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## ESTABLISHMENT OF A NETWORK FOR THE PUBLIC ATMOSPHERIC AIR MONITORING AND INFORMING THE POPULATION

*The object of research is monitoring the state of atmospheric air pollution in agglomerations with subsequent informing the population. Monitoring the state of the city's atmospheric air is of great importance both at the state level and for the public. In this work, public monitoring of atmospheric air is created on the example of the city of Poltava (Ukraine). The creation of a network for public monitoring of the state of air pollution in the city provides for independent monitoring of air pollution, based on decrees and other guidelines on air quality. In accordance with the existing requirements, the state monitoring of atmospheric air has a number of disadvantages, namely:*

- lack of monitoring of suspended solids, including PM2.5 and PM10;
- monitoring of atmospheric air pollution at stationary observation posts is carried out a maximum of 4 times a day;
- lack of a system of informing the population about the state of the air in the city, in particular, PM2.5 and PM10 pollution;
- lack of automated systems for analyzing air quality, that is, monitoring is carried out by sampling.

*In contrast to the conduct of state observation, public monitoring will provide not only informing the population, involving them in monitoring, but will also increase environmental awareness, responsibility, and create an additional tool for controlling air pollution. For the effective functioning of the public monitoring network, rules have been developed for conducting public monitoring of the state of atmospheric air pollution in the city with a description of the location of pollution sensors, their operation and basic requirements. Also, a website has been developed based on the monitoring database, reflecting the results of public monitoring. Taking into account that if the database contains data on the indicators of installed sensors (point measurements), then the site for informing the population is a visualization of the control results throughout the city, that is, it will act as a model for the distribution of pollution in the city's atmospheric air.*

**Keywords:** atmospheric air, PM2.5 and PM10 pollution, measurement sensors, city grid, public information, observation network.

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### 1. Introduction

The issue of monitoring and quality of atmospheric air is regulated by a number of regulatory documents and continues to improve. In this regard, there are problems of inconsistency of the existing monitoring systems in the regulatory documents. An example can be the latest changes in the field of atmospheric air monitoring in Ukraine, specified in the Resolution of the Cabinet of Ministers of Ukraine dated August 14, 2019 No. 827 «Some issues of state monitoring in the field of atmospheric air protection». According to this resolution, there are a number of shortcomings of the current monitoring system, namely:

- lack of monitoring of suspended solids, including PM2.5 and PM10;
- lack of data on pollution covering the entire territory of the city (agglomeration, according to the

decrees), that is, the available information is relevant only pointwise;

- monitoring of atmospheric air pollution in stationary observation posts is carried out a maximum of 4 times a day;
- lack of a system of informing the population about the state of the air in the city, in particular, PM2.5 and PM10 pollution;
- lack of automated systems for analyzing air quality, monitoring is carried out by sampling.

Air monitoring is an integral part of political development strategies for both individual cities and countries as a whole [1, 2]. A significant part of the research carried out by scientists around the world contributes to the development of the protection of the atmospheric basin of cities, the determination of the impact of pollution and the improvement of the quality of the environment [3, 4]. However, it is impossible to achieve a high-quality result

in the ecological sphere, if to talk about an urbanized habitat, if the public is not involved. Monitoring studies and informing the population about their results is important from the point of view of both scientists and the public [5].

The most common in atmospheric air monitoring is the use of geographic information technologies and systems. These systems consist of a hardware complex, a software complex and an information block. However, it is quite justified to include in the components of geoinformation technologies and people – developers and users, without whom the existence of other components as a system is impossible. In this case, a system consisting of five components is formed [6]. Most of the software products [7–9] developed for monitoring atmospheric air, providing the ability to visualize the observation results, require a large amount of input data. In addition to the exact parameters of emission sources, it is necessary to use a large array of meteorological data, which is not always possible to obtain. There is also a need to create a public information system that is easy and quick to administer, and convenient and understandable for the user. Thus, the available software products [10] are aimed at measuring pollution from certain sources, or are unsuitable for fast data manipulation.

Therefore, it is urgent to create a system for monitoring the atmospheric air of the city with the ability to provide public access to the observation results. Thus, *the object of the study* is to monitor the state of atmospheric air pollution in agglomerations with subsequent information to the population (for example, Poltava, Ukraine). *The aim of research* is to create a network for public monitoring of the state of air pollution in the city, and to create a site for informing the population, which will provide public access to simple and understandable maps of the state of air pollution in the city.

