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INFORMATION AND ANALYTICAL SYSTEM FOR COLLECTING, PROCESSING AND ANALYZING DATA ON AIR POLLUTION

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Abstract. *The presented information and analytical system is designed to provide convenient management of the processes of collecting, processing and analyzing air pollution data. The system is a web application built on the basis of the R programming language using the Shiny web service and works with data from Vaisala monitoring stations. The created service receives data from the monitoring stations on various air parameters such as wind speed, temperature, and levels of pollutants such as PM2.5, CO, and NO2.The main functions of the web service include uploading data to a dedicated server, processing data with the ability to round time ranges, interactive data visualization using graphs and charts, building air quality charts, and presenting AQI, which can be used to classify pollution levels and generate recommendations for different sensitivity groups of the population.The system allows users to download data from the server in various formats or access the original data from the Vaisala server. In addition, users can convert data to different units of measurement. The web service can be of interest to both household users and professionals in various fields, including environmental researchers in Ukraine, governmental environmental control organizations, municipal and public organizations interested in a clean environment. By improving the availability and analysis of air quality data, this service contributes to the preservation of the environment and public health.*

Анотація. *Представлена інформаційно-аналітична система призначена для зручного управління процесами збору, обробки та аналізу даних про забруднення повітря. Система являє собою веб-додаток, побудований на основі мови програмування R з використанням веб-сервісу Shiny і працює з даними станцій моніторингу Vaisala. Створений сервіс отримує дані від станцій моніторингу про різні параметри повітря, такі як швидкість вітру, температура та рівні забруднюючих речовин, таких як PM2,5, CO та NO2. Основні функції веб-сервісу включають завантаження даних на виділений сервер, обробку даних з можливістю округлення часових діапазонів, інтерактивну візуалізацію даних за допомогою графіків і діаграм, побудову діаграм якості повітря та представлення AQI, за допомогою якого можна класифікувати рівні забруднення та розробити рекомендації для різних чутливих груп населення. Система дозволяє користувачам завантажувати дані з сервера в різних форматах або отримувати доступ до оригінальних даних із сервера Vaisala. Крім того, користувачі можуть конвертувати дані в різні одиниці вимірювання. Веб-сервіс може бути цікавий як побутовим користувачам, так і професіоналам різних галузей, у тому числі екологам України, органам державного екологічного контролю, муніципальним та громадським організаціям, зацікавленим у чистоті довкілля. Покращуючи доступність та аналіз даних про якість повітря, ця послуга сприяє збереженню довкілля та здоров'ю населення.*

Keywords: *air quality monitoring, Vaisala, Shiny, data analysis, environmental analytics, data visualization, AQI, web application, pollution analysis.*

Ключові слова: *моніторинг якості повітря, Vaisala, Shiny, аналіз даних, екологічна аналітика, візуалізація даних, AQI, веб-додаток, аналіз забруднення.*

I. INTRODUCTION

The study of the processes of collecting, processing, analyzing and downloading data from environmental monitoring stations used by environmental enterprises at the municipal level in Ukraine revealed that high-precision software and hardware solutions from Vaisala are often used to implement these processes. It should be noted that the cloud services where environmental data can be stored and which are supplied by the station manufacturer are paid and quite expensive in the Ukrainian reality ($300 per station per year). The research revealed that the network gateways that transfer data to Vaisala cloud services have the ability to reconfigure the direction of data transmission to any correctly configured server that has a domain name or an open static IP address. Accordingly, it is possible to refuse from the expensive Vaisala cloud service and implement your own solution for accumulating and visualizing environmental data, which will be free for use by all user groups and will support the expansion of functionality based on scientifically sound methods of environmental data analysis. In addition, the implementation of a proprietary environmental data storage service will provide an opportunity to collect heterogeneous data from stations of different levels of environmental monitoring (public, municipal, state) in one system, which will allow researchers, household users and regulators to obtain complete information about the state of air pollution in real time.

II. LITERATURE ANALYSIS

2.1. Environmental monitoring in Ukraine and worldwide

Environmental monitoring of atmospheric air plays a pivotal role in preserving the natural environment and ensuring public health worldwide. This process determines the degree of air pollution and serves as a tool for taking measures to reduce its negative impact.

Environmental monitoring is a system for collecting and analyzing data on the state of atmospheric air and its impact on the environment. In developed countries, this process becomes an integral part of sustainable development strategies, assessing pollutant concentrations and meteorological conditions [1].

The effectiveness of environmental monitoring lies in its ability to provide objective data to identify pollution trends and evaluate the effectiveness of measures to reduce negative impacts. This is crucial for determining emissions of harmful substances, such as nitrogen and sulfur oxides.

For example, European Union countries employ a standardized approach to air quality monitoring [2], utilizing networks of stations and remote sensing technologies for regular monitoring of pollutant concentrations. This allows them to react effectively to changes in the atmospheric environment.

In the United States, the Air Quality System (AQS) program [3] monitors over a thousand stations, providing quality data for air quality analysis. This is a significant example of integrating technology and public participation.

