Development of modern research methodology atmosphere pollution in Bishkek city based on a mobile ecological laboratory

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Abstract. The work substantiates the need for scientific development to improve environmental pollution in the city of Bishkek. It has been proven that during the autumn-winter period there is increased air pollution from many different sources. It is proposed to use comprehensive scientific research to identify sources of smog formation, its composition and sources of pollution. The presented method allows one to obtain a vast array of information on air pollution. The need has been established to continue comprehensive monitoring of the environmental situation in our city. It is proposed, based on environmental monitoring, to develop certain conclusions and recommendations to reduce the presence of harmful substances in the air, especially with the beginning of the autumn-winter period.

1 Introduction

The study is aimed at the overall improvement of the environment in the city of Bishkek and the Chui region. The environmental situation in Bishkek as a result of technogenic impact tends to significantly deteriorate in terms of a number of harmful substances, the appearance of smog, etc., especially in the autumn-winter period. Currently, there is no specific information on the causes of pollution and methods for eliminating this negative impact on the atmosphere. There are certain prerequisites for thinking that it is the transport component that is dominant in the overall technogenic industrial pollution on the territory of Bishkek, but no one takes into account the pollution from the use of low-quality fuel for heating in the autumn-winter period and the pollution from the capital's thermal power plant.

On the basis of the modern mobile laboratory of the KRSU, it is possible to conduct an independent examination of vehicles participating in international transport, certification of road transport and air pollution objects. In accordance with the goals and objectives of the monitoring, a model is created that allows, based on the results obtained, to determine the functional integrity of the object, identify the reasons for changes in its natural state and assess their consequences on the environment and develop a methodology for calculating emissions of pollutants from stationary and mobile sources of pollution.

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The data obtained from the measurements will ensure the reliability of the information for preparing the necessary forecasts and options for management solutions to the task at hand.

2 Experimental technique

According to many indicators of air pollution, Bishkek periodically ranks among the top five in the anti-rating of the most polluted cities in the world. The state of atmospheric air pollution is assessed according to the environmental indicators “Air quality index (AQI)” - air quality index and “PM2.5” - PM2.5 solid particles ranging in size from 1.0 to 2.5 microns. In many ways, the state of air pollution depends on three main types of pollution sources: industrial emissions, harmful emissions from road transport, emissions from the private sector. With such high levels of air pollution, we are talking about a violation of sustainable development (harmonious and balanced development) and ensuring the quality of life of people. Against this background, a common concept of sustainable development has emerged, combining an economic, social and environmental platform.

In 2023, the only modern, mobile, research “Laboratory for monitoring environmental safety and technical condition of transport facilities, transport infrastructure and industry” in the Kyrgyz Republic was created at the Kyrgyz Russian Slavic University. On the basis of this laboratory, full-fledged research was carried out at a high and high-quality level, which allows us to move to a new, modern stage in the study of the formation of smog, its composition and sources of pollution.

Fig. 1. Mobile laboratory for monitoring environmental safety and technical condition of transport facilities, transport infrastructure and industry.

Existing stationary laboratories cannot provide a full range of pollution sources. In contrast, a mobile laboratory can continuously monitor the state of atmospheric air at any point around the clock, and also monitor the exhaust gases of individual vehicles selectively.

A mobile laboratory for monitoring environmental safety and technical condition of transport facilities, transport infrastructure and industry makes it possible to carry out not only meteorological observations, but also to check vehicle exhaust gases and monitor the state of the surrounding air. In addition to particulate matter PM 2.5 and PM 10, the equipment can detect air pollution in several directions. Namely:

- Monitoring the state of meteorological conditions:
  - Atmosphere pressure.
  - Air temperature.

- Relative humidity.
- Wind speed.
- Direction of the wind.

- Monitoring the state of ambient air pollution:
  - Sulfur dioxide SO_2.
  - Nitrogen monoxide NO.
  - Hydrocarbons CH.
  - Carbon dioxide CO_2.
  - Nitrogen dioxide NO_2.
  - Formaldehyde H_2CO.
  - Carbon monoxide CO.
  - Oxygen O_2.
  - PM2.5.
  - PM10.
  - Formaldehyde H_2CO.
  - Volatile organic compounds (TVOC).