## 2. Methods of research

Public monitoring of the state of air pollution is a network of sensors to determine the concentration of pollutants in the air basin of cities. The location of the measurement points of contamination should be fixed, but at the same time, it can be quickly changed in accordance with the assigned task of a certain study or analysis. The purpose of creating and implementing a public control network is to conduct an independent assessment of the quality of the city's atmospheric air with subsequent informing the population about its results. This type of monitoring is aimed not only at attracting the public and increasing their environmental awareness, but also serves as a primary analysis of the state of air pollution. The data obtained can be used to provide recommendations on the establishment of additional posts for state monitoring of atmospheric air quality, as well as operational control for certain tasks.

Given that public monitoring, as indicated above, is versatile and can be used for a variety of tasks, the requirements for installing surveillance sensors are flexible. To obtain general values of atmospheric air pollution in the city, taking into account industrial, residential, park zones of the city, as well as suburban areas, the main recommendations for installing sensors are:

- installation on sites, ensures the absence of stagnation of air flows;
- installation at a distance of 1.5, 4 or 6 m from the ground;
- installation at a distance of 10 m from a road with heavy traffic (or closer, if it is necessary to determine the influence of traffic on this section);
- in suburban areas to determine the anthropogenic impact of the urban environment.

At the beginning of the experiment of creating a public control network for the city of Poltava (Ukraine), a grid was created for further displaying data of 7×7 cells.

Considering that each cell contained a significant area of the city's territory, and new sensors, falling into cells where research had already been carried out, would be inconvenient for display and incomprehensible to the target user, the size of the 12×12 cells grid was changed (Fig. 1).

This solution allows to preserve the grid in suburban areas, for further expansion of the public monitoring network, and also divides the central area of the city into smaller cells, prevents overlap of indicators of various sensors. So, the grid consists of 144 cells. Each cell covers an area of 1.65 km<sup>2</sup>. The total area of the city is 103 km<sup>2</sup>, therefore, 64 central cells completely cover the city's territory.

