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# ҚАЗАҚСТАННЫҢ БИОЛОГИЯЛЫҚ ҒЫЛЫМДАРЫ

# БИОЛОГИЧЕСКИЕ НАУКИ КАЗАХСТАНА

## ҚАЗАҚСТАННЫҢ БИОЛОГИЯЛЫҚ ҒЫЛЫМДАРЫ

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## THE ANALYSIS OF THE ATMOSPHERIC AIR MONITORING SYSTEM ACTIVE IN THE CITY OF PAVLODAR

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### **Summary**

*The article is dedicated to the analysis of the atmospheric air monitoring system active in the city of Pavlodar. The problem of the atmospheric air pollution from motor transport, one of the sources of contamination, was considered. The data of the information bulletins of republican state enterprise «Kazgidromet» within the city of Pavlodar was studied and analyzed, which allowed to reveal the series of patterns: it was found that carbon monoxide, sulfur dioxide, nitrogen dioxide, nitrogen monoxide and particulate matter PM-10, PM-2.5 have been to a greater extent the atmospheric air contaminants. The analysis of the influence of motor transport on the environment was conducted, the size composition of exhaust gases of engines of various types of motor transport was described in details by the authors. Moreover, the street traffic congestion was determined, proposals and required recommendations on optimization of the given situation were made.*

**Key words:** *Monitoring system, atmospheric air, sources of pollution, hazardous substances, motor transport, stationary monitoring network.*

Problems of environment protection have been discussed urgently and have been remaining relevant for several years. With the growth in scientific and technical progress and production the need for the active study of the given theme as well as the creation of activities for environment protection has been rising. The current ecological situation requires a complex approach in the examination of the current situation with the atmospheric air quality [1].

One quarter of all the emissions from industrial enterprises and CHPs in Kazakhstan accounts for Pavlodar region. Over the years Pavlodar region has been one of the best in the development of ferrous and non-ferrous metals industry, production of alumina and oil. However, the development of these branches increases the pressure on environment pollution in Irtysh region; therefore problems of the examination of atmospheric air quality have been remaining rather relevant.

The statistics shows that annually 4.5 million tons of harmful substances are emitted into the atmosphere of Kazakhstan annually. One quarter of this volume accounts for Pavlodar region. 98 per cent is formed in the territory of three cities – Pavlodar, Ekibastuz and Aksu. The problem of the pollution of the air basin of regional human settlements has been remaining relevant.

For the hygienic assessment of tendencies in changing the state of atmospheric air it is necessary to know, apart from the composition of the harmful substances conditional on the specificity of their influence on the human organism, the concentration determining the intensity of an effect of one or another ingredient. The concentration of atmospheric contaminations depends on a number of factors, such as size and emission height of the source of release and pollution, temperature inversion, meteorological conditions (wind direction and speed, atmospheric pressure, solar radiation, cloudiness, precipitation), terrain, the availability of green vegetation and etc.

The larger is the emission per unit of time, the more substances emitted are supplied into the air flow, in which therefore the higher concentration of contaminants is created. To a great extent the emission depends on the intensity of an enterprise, its operating mode, the availability of treatment facilities, their performance, meteorological factors, from which wind direction and speed, atmospheric thermal stratification and air humidity deserve a special consideration. Cloudiness, fogs, radiation situation and precipitation have an impact on the degree of pollution [2].

Environmental monitoring is an important step in the scientific research allowing conducting the analysis and forming the fair assessment of the ecological situation to date. The monitoring should be adapted to various situations: the identification of contaminants for a particular period of time or the collection of samples in several places of the miscellaneous remoteness from the source of pollution for the more accurate result. For this purpose two kinds of posts are available: stationary and mobile [2].

The stationary post is designed to provide the continuous registration of the contaminants content or the regular air sampling for the subsequent analysis. The support stationary posts, which are aimed at the identification of the long-term changes in the basic and most prevalent specific contaminants content, stand out from among stationary posts.

The mobile post is intended for the regular air sampling, when it is not possible (appropriate) to establish the stationary post or it is necessary to study the condition of air pollution in certain areas, for instance, in new residential areas. The mobile (under-torch) post is aimed at the sampling under the smoke (gas) torch with a view to the identification of the influence zone of a given source of industrial emissions.