Environmental monitoring is crucial for developing environmental conservation strategies and policies [4]. The growing demand for monitoring is associated with citizens' awareness of environmental issues and becomes an essential component of environmental management systems.

Ukraine is actively developing its atmospheric air monitoring system [5], employing modern technologies. The state monitoring system is based on international standards and considers regional contextual features [6], including historical challenges such as Chernobyl and war.

In Ukraine, environmental monitoring of atmospheric air proves to be crucial in addressing environmental problems caused by the war [7]. This monitoring allows timely detection of pollutants and their impact on the environment and human health. Ukraine is gradually implementing modern technologies for objective data collection and developing environmental management strategies.

Air quality monitoring in Ukraine is in a constant process of improvement, with plans for future utilization of modern technologies such as satellite systems and remote sensing. This will contribute to obtaining accurate real-time data.

Environmental monitoring of the atmosphere in Ukraine is crucial for developing strategies for ecosystem preservation and public health. Its results form the basis for effective measures to reduce the impact of anthropogenic factors on the atmospheric environment.

Thus, environmental monitoring of the atmosphere in Ukraine identifies and addresses environmental challenges, contributing to the conservation of natural resources and ensuring public health. Its role in addressing global environmental issues is pivotal for sustainable development and the preservation of the planet for future generations.

2.2. General characteristics of the Air Quality Index

The Air Quality Index (AQI) [8] is a key tool for assessing the degree of atmospheric pollution and its impact on health and ecosystems. It is determined through a numerical expression of contamination levels by various substances. AQI is used in many countries, including Ukraine, where it facilitates air quality monitoring and management, informs the public, and assists in developing strategies to reduce the impact of pollution on health and the environment. AQI is an internationally recognized standard that simplifies the comparison of air quality on a global scale. This tool is a crucial element for making informed decisions in the field of environmental protection and public health.

2.3. Analysis of existing systems for monitoring environmental parameters

The analysis of air quality monitoring systems reveals a variety of resources, including the European Environment Agency (EEA) [9], AQICN [10], and Breezometer [11]. EEA offers a standardized approach and covers EU countries but is geographically limited. AQICN, available to all users, has a user-friendly interface and considers more pollutants. Breezometer provides accurate information on dust and pollen but is limited regionally. Each system has its advantages and disadvantages, innovations, and limitations, which are crucial to consider when choosing an air quality monitoring solution.

AirNow [12] in the United States provides real-time air quality information using the AQI index, focusing on the entire country. Clean Air Partners [13] is a network of 200 organizations offering historical air quality data. LondonAir [14] in London uses interactive maps for real-time monitoring. In Hong Kong, AQHI [15] considers the impact of pollutants on health. In Japan, Taiki Kankyo Map [16] and Soramame [17], in Germany, Luftdaten Berlin [18], and IQAir [19] worldwide provide convenient tools for monitoring and comparing air quality in different regions of the world.

Eco City [20], a Ukrainian monitoring site, provides an interactive map with air quality sensors and detailed information. The system covers indicators such as PM2.5, PM10, temperature, humidity, and others, presenting data in a convenient and straightforward interface. The analysis of other environmental systems emphasizes the diversity of technologies and methods, indicating the need for further development and improvement for effective environmental monitoring worldwide.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

3.1. Objective, object and subject of the research

The object of the research is the process of collecting, processing, analyzing and downloading data from Vaisala environmental air monitoring stations.

The subject of the research is an information-analytical system for automated collection, processing and analysis of data on the state of air pollution using environmental monitoring stations.

The purpose of the research is to analyze existing web-based air monitoring services and create a comprehensive information and analytical system with the functions of collecting, processing and analyzing air pollution data, which will allow environmental researchers in Ukraine, governmental environmental control organizations, municipal and public organizations to make decisions aimed at maintaining a clean environment.

3.2. Choosing means and setting goals to achieve the purpose

Using the R programming language and the Shiny library to develop a web application for analyzing air pollution data is a justified choice. Compared to other technologies such as Laravel, Python, Django, JavaScript, Node.js, Java, and Spring, R and Shiny stand out for their specialization in statistical data analysis and interactive visualization interfaces. Their ease of scalability, integration with the data ecosystem, and strong community support make them effective tools for this project.

Considering the functionality of the Vaisala web application and the advantages of R and Shiny for creating an information-analytical system, the technical task is as follows:

1. Develop a web application in the R programming language using Shiny for interactive collection, processing, and analysis of data from Vaisala monitoring stations.
2. Provide the ability to convert data into different measurement units, process data, including rounding, with the option to select a time interval (up to 20 minutes, 1 hour, 4 hours to a day, to a week, to a month, to a quarter, to a year).
3. Implement data visualization in the form of graphs and diagrams to display air quality parameters.
4. Enable data download in a convenient format, selection of one or all parameters, including formats such as csv, xlsx, txt, with rounding options.
5. Ensure interaction with researchers or system users who use the data to make decisions regarding ecology and air quality.