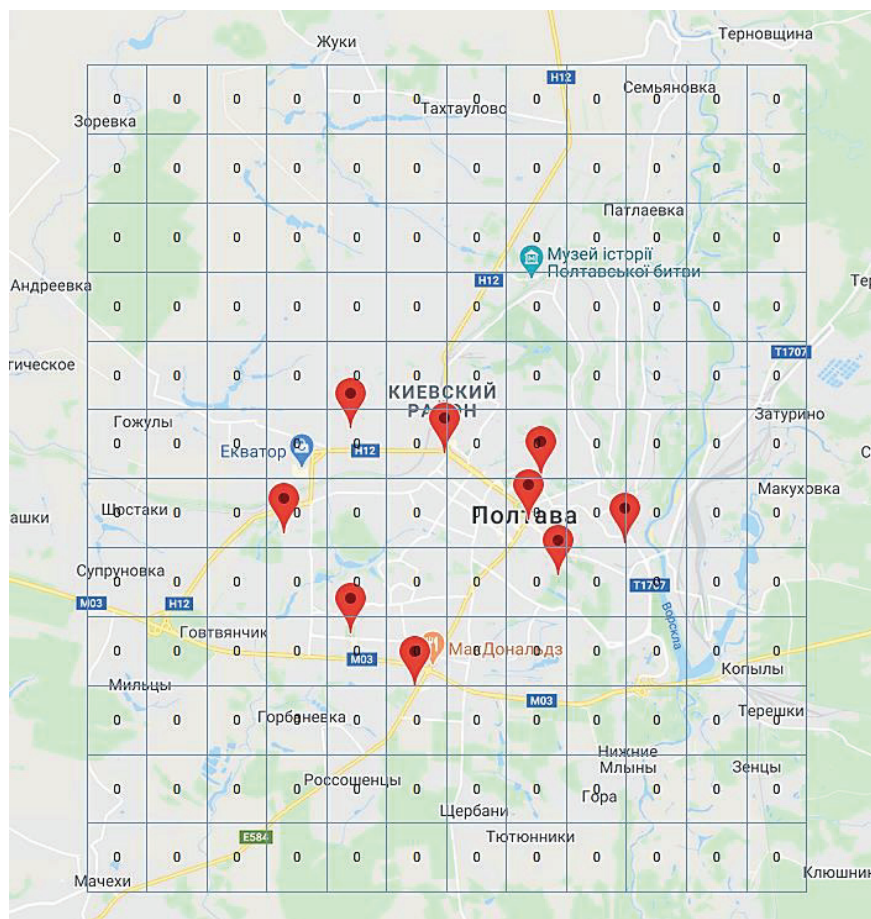


Fig. 1. View of public monitoring grids

The installed sensors measure the air pollution of the city with suspended particles PM2.5 and PM10. The main technical characteristics of the sensors for measuring the specified contamination are:

- measurement principle – optical, operating on the principle of scattered light;
- measurement range (PM2.5) – 0–500  $\mu\text{g}/\text{m}^3$ ;
- working temperature range – (-10)...+60 °C;
- measurement accuracy – ( $\pm 10$ )  $\mu\text{g}/\text{m}^3$  in the range of 0–100  $\mu\text{g}/\text{m}^3$ ,  $\pm 10$  % in the range of 100–500  $\mu\text{g}/\text{m}^3$ ;
- working range of humidity – 0–99 %.

During the experiment, 9 sensors were installed, covering most of the city. The sensors operate in an autonomous continuous mode, but to create a network for informing the population, pollution indicators were used for the following hours: 00:00, 6:00, 12:00, 18:00. Also, the task of visualizing the results of public monitoring on the website for informing the population is to create a model of plane air pollution in the city, and not to reflect the point readings of sensors.

### 3. Research results and discussion

An analysis was made of the task of creating a website for informing the population about the results of public monitoring and the choice of a method for its solution. As a result of the analysis of the subject area, it was revealed that there is a need to create a system for visualizing data obtained using an expanded network of public monitoring of the state of atmospheric air (for example, the city of Poltava). A number of shortcomings of the existing information and technical capabilities have been identified, which do not allow displaying the data of the above monitoring. The main requirement for the visualization of public monitoring data is the clarity of the observation results, in terms of dividing the city territory into certain areas and indicating the concentration of dust in these areas.

That is, there is a need to create a visualization system for the obtained public monitoring data from the point of view of their flat distribution, and not a reflection of the point measurement, which are currently available sites for informing the population, which is also uninformative or inconvenient to use.

To implement a warning system for monitoring atmospheric air, the CMS Wordpress tool was chosen, which is one of the most popular CMS (content management systems). A content management system is a set of different kinds of scripts for creating, editing and managing a website; in professional jargon, such systems are called engines. These systems allow to create publications, are responsible for displaying media elements and placing widgets.

For the development of the site, the Joins WP theme was used – an empty Wordpress theme with a basic set of functions, which includes the Foundation CSS framework.

To display the model of the distribution of pollutants in the atmospheric air of the city, the JavaScript library GMapsTable was used, based on the imposition of an html object on a Google map at specified coordinates, usually SVG objects are imposed on a Google map using a similar method. In this library, this method is adapted for overlaying html tables for data visualization. With the help of this library, the output of grouped data on the city grid is implemented, and not point data.

The site itself is one page with data on the state of the level of atmospheric air pollution per day. The map is displayed at full height and width of the screen. On the left is the floating sidebar, which is the main navigation element. It has the following elements: tabs for switching between PM2.5 and PM10 sensors, in which there are switches for every 6:00 data and a calendar for navigating by day. When switching the taboo and the internal switch, the data visualization on the map and the image of the pollution scale for this type of sensor change.

Interface elements are implemented using metaboxes. Metaboxes are specific post properties that are added to the site structure, usually by plugins. These are panels containing all the necessary elements that are required to edit the post data. They are located on the admin panel editing screens, where such features as grid management are implemented (2 grids have been created: 7×7 and 12×12 cells), and with the help of a taboo, the user can quickly switch between sensors and add information every 6 hours for each of them. By default, these fields will be required.

It is the last post that will be displayed on the home page.