The tendency is that the atmospheric air pollution monitoring is currently applied to by government structures and industrial corporations. According to the Ecological Code of the Republic of Kazakhstan every enterprise of category from 1 to 4 should implement industrial environmental monitoring and control in the territory of their sanitary protection zones [3].

The systematic observation and assessment of the state of the environment in the territory of the Republic of Kazakhstan is conducted by the republican state enterprise «Kazgidromet». The state ecological monitoring (monitoring of environment and natural resources) is a complex system of the observation of environment and natural resources, inter alia with the use of the data of the remote sensing of the Earth from space with the purpose of the assessment, forecast and control of the changes of their state under the action of natural and anthropogenic factors.

For the assessment of atmospheric air quality the republican state enterprise «Kazgidromet» uses the following air quality indicators:

- the standard index (SI) – the highest measured in the city maximal non-recurrent concentration of any contaminant divided by MAC;

- the highest recurrence (HR) of exceeding MAC (%) – the highest recurrence of exceeding MAC by any contaminant in the city air;

- the index of atmospheric pollution (IAP) – an indicator of atmospheric pollution. For its calculation the average values of the concentration of various contaminants divided by MAC and adduce to the hazardousness of sulfur dioxide are used. On the basis of the data of the stationary observation network the general assessment of the city atmospheric air on several substances (suspended particles,

sulfur dioxide, carbon monoxide, nitrogen dioxide and others) was undertaken.

To date the observation of the state of the atmospheric air in the residential zone of

the city of Pavlodar is implemented by the republican state enterprise «Kazgidromet» at 7 stationary posts (picture 1, table 1) [4].

Table 1. The location of the observation posts and the impurities identified.

| Post number | Sampling time-frame | Conduction of observation         | Post address  | Impurities identified  |
|-------------|---------------------|-----------------------------------|---|--|
| 1           | 3 times per day     | manual methods (discrete methods) | <i>intersection of Kamzin Str. and Chkalov Str.</i> | suspended particles (dust), sulfur dioxide, sulphates, carbon monoxide, nitrogen dioxide, hydrogen sulphide, phenol, chlorine, hydrogen chloride |
| 2           |                     |                                   | <i>Aimanov Str., 26</i>                             |  |
| 3           | every 20 minutes    | on a continuous basis             | <i>Lomov Str.</i>                                   | suspended particles PM 10, sulfur dioxide, carbon monoxide, nitrogen dioxide and monoxide, ozone (ground-level), hydrogen sulphide               |
| 4           |                     |                                   | <i>Kaz Pravda Str.</i>                              | suspended particles, sulfur dioxide, carbon monoxide, nitrogen dioxide and monoxide, hydrogen sulphide   |
| 5           |                     |                                   | <i>Estay Str., 54</i>                               | suspended particles PM 2.5, suspended particles PM 10, nitrogen dioxide and monoxide, ozone (ground-level), ammonia                              |
| 6           |                     |                                   | <i>Zaton Str., 39</i>                               | suspended particles PM 2.5, suspended particles PM 10, sulfur dioxide, ozone (ground-level), hydrogen sulphide                                   |
| 7           |                     |                                   | <i>Toraigyrov Str. – Dyussenov Str.</i>             | suspended particles PM 2.5, suspended particles PM 10, nitrogen dioxide and monoxide, ammonia  |

According to the data of the stationary observation network of the republican state enterprise «Kazgidromet» (picture 1) the level of atmospheric air pollution was rated as heightened in 2020, it was determined by the values SI = 4 (the heightened level) and HR = 3% (the heightened level) for suspended particles (dust) in the area of post #2 (Aimanov Str., 26) (picture 1).

According to the data of the stationary observation network the level of atmospheric

air pollution was rated as heightened, it was determined by the values of the highest recurrence of exceeding MAC (HR) – 2.4%, the highest measured in the city maximal non-recurrent concentration in shares of MAC (standard index) – 6.1. The air is mostly polluted by carbon monoxide.

