Software Tools for Assessing the Environmental Safety of City Filling Stations

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Abstract. The article presents the results of the development of software tools for controlling and monitoring the impact of urban filling stations in urban development, which allows an interactive assessment of the environmental safety of existing or newly built city filling stations and a list of measures to reduce their negative impact on the environment. The software toolkit is designed in the MVC style, supports its own data storage format and is implemented using the Microsoft Visual Studio programming system using WPF and .NETCore technologies, in the C# language. When working with software tools, the user is provided with the following functionalities: filling out the petrol station questionnaire (number, name, address and date of the initial assessment of a particular petrol station), saving and loading a session on working with the assessment of a particular petrol station, assessment, calculation and cyclical improvement of the indicator of the environmental assessment of petrol stations (the choice of measures, depending on the obtained primary indicator of environmental safety), until the maximum possible class of environmental safety of a particular filling station is achieved and reporting on the resulting assessment.

1. Introduction

The intensive growth in the number of filling stations in cities is an object of increased environmental danger, as it is a source of constant emission of harmful substances into the environment. Studies have shown that the location of filling stations within the city is chaotic, often without taking into account the regulatory requirements governing the size of the sanitary gap to residential buildings, and factors contributing to the spread of harmful substances. All this leads to a deterioration of the ecological situation in the city and an increase in the negative impact on human life.

2. Materials and methods

An analytical review of scientific research and existing methods and techniques for determining the spread of harmful substances from sources of atmospheric pollution located on the territory of filling stations showed that the known methods and techniques for ensuring environmental safety do not fully meet modern requirements, are isolated and are devoted to solving certain issues of emission and the spread of harmful substances from the transport infrastructure of the city [1-10].
Of greatest interest is the methodology [6], which makes it possible to assess the degree of influence of the filling station on the adjacent buildings and people's livelihoods, taking into account all possible factors. It is important to note that one of the results of this methodology is a list of possible measures that will improve the environmental safety class of filling stations and reduce their negative impact on the urban environment. However, this technique is very laborious and requires a large number of heterogeneous assessments, their analysis, processing of the results, the correlation of the results obtained with the environmental safety class, as well as the formation of a list of measures to improve the safety class of the filling station. The use of automation to assess and improve the environmental safety class of petrol stations can significantly simplify the application of the approach under consideration.

Automation of this process will facilitate the expert's work, namely, to assess the environmental safety of the petrol station. Based on its results, generate reports, if necessary, in an automated mode, form a list of measures to improve environmental safety.

After analyzing the existing software products in the field of calculating and determining emissions of harmful substances into the atmosphere from various objects, including from petrol stations, the following conclusions were drawn [11-14]:

- Have an overloaded interface or, conversely, there is not enough information to understand the state of the ambient air;
- Rely on American calculation systems and the AQI air quality index, and do not use the methods recommended by the Ministry of Nature (with the exception of expensive professional programs) - mobile applications;
- Mobile applications do not perform a comparative analysis with MPCs established by the Resolutions of the Chief State Sanitary Doctor of the Russian Federation;
- Desktop applications have a high cost and carry out calculations based on regulatory documents, in connection with which there is no complete picture of the environmental friendliness of petrol stations;
- Do not take into account the assessment of the impact of the filling station on the ecological state of the environment;
- Do not propose measures to improve the environmental friendliness of petrol stations.

As a result, the task was set to develop software tools, which allows not only to quickly assess the impact of petrol stations on the adjacent buildings, but also to propose measures to improve the class of electronic fuel stations, which will reduce the degree of negative impact of existing or newly designed petrol stations on the environment due to introduction of the necessary protective measures.