To manage the site, it is necessary to log in to the domain address with the addition of url/dashboard and/wp-admin or /wp-login.php. For example: <http://city-air-dust.ho.ua/dashboard>. After authorization, a transition occurs in the CMS. To create a publication, create a post of the Maps Data type. There are many ways to create, the fastest from the top bar admin panel.

Fig. 2 shows an example of filling a post.

First of all, it is necessary to name the post in the (d-m-y) format to generate a page link in the form <http://city-air-dust.ho.ua/map/07-06-2020/>. In the left sidebar of the publication of the post, the publication date is changed to the desired day, thus the day for which the post will be published is determined, which is necessary for the engine to correctly determine the most recent post to which the redirection will be made from the main page of the site. In the ACF widget of the CPT: Maps Data group, the required grid size is selected to fill the data. At the bottom of the widget, PM2.5 and PM10 tabs are available, which contain fields for filling in information about sensors for every 6 hours. The padding of both tabs is set to be required by default. If these fields are not filled in when to click the publish button, the post will not be published and the fields that must be filled in will be highlighted.

After the post is published, going to the main page of the site, it is redirected to the last post with visualization of the state of atmospheric air pollution in a convenient visual form on the map. Fig. 3 shows the final result.

To go to the page, it is necessary to select the desired date in the calendar and click the «Go to» link, after selecting the date, the post link is generated automatically. At the top of the calendar, the current date of the post is displayed, so that the user understands that the data is reflected by the date.

After clicking the Go to link, the post is loaded on another day. For the convenience of users, if there is no publication of observations for a certain day, this date can't be selected in the calendar.

When switching between the PM2.5 and PM10 sensor tabs, the data on the map changes, and the scale display for this sensor changes. Also, when switching taboo, the data is displayed exactly for the hour that was last elected.