In our research, it was decided to reverse the influence of urban development on the degree of gas pollution in residential areas. It was decided to analyze and raise the issue of introducing processes of economic, technical and social influences, in which natural resources, investments, the direction of scientific and technological development, personal development and changes in the management sphere should be coordinated with each other to strengthen the potential needs of man and society.

To conduct the research, one microdistrict of the city of Bishkek was selected, where a wide range of different buildings are located. For a full-fledged study, it is necessary to check the influence of the number of storeys of houses, their length and location according to the cardinal directions and wind rose. In the Vostok 5 microdistrict you can find all these types of buildings. The number of floors of houses here ranges from five to twelve, and the length of the houses varies from single-entrance to eight-entrance buildings.

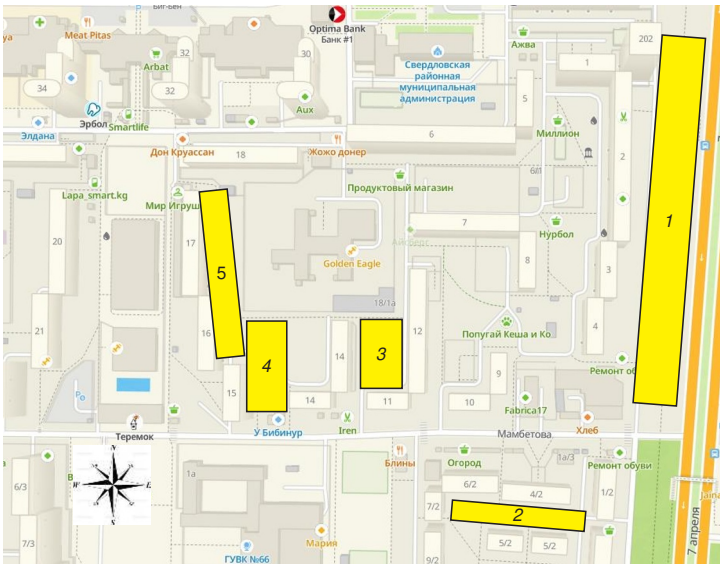


Fig. 2. Air quality monitoring sites in the Vostok-5 microdistrict of Bishkek.

After analyzing the buildings, five sections of this microdistrict were selected, which include all types of development.

When selecting sites and measurement points, it was taken into account that in more than 80% of cases, the wind direction in the city of Bishkek and the Chui Valley is western.

At each site, several measurement points are identified, from three to twelve, which is necessary to determine the influence of residential buildings on wind direction and airflow, depending on the location of the height and size of the residential building.

Fig. 3. Location of observation posts 3 and 4 of air quality monitoring sites in the Vostok-5 microdistrict of Bishkek.

To obtain a wide range of data, measurements were taken four times a day between February 5 and February 29 this year. During this period, air temperatures ranged from -10°C to +17°C. There were both sunny days and rain and snow. Wind from calm to gusts within 5 m/s.

3 Results and Discussion

Our goals regarding the environmental situation of the air are to develop methods for monitoring air for various components, to determine whether the theory of climate change is adequate, and to organize the transfer of data to the state level. To do this, it is necessary to minimize all errors in work and development of methodology, and it is necessary to use the full function of research control.

Let's make a selection of the results of observing weather conditions. Let's take only morning measurements, time 9.00, selectively from general research protocols with different weather conditions, but from one site.

For a clearer comparison of the influence of weather conditions on the pollution of courtyard areas, let’s take three days where the weather was constantly changing every day. On February 15 it was sunny and warm, +17°C, on February 16 it was cloudy, wind and snow, -6°C, and on February 17 there was a slight wind, clear, -10°C.

Due to the large amount of information, we will not provide the remaining protocols of measurement results for given areas. But they were taken into account in the general analysis and formulation of conclusions.

