 1 January 2017 it has been illegal to bury wastes containing useful materials (plastic, glass, ferrous-metal scrap, recyclable paper). Such wastes constitute up to 60% of household solid wastes (Bukreev and Korneyev 1999). The territorial schema for Moscow Oblast' for 2019 suggests creating the facilities to remove useful materials from garbage. At present for practical purposes they do not exist (Comprehensive strategy… 2013).

After annexation Moscow found that four landfills came with the new territories: Salar'evo (60 ha), Sosenki (40 ha), Malinki (8.6 ha), and Rakitiki (4 ha) (Fig.5). Currently they are closed and undergoing reclamation. In addition, about sixty unsanctioned dumps turned up in Moscow new adjoint area. Along with the removal of large areas, the main negative effects of landfills are the leaching of filtrates into the soil and groundwater, emission of greenhouse gases such as carbon dioxide and methane, spontaneous combustion, unpleasant odor, and a massive infestation of rodents. (Fig. 5)

Currently there is no plan to open new landfills or other facilities for recycling in New Moscow, and so it is difficult to say how the problem of dealing with wastes will be resolved. However, despite the afore-mentioned law banning the burial of wastes that can be recycled, at present 34 landfills are in operation in Moscow Oblast' which continue to receive garbage from the capital, among other sources. Moreover, new landfills are planned for five spots in Moscow's hinterland. According to expert opinion, these tracts are located primarily in the eastern and southeastern parts of Moscow Oblast', which are densely populated and have insufficient infrastructure. All the new landfills moreover will have trash-reprocessing plants. Therefore, the question of opening new landfills in the future for household waste, or industrial and construction waste, remains open, despite the official ban. Along with the landfills, four plants for the terminal detoxification of wastes, each with a capacity of 700 000 tonnes, are planned for Moscow Oblast' (Fig. 5). Half of the plants' capacity will be reserved for the terminal detoxification of household solid wastes coming from Moscow (Comprehensive strategy… 2013).

In reality, the environmental consequences will depend on two factors: 1) whether or not the waste collected will be sorted and 2) the temperature of the terminal detoxification. Widely accepted as best practice to maintain safety is to employ high temperature incineration (over 2000° C) and pyrolysis (high-temperature anaerobic disintegration) at a temperature near 3000° C (Drobnaya and Gubonina 2008). But if the incineration will consist of burning the unsorted flow of trash at a low temperature, the fears of the nature-protection groups will be justified. The main negative consequence would be emissions into the atmosphere both of fine ash and metallic dust and the known-carcinogenic dioxin. The radius of toxic contamination from a trash-incineration plant can reach 25 km. (taking into account the wind pattern) (Gorbacheva 2009); accordingly both Moscow Oblast' and New Moscow fall within the potential zone of contamination.

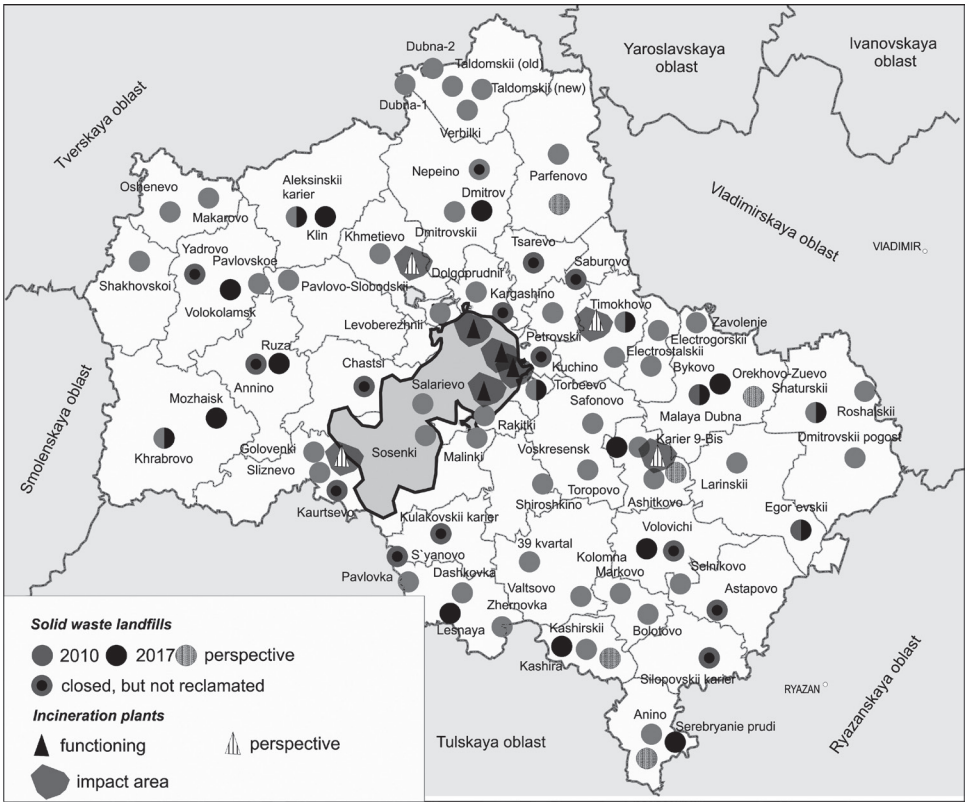

Fig. 5. Transformation of the garbage-processing infrastructure in Moscow Oblast' and Moscow, 2010-2017 (Comprehensive strategy... 2013)

CONCLUSION

Despite the fact that Moscow's annexation of new territories was to a large extent presented as the solution to environmental problems, there are negative tendencies in New Moscow. The number of pollution sources as well as the size of the built landscape is increasing steadily; this is causing the balance between transformational and inherited factors to change rapidly in the dynamic environmental situation.

1. The developmental legacy, or "path dependency," plays an exceedingly large role in the new territories. One of the factors affecting the level of impact is the structure of the automotive fleet, the planning structure, bridges, the width of the roads, the structure of the road network, the network's weak connectivity, the enhanced role of transit functions, and so on. Currently the density of the road network and its connectivity are growing significantly more slowly than the quantity of multi-story residential buildings in New Moscow.

Also among the inherited factors is the increase in the number of boilers, heating mains, and purification facilities to protect water sources, which leads to greater strain on the territory's natural environment.

2. Transformational factors, which both intensify (e.g., the number of automobiles) and reduce (e.g. improved fuels and engines) the anthropogenic impact, depend to a great extent on the socio-economic situation and it is these factors that have caused the changes seen in recent years. As a result of the changes discussed above, the correlation between volume of harmful emissions and size of the automotive fleet has come to an end. The significance of these factors is extremely great.

The proportion between transformational and inherited factors changes rapidly in the formation of the environmental situation. Thus, if for Moscow in the old boundaries the inherited factors are mainly negative for the formation of the environmental situation, and the transformation takes place in the direction of a slow and gradual improvement, and for the territory of New Moscow, both groups of factors are still acting in the direction of the negative scenario.

3. Trends in the environmental situation on the territory of Moscow in new borders:

- closer to the territory of Moscow in the old borders on the pollution sources structure and specific emissions into the atmosphere based on the volume of production, since the most non-industrial part of the Moscow region was chosen for accession to Moscow

- close to the corresponding belt of the Moscow region in terms of environmental efficiency (the degree of capture of emissions and waste);

- own trends due to the effects of rapid population growth – the growth of air emissions from housing and transport. Despite the fact that the level of pollution in the New Moscow is low, but the environmental efficiency is also low. As a result, pollution levels are growing rapidly.

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