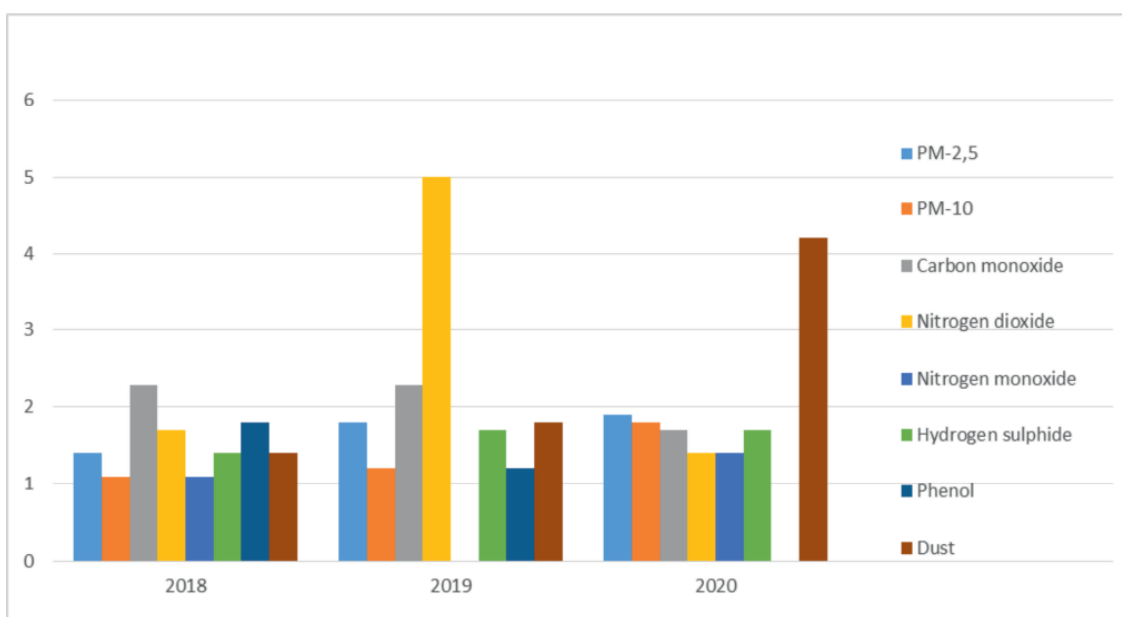
For the whole city the average monthly concentration of ozone reached 1.1 MAC, the concentration of other contaminants didn't exceed MAC.



Picture 1. The scheme of the location of the stationary network of the observation of the atmospheric air of the city of Pavlodar

Exceeding more than 1 MAC for suspended particles PM 2.5 - 9, suspended particles PM 10- 29, for hydrogen sulphide – 31, for carbon monoxide – 6 was identified, 4 cases of exceeding more than 5 MAC for carbon monoxide were observed [4].

Having analyzed the dynamics from 2018 to 2020 it should be noted that in general the level of pollution remains high, the level of the various substances content changes every year (picture 2).



Picture 2. The graph of the dynamics of the pollution of the city of Pavlodar from 2018 to 2020

In the given work we would like to examine one of the sources of atmospheric air pollution – the motor transport. As all are aware transport is one of the most important components of social and economic development consuming the significant amount of resources and affecting the environment seriously [5].

The relative amount of the emissions into the atmosphere per resident exceeds the republican average indicator almost 4 times. In the regional center the level of environment pollution by benzopyrene (substance of first hazard class), zinc, chromium, lead, rubidium, nickel, copper, manganese, iron, chlorine, mercury and the substances which accumulate in the organism and in high concentration can cause a number of the diseases of the upper respiratory tract, erode the immunity and contribute to the exacerbations of diseases. In some cases they lead to death.

The increase of emissions occur through the low technical state of automobiles, the use of defective motor fuel (leaded petrol), the lack of the equipment for cleaning waste gases (the catalytic converters) and the inadequate system of emission control.

