

# Sustainable urban development: the impact of an asphalt plant on the quality of atmospheric air

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**Abstract.** The development of industry, the use of various chemicals in technological processes, the large emissions of industrial enterprises, the use of pesticides and chemical fertilizers in agriculture have caused environmental pollution with harmful substances. Environmental protection is now becoming one of the economic problems and is an extremely urgent task of humanity. The purpose of this article is to present the main results of the study and analysis of atmospheric air pollution by the asphalt plant, which is located almost in the center of Yekaterinburg; to investigate the compliance of the existing hazard class of the enterprise, which increases its production volumes, to correct the size and location of the sanitary protection zone of the plant, taking into account the wind rose, and to try to propose a number of measures to reduce the negative impact of the plants in this industry. In considering the impact of anthropogenic activities on nature, attention should be paid to the concept of sustainable development, which carries principles based on the satisfaction of human needs, with a focus on caring for the well-being of future generations. If we consider the issue from the perspective of this concept, then the asphalt plant, in order to prevent possible environmental damage, should invest material and money to further minimize the amount of pollutants.

## 1 Introduction

One of the components of the definition of "sustainable development" is the cleanliness of the environment. Limiting the harmful effects of pollutants on the environment plays an important role in ensuring the suitability of urban areas for living.

According to the UN definition, "a sustainable city is a city in which achievements in social, economic, and physical development are constant. A sustainable city is constantly provided with natural resources, on which sustainable development depends. A sustainable city supports the long-term safety of its residents, including from natural disasters." In other words, the sustainable development of the city ensures the safety of its population and a high quality of life [1,2,3].

In our study, we decided to present the impact on the air space of the city, the district, the presence of a construction plant on the territory, and also to show how the environmental

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indicators of these industries, such as the hazard class, the size and geography of the sanitary protection zone, can change over time.

Asphalt plants produce asphalt concrete, which is used for the construction of road surfaces. During the production process, gases and solid particles are released from the installation stakes, which enter directly into the atmosphere with little or no treatment. These emissions could be controlled, but most asphalt plants in Russia do not have adequate provision for pollution monitoring devices. During production activities, fuel combustion products, such as carbon oxides, soot, benz(a)pyrene, and sulfur dioxide, enter the atmospheric air [4,5,6,7,8,9].

The most common air pollutant from asphalt production using methods based on high temperatures is inorganic dust, which is formed as a result of the influence of high temperatures during the preparation of asphalt concrete.

At the stage of operation of the facility, you can see the full extent of the danger posed by the plant, during which the proposed asphalt concrete plant will operate.

The potential impact on the environment and human health associated with the operational phase of the asphalt plant is the direct harm affecting the environment and human health [5,7,10,11,12].

## 2 Main points, methods and results

In this article, we will present the results of a study of the current activities of LLC "Yekaterinburg Asphalt Plant» (Fig. 1.), according to the current documents, the enterprise belongs to the third category of danger and is medium-dangerous.





**Fig. 1.** Location of the plant in the city; type of work site.

In our work, we decided to make sure of the hazard class of the plant at the moment, because we are seeing an increase in production. The list of substances that make the greatest contribution to air pollution from the activities of this plant: alkanes C12-C19 (limit hydrocarbons C12-C19) - 18.306526 t / year; carbon monoxide-10.325145 t / year; inorganic dust: 70-20% SiO<sub>2</sub>-3.002978 t / year; nitrogen dioxide - 2.078346 t / year.

Recall that for calculations to identify the hazard category, enterprises (CPC) are guided by the value of the mass ratio of the gross emission of substances according to the average daily criterion of the maximum permissible concentrations of this substance [6,7].

The hazard category of the enterprise is calculated by the formula 1:

$$CPC_{n\ i=1} = \sum(M_i/MPC_i) * \alpha_i \quad (1)$$

where  $M_i$  – mass of release of the  $i$ -th substance, t / year;

$n$  – number of substances used;

$\alpha_i$  – a dimensionless constant that allows you to correlate the degree of harmfulness of the  $i$ -th substance with the harmfulness of sulfur dioxide;

$MPC_i$  – the average daily maximum permissible concentration of the  $i$  – th substance, mg/m<sup>3</sup>.