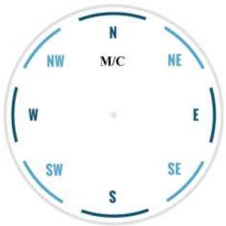
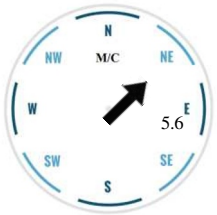
Protocol No.___5-15_____ of____02.15. 2024				Protocol No._____5-6_____ of____02.15. 2024				Protocol No.___6-17_____ of____02.16. 2024			
Measurable options	MPC norms		Options measurements	Measurable options	MPC norms		Options measurements	Measurable options	MPC norms		Options measurements
O_2	%	%	20.92	O_2	%	%	20.91	O_2	%	%	20.98
CO	mg/m^3	5	1.6	CO	mg/m^3	5	0.2	CO	mg/m^3	5	0.3
SO_2	mg/m^3	0.5	0.000	SO_2	mg/m^3	0.5	0.000	SO_2	mg/m^3	0.5	0.000
NO	mg/m^3	0.6	2.22	NO	mg/m^3	0.6	1.67	NO	mg/m^3	0.6	0.556
CH	%	1	0.010	CH	%	1	0.010	CH	%	1	0.010
CO_2	%	0.045	0.020	CO_2	%	0.045	0.020	CO_2	%	0.045	0.030
NO_2	mg/m^3	0.085	0.000	NO_2	mg/m^3	0.085	0.000	NO_2	mg/m^3	0.085	0.000
H_2CO	mg/m^3	0.035	0.098	H_2CO	mg/m^3	0.035	0.098	H_2CO	mg/m^3	0.035	0.078
PM 2,5	$\mu g/m^3$	160	46	PM 2.5	$\mu g/m^3$	160	44	PM 2.5	$\mu g/m^3$	160	172
PM 10	$\mu g/m^3$	300	96	PM 10	$\mu g/m^3$	300	88	PM 10	$\mu g/m^3$	300	55
TVOC	$\mu g/m^3$	__	0.10	TVOC	$\mu g/m^3$	__	0.00	TVOC	$\mu g/m^3$	__	0.00
Wind speed and wind direction: 				Wind speed and wind direction: 				Wind speed and wind direction: 			
Measurement time	9:00			Measurement time	9:15			Measurement time	8:33		
Humidity %	27			Humidity %	27			Humidity %	68%		
Atmosphere pressure hPa	924.7			Atmosphere pressure hPa	924.7			Atmosphere pressure hPa	939		
Precipitation	mm	Precipitation		Precipitation	Precipitation	Precipitation		Precipitation	mm	Precipitation	
Ambient air temperature	+17.2℃			Ambient air temperature	+17.2℃			Ambient air temperature	-6.1℃		

Fig. 4. Observation protocols of two monitoring posts air quality in the Vostok-5 microdistrict of Bishkek for 02/15/2024 and 02/16/2024.