3. Results

For a quantitative assessment of the environmental safety of filling stations, it is proposed to combine all the identified factors affecting the state of the urban environment from sources of emissions at filling stations into six categories:

\[
F = P_1, P_2, P_3, P_4, P_5, P_6
\]  

Where \( P_1 \) are natural and climatic factors, they include meteorological conditions - the speed and direction of the air flow, precipitation, fog, calm, temperature inversion and terrain; \( P_2 \) - urban planning factors, take into account the location of residential and public buildings relative to the petrol station and sanitary gaps between them, the presence around the petrol station of structures that help to contain the spread of harmful substances: trees, shrubs, utility buildings, protective screens and fences; \( P_3 \) - architectural and planning factors, take into account the plan and layout of objects on the territory of the petrol station (operator room, fuel dispensers with a canopy, breathing tubes, additional outbuildings), as well as their shapes and sizes; \( P_4 \) - technological factors, take into account the
technological features used at the filling station: the technology of filling the tank (using a petrol equalizing system), the use of modern technological equipment, the procedure for filling a car, the level of qualifications of the filling station workers; P_5 - technical factors, take into account the technical condition and service life of the petrol station equipment, the composition of the tank farm (volume, quantity, method of placement: underground or aboveground), the throughput of the petrol station, which is directly related to the number of fuel dispensers; P_6 - qualitative factors, taking into account the presence of a background concentration of harmful substances in the urban environment, the type and quality of the fuel sold, as well as the heterogeneity of the composition of the traffic flow [15].

Each factor \( N_k \) includes a set of indicators \( i = 1,2,\ldots, m \), for each of which the possible options for compliance are determined, adopted based on the results of the analysis of regulatory technical and methodological documentation, as well as scientific works devoted to ensuring the environmental safety of transport infrastructure facilities. Each option is assigned a certain number of points. The value of the assigned points for each criterion (option) depends on the degree of their influence on the environmental safety of the filling station. All accepted criteria refer to the type of stimulants - indicators that should have the highest possible value.

The result of a multi-criteria analysis of factors is an indicator for assessing the environmental safety of a petrol station (\( \Psi \)), which makes it possible to comprehensively assess the influence of all factors and indirectly characterize the degree of negative impact of a petrol station on the urban environment not only of existing petrol stations, but also of newly designed ones, having previously estimated the possible harm from their operation in the future:

\[
\Psi = \frac{K}{T} \cdot 100\%
\]

(2)

Where \( K \) - is the sum of points for all criteria of factors; \( T \) - the maximum possible number of points for all criteria and equal to 182 points:

\[
K = \sum_{i=1}^{6} N_{p_{1i}} + \sum_{i=1}^{4} N_{p_{2i}} + \sum_{i=1}^{4} N_{p_{3i}} + \sum_{i=1}^{4} N_{p_{4i}} + \sum_{i=1}^{5} N_{p_{5i}} + \sum_{i=1}^{4} N_{p_{6i}}
\]

(3)

where \( N_{p_{11}}, N_{p_{21}}, N_{p_{31}}, N_{p_{41}}, N_{p_{51}}, N_{p_{61}} \) - is a set of indicators for each criterion.

The indicator of the environmental safety of the filling station (\( \Psi \)) serves as a decision-making criterion. To substantiate decision-making in accordance with the obtained value of the indicator of the environmental safety of the filling station, a rating system for determining the class of environmental safety of the filling station is proposed.

In the course of designing software tools based on the unified modeling language UML, a use case diagram was built that displays its functional structure (figure 1). The main subject is a user - an expert who assesses the ecological state of the city filling station.

The Session Opening scenario consists of two possible user actions: filling out a questionnaire for conducting an initial environmental assessment of a city petrol station or uploading a file with an already conducted initial environmental assessment to further determine measures to improve the environmental safety class of a city petrol station. The scenario of use "Interaction with factors" is used both for the initial environmental assessment and in the case of changes in the values of the necessary criteria during the uploaded file with the already existing environmental assessment of the petrol station. The scenario of use "Interaction with events" is used by the user if it is necessary to increase the environmental safety class of the petrol station. The scenario of use "Session saving" is applied after the environmental assessment of the city petrol station and the calculation of the environmental safety class or after the work to improve the environmental safety class of the petrol station.
4. Discussion
Based on the design, functional blocks were identified, which were implemented in the form of software modules. The structural diagram of the software toolkit is a diagram of the interaction of its components based on a three-tier architecture for building applications and includes the following parts:

- Data abstraction layer. Loading data from a database, file and saving data. Data arrives or is sent to the next level - the business logic level. The database in this software application is implemented as a set of document-oriented binary files, the data in which is serialized (deserialized) and has the *.dbgs extension:
  1. A table of factors and a corresponding set of criteria for each factor;
  2. Table of images characterizing the ecological characteristics of urban petrol stations;
  3. Table of rating of evaluation criteria affecting the spread of hazardous substances from petrol stations.

Figure 1. Diagram of precedents of the system for assessing the environmental safety of urban petrol stations.
4. The table contains a list of measures to improve the environmental safety class of city filling stations.

- Business logic level. Data transformation is in progress: calculation of indicators of fuel station electronic safety. Data comes in or is sent to the next level - the presentation level;
- Presentation level. The data is displayed to the end user. He can see them and perform manipulations (but in this case, the data will pass through the business logic level). The level renders graphic (mainly) elements, and simple business logic operations: data validation, etc. As an architectural pattern for the implementation of the presentation level, the architectural pattern MVVM is used.

The use of a three-tier architecture has made it possible to develop a competent and functional application framework, which plays a large optimization role in a software product. That is, if you need to make changes to the software product, you will not need to rebuild or design a new architecture, you will only need to add a new component to it and bind it to the business logic level [16].

The developed software product is a desktop application supplied with an installation package [17]. The software product was implemented in the object-oriented programming language C# using the Visual Studio IDE and using WPF and .NETCore technologies. To create an installer for the software product, the Inno Setup program was used using the Script Pascal and C++ languages. To implement the database, non-relational document-oriented binaries were developed. To form and view the generated report on the actions taken, the Microsoft Word text editor was used.

The software application provides two options for working with the main menu: the first is to conduct an initial environmental assessment of the petrol station, the second is to download a file with an environmental assessment of the petrol station.

To carry out the initial assessment, it is necessary to fill in the input data about the city petrol station under study: the name of the fuel company, its number, address of the location. The assessment date appears automatically. After that, it is necessary to select an environmental factor, as a result of which the assessment criteria corresponding to it will be loaded on the right, affecting the spread of harmful substances from petrol stations and containing options for compliance, each of which has been assigned a certain number of points. The user conducts an environmental assessment of the city petrol station for all six factors. Then he clicks on the "Calculate" button, as a result, a dialog box appears with the result of calculating the indicator of the environmental safety of the filling station and the corresponding class of environmental safety, as well as a list of measures necessary to increase the indicator of the environmental safety of the filling station.

If it is necessary to increase the environmental safety class of this filling station, the user has the opportunity to select the necessary measures and click on the "Recalculate" button and get a new result. After carrying out the necessary calculations, the user has the ability to save the data: generating a report in a Word format file with the results of all calculations performed, generating a file with the *.gs extension containing the results of the initial assessment of the environmental state of the city filling station, which can be downloaded later for further work (all indicators of the assessment criteria by factors, as well as data on filling stations will be loaded automatically).

The software toolkit provides for checking the correctness of the entered data and filling out the fields of the petrol station questionnaire during the initial assessment and displaying messages if the user, leaving the software application, forgot to save the results of the initial environmental assessment according to the criteria in *.gs format and if he did not generate a report on the performed calculations in Word format.

5. Conclusion

Thus, the use of software tools based on the methodology [6] will allow: monitoring the state of the urban environment from the impact of sources of harmful emissions at filling stations; assess the state of the environmental safety of the filling station; to determine the need for environmental protection
measures of a constructive, technical, organizational, legal and planning and urban planning nature to improve the environmental safety of filling stations. There is a possibility of further development and improvement of software tools, as well as its integration into a web-oriented system.

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