To identify the hazard category, you can also use other criteria, such as the maximum single MPC and approximately safe levels of exposure to pollutants in the atmospheric air of populated areas, in the absence of the necessary criterion – the average daily MPC.

For further work, it is necessary to use the following characteristics of pollutants: the hazard class of the substance, the criterion used and its value, the total emission of the substance per year.

All the above-mentioned characteristics related to the studied pollutants released into the atmospheric air by the asphalt plant are contained in Table 1, where all our calculations were made in accordance with formula 1 for each pollutant [4,7,8,10].

In the emissions of the investigated enterprise, there are 16 types of pollutants, where the maximum single maximum permissible concentration is set for 11 substances; the average daily maximum permissible concentration is set for 2 substances; the MAXIMUM (approximate safe level of exposure of pollutants to the atmosphere) is set for 3 substances.

**Table 1.** Results of calculation of the hazard category of the enterprise "Yekaterinburg Asphalt Plant" LLC.

Polluting substance	Hazard class	$a_i$	MPC <sub>i</sub> , mg/m <sup>3</sup>	M <sub>i</sub> , t/year	M <sub>i</sub> /MPC <sub>i</sub>	(M <sub>i</sub> /MPC <sub>i</sub> ) $a_i$
di Iron trioxide (Iron oxide) (in terms of iron)	3	1	0.040	0.02475900	0.618975	0.618975
Manganese and its compounds (in terms of manganese (IV) oxide)	2	1.3	0.001	0.00066700	0.667000	0.590695394
Nitrogen dioxide (Nitrogen (IV) oxide)	2	1.3	0.040	2.07834600	51.958650	169.9633241
Nitrogen (II) oxide (Nitrogen oxide)	3	1	0.060	1.31383000	21.897167	21.89716667
Carbon (Soot)	3	1	0.050	0.00444500	0.088900	0.0889
Sulfur dioxide-Sulfur Dioxide Anhydride	3	1	0.050	0.11490600	2.298120	2.29812
Dihydrosulfide (Hydrogen Sulfide)	2	1.3	0.008	0.00000001	0.000001	0.00000002
Carbon oxide	4	0.9	3.000	10.32514500	3.441715	3.041567186
A mixture of natural mercaptans (Odorant SPM-TU 51-81-88)	3	1	0.00005	0.00000001	0.000110	0.00020
Methane gas	4	0.9	50	0.00376500	0.000075	0.000194588
Benz/a / Pyrene (3,4-Benzopyrene)	1	1.7	0.000001	0.00003700	37.000000	463.3860238
Gasoline (oil. low-sulfur)	4	0.9	1.5	0.00039900	0.000266	0.00060589
Kerosene	4	0.9	1.2	0.06271100	0.052259	0.070201474
Alkanes C12-C19 (Limit hydrocarbons C12-C19)	4	0.9	1.0	18.30652600	18.306526	13.68816851
Nonorganic dust: 70- 20% SiO <sub>2</sub>	3	1	0.100	3.00297800	30.029780	30.02978
Abrasive dust (White corundum. Monocorundum)	3	1	0.500	0.01152000	0.023040	0.02304
Total:				35.25003401	166.38258362	705.697

Again, we remind the reader that according to the degree of impact on the human body, the pollutants present in the emissions of the enterprise are divided into several hazard classes, indicated in Table 2.

**Table 2.** Hazard classes of pollutants.

Hazard class	Degree of danger	Examples of substances
I	extremely dangerous	benz/a / pyrene (3,4-benzpyrene)
II	high-risk	manganese and its compounds (in terms of manganese (IV) oxide), dihydrosulfide( hydrogen sulfide), nitrogen dioxide (nitrogen (IV) oxide);
III	moderate-risk	di Iron trioxide( iron oxide), nitrogen (II) oxide (nitrogen oxide), carbon (soot), sulfur dioxide, a mixture of natural mercaptans (odorant SPM-TU 51-81-88), inorganic dust: 70-20% SiO <sub>2</sub> , abrasive dust (white corundum, monocorundum);
IV	low-risk	carbon monoxide, methane, gasoline (petroleum, low-sulfur), kerosene, alkanes C12-C19 (limit hydrocarbons C12-C19)

At the final stage of the calculations, we obtained the sum of the results for each substance, which amounted to 705.697. Based on the final value, it can be concluded if the CPC < 103, namely 705.697, therefore, according to the calculated data, the enterprise belongs to the IV hazard category.