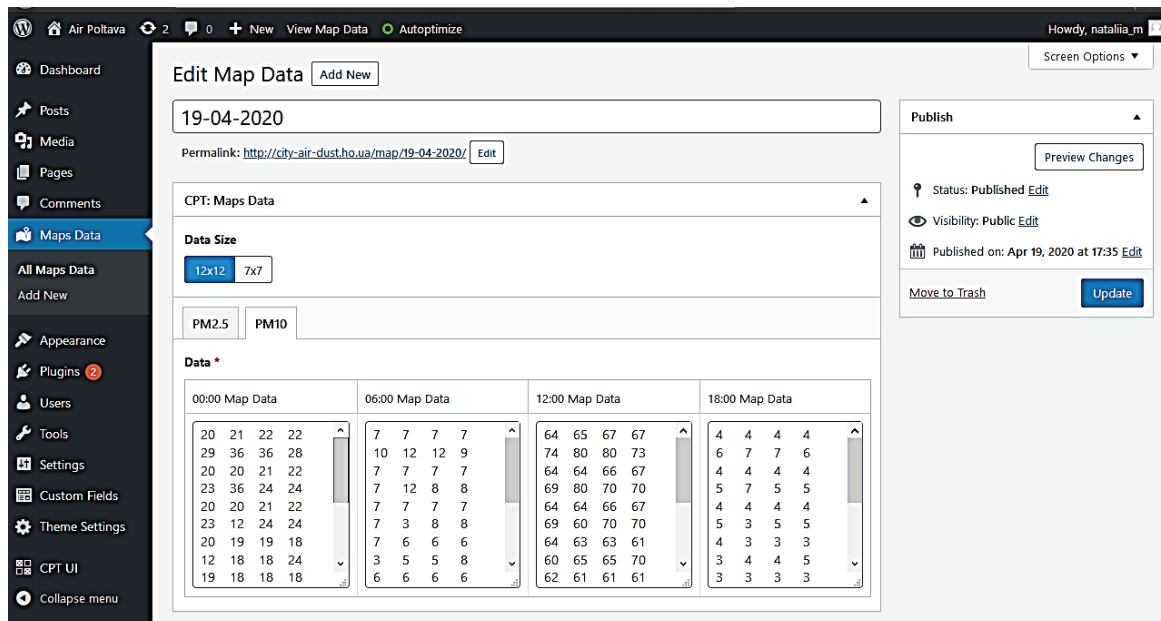


Fig. 2. Filling the post with content

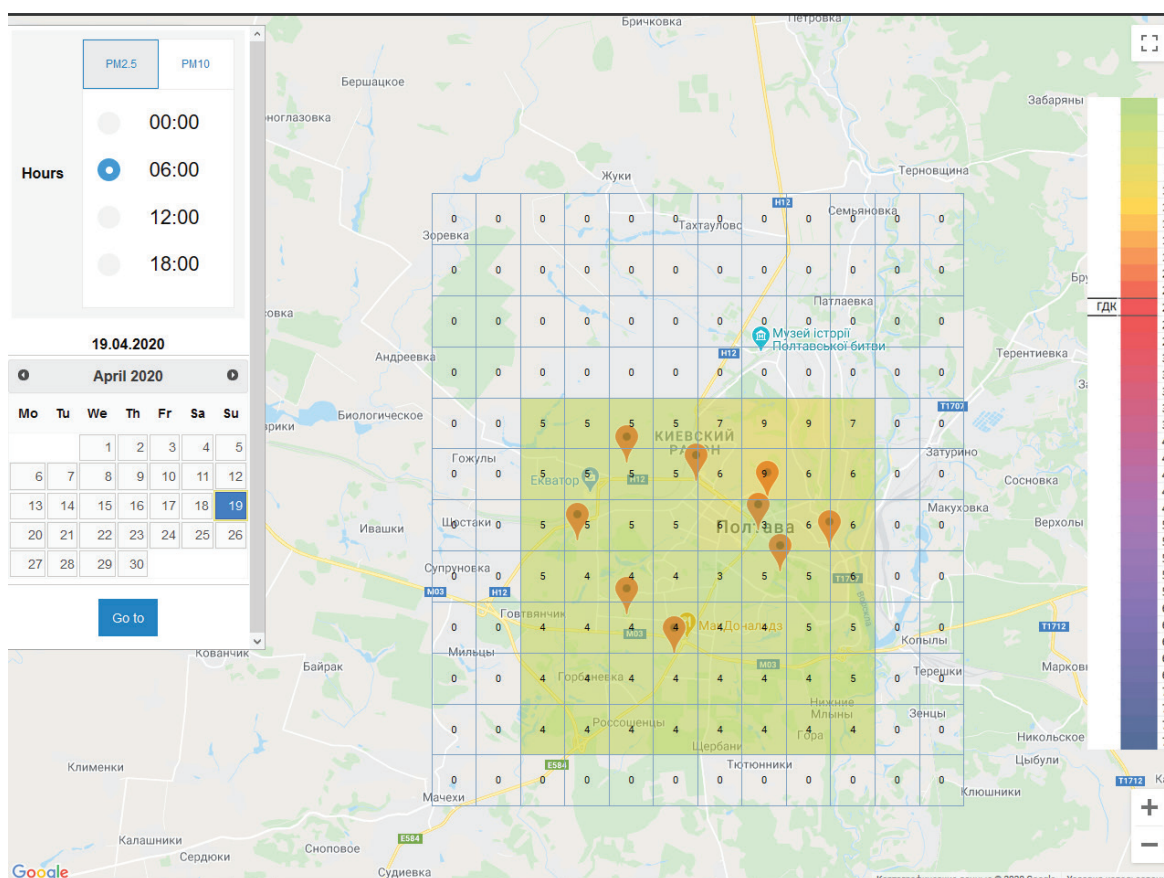


Fig. 3. View of post after publication

#### 4. Conclusions

As a research result, it is found that by creating a network of public monitoring of atmospheric air the following problems can be solved:

- at the state level – assistance in the implementation of the state monitoring program in the field of

atmospheric air protection in accordance with the Resolution of the Cabinet of Ministers on the monitoring procedure;

- at the enterprise level – assistance in identifying the impact of emissions from «neighboring» city enterprises;
- at the public level – assistance in the availability of accessible and independent control over the air quality

in the city, as well as the direct increase of the environmental awareness of the city's citizens;

– at the scientific level – assistance to scientists and other interested structures in obtaining up-to-date information on atmospheric pollution for the purpose of further analysis, research and reporting.

To inform the population about the data obtained, a website has been implemented for publishing the results of measuring the level of atmospheric air pollution using public control. As a result, calculations and analytical studies turn into user-friendly thematic maps of atmospheric air pollution in the city PM2.5 and PM10.

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