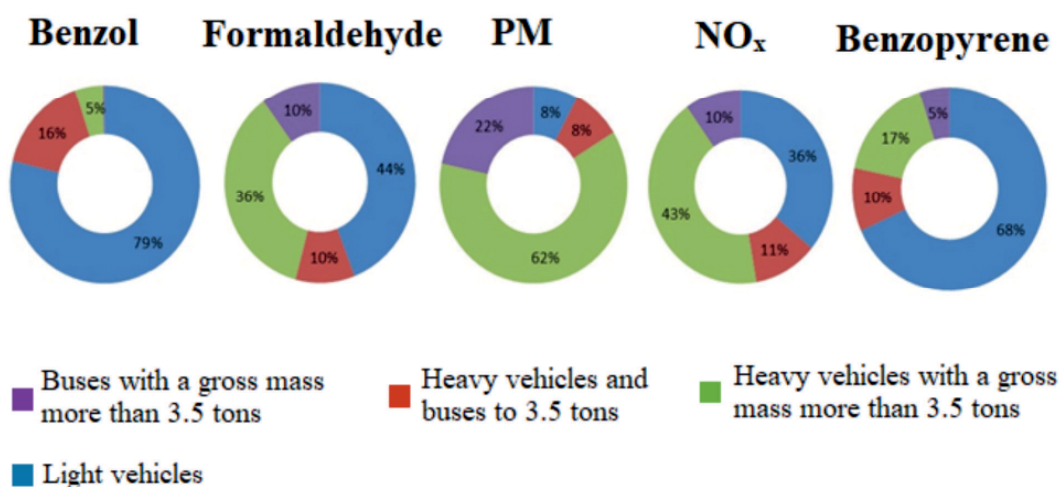
The emissions from the motor transport rose by 2.6 thousand tons and accounted

for 35.8 thousand tons. The ingredients of the emissions are characterized in the following way: the maximal non-recurrent concentration amounted to 3.6 MAC, hydrogen chloride – to 2.9 MAC, carbon monoxide – to 1.6 MAC, nitrogen dioxide – to 1.4 MAC (IAP accounted for 2.6) [4].

The major sources of the air basin pollution in the exploitation of the motor transport are the internal combustion engines, which emit waste gases, fuel evaporations and contaminants into the atmosphere.

Near 280 components, which by chemical properties and the impact on the biosphere are separated into non-toxic (N<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>) and toxic (NO<sub>x</sub>, C<sub>x</sub>H<sub>y</sub>, SO<sub>2</sub>, H<sub>2</sub>S, aldehydes, char and others), are contained in the waste gases of the motor engines in total.

The waste gases of the internal combustion engines include more than 200 items of hazardous substances and compounds, among which there are carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), hydrocarbons (CH), formaldehydes, dust, char, benzopyrene - 3,4, etc. On picture 3 the data on the size composition of the contaminants with the ranking on motor transport engines are reflected.



Picture 3. The size composition of the waste gases of the engines of the various types of transport

Petrol engines in comparison to diesel ones exhibit a higher toxicity. The most toxic components of the waste gases are: carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (CnHm), in the case of the use of leaded petrol – lead, 50% of which is deposited in the form of residue on the engine details and in the exhaust pipe; the remainder is supplied into the atmosphere.

Lead is present in the waste gases in the form of the smallest particles of size from 1 to 5 mkm, which remains in the atmosphere for a long time. The concentration of lead in the atmosphere of the roadside is 20 times higher than in other places [6].

Let us undertake the calculation: if we accept that the average mileage of every automobile is 15 thousand kilometers, than

the atmosphere is impoverished for 4350 kg of oxygen and is saturated for 3250 kg of carbon dioxide, 530 kg of carbon monoxide, 93 kg of carbohydrides, 7 kg of nitrogen oxides.

In the streets with the highest traffic density in the city of Pavlodar the analysis of the traffic density for 5 and 30 minutes was implemented by us.

Having analyzed the determination of the traffic density of the major transport links of the city of Pavlodar it was revealed that the environmental pressure on Academician Satpayev Street, Toraigyrov Street and Lermontov Street is rather high and amounts for 20000 units of motor transport per day, on N. Nazarbayev Avenue – for approximately 3000 units of motor transport per day.