As you can see, there was a decrease in the hazard class of the plant as a pollutant at the time of research, this is a good indicator of the environmental safety of production and the environmental situation of the territory where the plant is located. And yet the cumulative effect of pollution from any production takes place.

According to the Resolution of the Chief State Sanitary Doctor of the Russian Federation of September 25, 2007 No. 74 "On the introduction of a new version of the sanitary and epidemiological rules and regulations of the SanPiN 2.2.1/2.1.1.1200-03", for industrial facilities and production facilities, structures that are sources of impact on the environment and human health, the approximate size of sanitary protection zones is established (SPZ).

According to the documents, the production of asphalt concrete at the plant under study is classified as hazard class 3 – for it, the sanitary protection zone is 300 m.

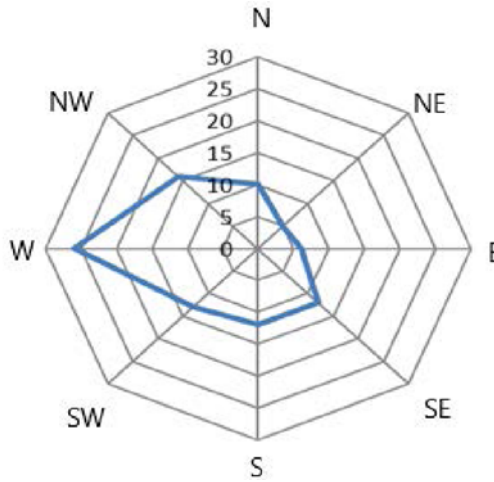
This means that no residential development is allowed within 300 m of the plant's fence, including individual residential buildings. Landscape and recreational areas, recreation areas, territories of resorts, sanatoriums and recreation centers, territories of horticultural associations and cottage development, collective or individual dacha and garden plots, sports facilities, playgrounds, educational and children's institutions, medical and preventive and health-improving institutions of general use are also prohibited [1,11,12].

Therefore, we will present in the article, based on the results of our study, the adjustment of the definition of the SPZ of the enterprise in accordance with the wind rose of the city of Yekaterinburg, the data for the construction of which are presented in Table 3.

**Table 3.** Repeatability (P,%) of winds of different directions and calms.

N	NE	E	SE	S	SW	W	NW
10	5	6	12	12	13	26	16

Let's imagine the construction of the wind rose of the city of Yekaterinburg (Fig. 2.).



**Fig. 2.** Wind Rose of the Yekaterinburg city.

Since the CPC is  $< 103$ , the standard size of the sanitary protection zone (SPZ), according to the SanPiN 2.2.1/2.1.1.1.200-03, for this enterprise is 100 meters. Since the KOP  $< 103$ , the standard size of the sanitary protection zone (SPZ), according to the SanPiN 2.2.1/2.1.1.1.200-03, for this enterprise is 100 meters [5].

Next, we will adjust the SPZ in accordance with the wind rose of the city of Yekaterinburg according to formula 2:

$$l = l_0 \cdot (P/P_0) \tag{2}$$

where  $l$  – calculated (corrected) value of the sanitary gap, m;

$l_0$  – the value of the SPZ in accordance with the CPC for enterprises;  $l_0 = 100$  m;

$P$  – wind repeatability in a particular direction according to the average annual actual wind rose, %;

$P_0$  – the average repeatability of the wind directions of one point with a circular wind rose, %.

At the eight-diamond rose of the winds:  $P_0 = 100/8 = 12,5\%$ .

When adjusting the width of the SPZ, taking into account the prevailing wind directions ( $P > 12,5\%$ ).