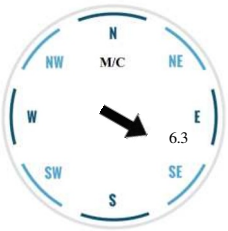
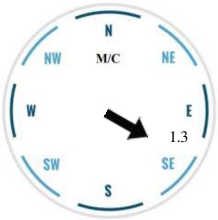
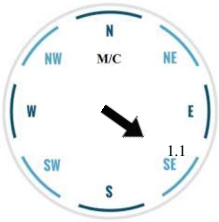
Protocol No.___6-18_____ of____02.16. 2024				Protocol No.___7-17_____ of____02.17. 2024				Protocol No.___7-18_____ of____02.17. 2024			
Measurable options	MPC norms		Options measurements	Measurable options	MPC norms		Options measurements	Measurable options	MPC norms		Options measurements
O_2	%	%	20.97	O_2	%	%	20.98	O_2	%	%	20.97
CO	mg/m^3	5	0.5	CO	mg/m^3	5	6.3	CO	mg/m^3	5	6.5
SO_2	mg/m^3	0.5	0.000	SO_2	mg/m^3	0.5	0.000	SO_2	mg/m^3	0.5	0.000
NO	mg/m^3	0.6	0.555	NO	mg/m^3	0.6	0.756	NO	mg/m^3	0.6	0.755
CH	%	1	0.010	CH	%	1	0.010	CH	%	1	0.010
CO_2	%	0.045	0.030	CO_2	%	0.045	0.040	CO_2	%	0.045	0.038
NO_2	mg/m^3	0.085	0.000	NO_2	mg/m^3	0.085	0.000	NO_2	mg/m^3	0.085	0.000
H_2CO	mg/m^3	0.035	0.078	H_2CO	mg/m^3	0.035	0.098	H_2CO	mg/m^3	0.035	0.098
PM 2.5	$\mu g/m^3$	160	5	PM 2.5	$\mu g/m^3$	160	172	PM 2.5	$\mu g/m^3$	160	5
PM 10	$\mu g/m^3$	300	76	PM 10	$\mu g/m^3$	300	55	PM 10	$\mu g/m^3$	300	76
TVOC	$\mu g/m^3$	__	0.00	TVOC	$\mu g/m^3$	__	0.00	TVOC	$\mu g/m^3$	__	0.00
Wind speed and wind direction : 				Wind speed and wind direction: 				Wind speed and wind direction 			
Measurement time	8:40			Measurement time	8:33			Measurement time	8:40		
Humidity %	70%			Humidity %	68%			Humidity %	70%		
Atmosphere pressure hPa	938			Atmosphere pressure hPa	939			Atmosphere pressure hPa	938		
Precipitation	mm	Precipitation		Precipitation	Precipitation	Precipitation		Precipitation	mm	Precipitation	
Ambient air temperature	-6.1℃			Ambient air temperature	-10.4℃			Ambient air temperature	-10.4℃		

Fig. 5. Observation protocols of two monitoring posts air quality in the Vostok-5 microdistrict of Bishkek for 02/16/2024 and 02/17/2024.

Due to the large volume of measurements and the multitude of protocols, we made a certain selection of the research results, which are reflected in Table 1.

Table 1. Sample of research results for February 2024.

Time and date		**Wind direction and speed (m/s)**		**Temperature (^{O}C)**	**air humidity (%)**	**Atmospheric pressure (GPa)**
9.00	5.02	NE	1	+4.8	58	931.9
9.00	6.02	E	1	+8.8	41	927.4
9.00	7.02	SW	3	+6.6	58	925.5
9.00	11.02	E	2	+16.5	29	930.0
9.00	12.02	W	1	-1.7	99	940.0
9.00	13.02	E	1	+9.2	70	938.8
9.00	15.02	S	0.1	+17.2	27	924.7
9.00	16.02	W	6	-6.1	70	939.4
9.00	17.02	NW	1	-10.4	97	938.4

As can be seen from some of the data presented, the sharply continental climate made it possible to carry out measurements in a wide range of weather conditions.

To monitor the general meteorological situation, at the Natural-Technical Faculty of the Kyrgyz-Russian Slavic University there is a stationary meteorological station, where modern equipment is installed on the roof of a four-story building, which allows you to constantly, automatically, monitor not only weather conditions, but also control the presence of solids. particles PM 2.5 and PM 10. After measurements along a certain route, the above protocols were filled out (Figure 4), which are compared with the indicators of the stationary station.

4 Conclusion

Having analyzed the observation protocols of the mobile laboratory, the following conclusions can be drawn:

- The concentration of harmful substances in the air varies depending on weather conditions.
- Since the private sector, which is not connected to gas and is heated with solid fuel in the cold season, is located at a sufficient distance from the Vostok-5 microdistrict, in our research sector it actually does not affect air pollution.
- Solid particles of dust and soot are carried eastward by the westerly wind and do not affect our measurements during research.
- The main source of pollution in courtyard areas is motor transport, which warms up before leaving in the morning hours during the cold season.
- In the vicinity of highways, courtyard areas are also actively polluted in cold weather, especially during peak load hours.
- In good warm weather, the concentration of emissions into the atmosphere is minimal.
- In cold weather, the concentration of harmful substances increases sharply.
- In cold windy weather, despite the increased air pollution from cars, the wind blows out all harmful substances, and their concentration decreases.
- Bishkek is located in a mountainous area, where the winds almost constantly blow in one direction. When designing residential buildings, it is necessary to use this data. This will reduce the concentration of harmful substances in courtyard areas

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