Table 2. The determination of the traffic density of the major transport links of the city of Pavlodar, units

| Street                      | for 5 minutes  |                |       | for 30 minutes |                |       |
|-----------------------------|----------------|----------------|-------|----------------|----------------|-------|
|                             | light vehicles | heavy vehicles | buses | light vehicles | heavy vehicles | buses |
| N. Nazarbayev Avenue        | 119            | 50             | 15    | 953            | 52             | 78    |
| Toraigyrov Street           | 127            | 15             | 19    | 702            | 75             | 95    |
| Lermontov Street            | 83             | 1              | 14    | 450            | 6              | 70    |
| Academician Satpayev Street | 50             | 1              | 16    | 61             | 7              | 103   |

In this regard it is necessary to optimize the transport links, to expand the use of the bypass roads of the regional center and to introduce the independent monitoring system.

The sources of the atmospheric air pollution in cities are also numerous automobile service facilities: parking lots, petrol stations, service stations and multiple other factors [7].

Having examined only one source of atmospheric air pollution we arrived at the conclusion that the situation with

the research of atmospheric air quality should be studied in details with the use of knowledge-based technologies.

The current system of environment pollution monitoring is based generally on the use of the chemical methods of analysis, which does not allow the assessment of the true danger of various contaminants for the habitat, the projection of the consequences for the living organisms. This approach should be safe and innovative, allowing monitoring on a new level [8]. Some of the alternative methods globally recognized

are the methods of biological indication based on the use of biological objects and allowing the reception of the integrated assessment of the ecological situation.

Furthermore, it is necessary to implement the systematic analysis of the data received and to propose the most appropriate recommendations on the reduction of atmospheric air pollution; it is viable to increase the number of the posts of the republican state enterprise «Kazgidromet» and to conduct the monitoring of the residential area of the city of Pavlodar.

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### **Павлодар қаласы аумағындағы атмосфералық ауа мониторингінің қолданыстағы жүйесін талдау**

#### **Аңдатпа**

Мақала Павлодар қ. аумағындағы атмосфералық ауа мониторингінің қолданыстағы жүйесін талдауға арналған. Атмосфералық ауаны ластау көздерінің бірі-автомобиль көлігімен ластау мәселесі қаралды.

Павлодар қаласы бойынша «Қазгидромет» РМПУ ақпараттық бюллетендерінің деректері зерттелді және талданды, олар бірқатар заңдылықтарды анықтауға мүмкіндік берді: атмосфералық ауаны ластаушылар көп дәрежеде көміртегі оксиді, күкірт диоксиді, азот диоксиді, азот оксиді және РМ-10, РМ-2,5 қалқыма бөлшектері болып табылатыны анықталды.

Авторлар сонымен қатар автомобиль көлігінің қоршаған ортаға әсерін талдап, әртүрлі көлік қозғалтқыштарының пайдаланылған газдарының сандық құрамын егжей-тегжейлі сипаттады. Сонымен қатар, көшені автомобильдермен толтыру туралы қорытынды жасалды және осы жағдайларды оңтайландыру бойынша ұсыныстар берілді.

**Түйінді сөздер:** Мониторинг жүйесі, атмосфералық ауа, ластану көздері, зиянды заттар, стационарлық бақылау желісі.

### **Анализ действующей системы мониторинга атмосферного воздуха на территории города Павлодара**

#### **Аннотация**

Статья посвящена анализу действующей системы мониторинга атмосферного воздуха на территории г. Павлодара. Рассмотрен вопрос загрязнения атмосферного воздуха одним из источников загрязнения – автомобильным транспортом.

Изучены и проанализированы данные информационных бюллетеней РГП «Казгидромет» по г. Павлодару, которые позволили выявить ряд закономерностей: установлено, что загрязнителями атмосферного воздуха в большей степени являются оксид углерода, диоксид серы, диоксид азо-

та, оксид азота и взвешенные частицами РМ-10, РМ-2,5.

Авторами также был проведен анализ влияния автомобильного транспорта на окружающую среду, подробно описан количественный состав отработанных газов двигателей различных видов транспорта. Кроме этого, сделан вывод о загруженно-

сти улиц автомобилями и были даны предложения и необходимые рекомендации по оптимизации данной ситуации.

**Ключевые слова:** система мониторинга, атмосферный воздух, источники загрязнения, вредные вещества, автомобильный транспорт, стационарная сеть наблюдений.

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