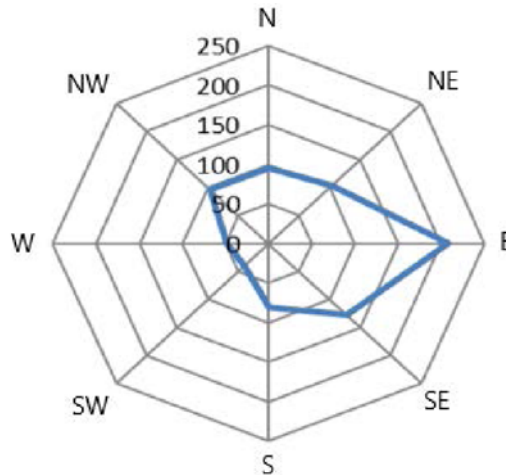
Next, we perform calculations to establish the boundaries of the SPZ and adjust it in accordance with the wind rose.

The establishment of the SPZ was carried out in the directions located to windward relative to the prevailing air flows. The results of calculations of the sanitary protection zone of the enterprise are presented in Table 4.

**Table 4.** Results of calculating the size of the sanitary zone, m.

N	NE	E	SE	S	SW	W	NW
96	104	208	128	80	40	48	96

The graphic image of the sanitary protection zone of the enterprise adjusted by us for calculations taking into account the wind rose is presented on Fig. 3..



**Fig. 3.** Sanitary protection zone of the investigated enterprise.

Thus, when adjusting the SPZ in accordance with the prevailing wind directions, the magnitude of the sanitary gap increased in the north-eastern, eastern and south-eastern directions.

Residential buildings fall within the boundaries of the SPZ, the distance from the enterprise to the nearest residential building is 154 m (east side). Which is a violation of the regulations of the MPI (noted above). It is necessary to take measures to reduce emissions into the atmosphere.

### 3 Research suggestions and discussion

Proposals for reducing the impact of asphalt plant (AP) atmospheric air

The regulation of emissions of harmful substances into the atmosphere is understood as their short-term reduction. The contribution of different sources of pollution should be considered when developing emission control measures. In each case, it is necessary to determine which sources should be used to reduce emissions.

In accordance with the calculation of the economic assessment, we determined that emission control measures should be developed for the following pollutants: nitrogen dioxide, hydrocarbons, and inorganic dust.

It is necessary to increase the technological efficiency of the processes accompanied by dusting, namely, the integration of the automation mechanism of the enterprise, as a result of which full control over all operations carried out by the installations will be obtained, in order to reduce the impact of emissions on the atmospheric air.

In addition, making the following changes to the gas treatment plant system:

- upgrade of already outdated dust collectors to updated ones, which will increase the degree of cleaning.

- introduction of a larger number of dust collectors (creation of a block of bag filters with a high extremely high degree of purification).

- modification of the gas cleaning system, namely the addition of the missing dust collectors necessary for the full functioning of the cleaning system (the gas cleaning system stated in the documentation contains a larger number of dust cleaning mechanisms than those that are currently functioning at the enterprise).

When analyzing the discussion of the topic, we liked some of the conclusions of scientists, which we will present to your attention. In countries with strict requirements for

environmental protection, a special covering – the so-called sarcophagus-was installed on the AP.

This makes it possible to more radically solve the problem of dust and hydrocarbon vapors entering the atmosphere, as well as significantly reduce the noise level.

This solution seems especially logical in the case of placing a gas station in the city. This, of course, will lead to a certain increase in the cost of the plant, but it will demonstrate care for people living nearby with AP.

It is not always possible to completely remove asphalt concrete plants from a large city, since this will lead to an increase in the delivery time of asphalt concrete mix (with a loss of its quality) to places of construction or major road repairs in the city itself [3,6,10].

Such a complex of technological solutions will allow you to minimize the level of dust in the atmospheric air and create favorable conditions for living in relative proximity to the asphalt plant.

## 4 Conclusion

Our presentation of the research results is based on an ecological and technological assessment of the impact of emissions from an asphalt plant on the air basin of a large city area. Namely, they showed the definition of the hazard class of the studied enterprise in relation to the environment, where they saw that at present this indicator has changed for the better.

We have built a sanitary protection zone considering the wind rose, which is necessary for the construction and operation of any industrial enterprise to limit the impact of emissions on biota and human health, on the sustainable development of the entire city.

As a result of all the work done, it is worth noting that thanks to the conducted even a small study, we were convinced that to study the sustainable development of the territory, it is necessary to monitor all socio-ecological and economic indicators of the city's enterprises, including the asphalt plant as a potential air pollutant.

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