3.3 Research methods

Theoretical: data collection and processing from the server of Vaisala environmental monitoring stations.

Experimental research is based on testing the efficiency of data transmission and storage, processing, data visualization, calculation of AQI in real conditions, and downloading the processed data.

3.4. Basic architecture of the research tools used

The air quality monitoring system is based on a central server that ensures data storage and processing. The database, also located on the server, is optimized for efficiently managing a large volume of information. The user interface is created using the Shiny Web App, providing interactivity and convenient access to data analysis. The technical architecture of the system utilizes advanced technologies to optimize data processing and analysis, ensuring the efficient operation of the large-scale system.

The Vaisala Beacon Station BWS500, is a compact meteorological station with advanced technology. This versatile station measures quality meteorological data and air quality data using an automatic weather station and an air quality sensor. Using an open API, the data can be integrated into third-party systems. The option to choose different sensors is provided based on user needs. The Vaisala Beacon Edge gateway ensures secure data transmission. The BWS500 is available in various configurations and is easy to install.

Another development by Vaisala is the WXT530 and the AQT530 air quality sensor. WXT530 features a wide range of measurements, providing accurate meteorological data for various applications. The station interacts with the Vaisala Beacon Edge EGW501, ensuring secure data transmission. AQT530 measures the concentration of gases and particulate matter in the atmospheric air using advanced technologies that ensure high measurement accuracy. Both devices can be applied in various fields, including meteorological monitoring and air quality control.

The information-analytical system is based on data from Vaisala station sensors, which include various parameters of atmospheric air. These data encompass wind speed, maximum wind speed, rainfall intensity, wind direction, rainfall accumulation, PM10, air temperature, PM2.5, relative humidity, SO2, H2S, atmospheric pressure, NO2, PM1, and CO. The system analyzes these parameters, taking into account air quality standards, and provides a user-friendly high-level analysis. Sensor information is strategically vital for the system, providing key data for air quality monitoring and management.

3.5 Scientific novelty and practical significance

The paper improves the model of an information-analytical system for collecting, processing and analyzing air pollution data by implementing basic analytical algorithms based on the R programming language, which, unlike others, makes it possible to use the free Shiny web service hosting platform during development and at the initial stages of implementation, to apply built-in data analysis and statistics calculation functions, which reduces the time required to visualize the result.

The created web service is a tool for researchers who use the collected data to analyze and make informed decisions. By providing access to a wide range of ways to analyze air quality parameters, it can become the basis for scientific research and environmental impact assessment.

Public authorities can use the data analyzed by the service to make informed and environmentally friendly decisions.

The web service is also open for use and improvement by research organizations interested in air quality monitoring and environmental research. The ability to share data and resources makes the system a valuable tool for expanding knowledge in the field of ecology and computer engineering.

The air quality monitoring system plays a crucial role in the interaction with various elements of the ecosystem. Its functioning is aimed at providing information support for research, management and decision-making in the field of ecology, which makes it an important tool for sustainable development and environmental protection.

IV. RESULTS

4.1. Vaisala web application functionality

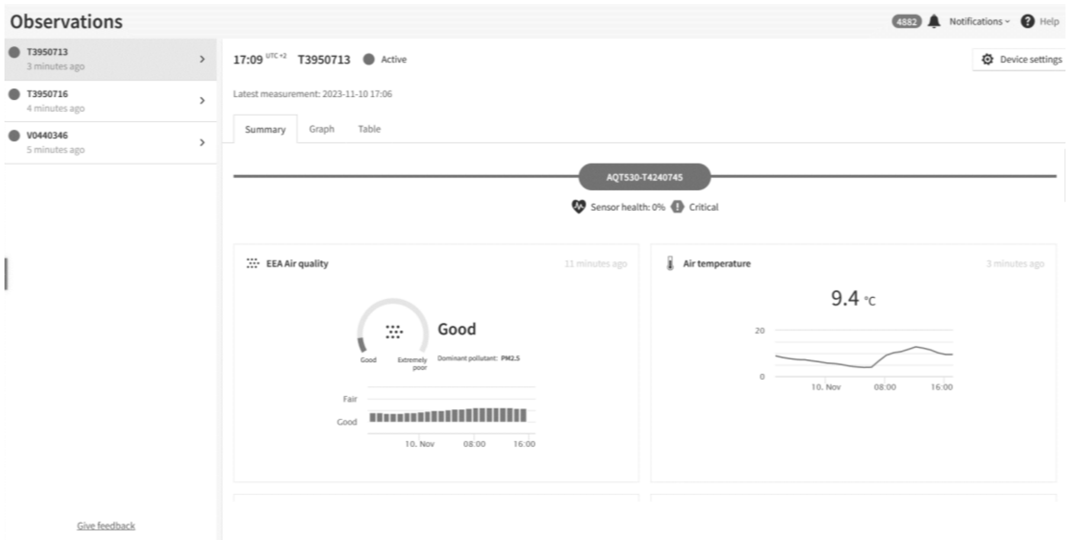
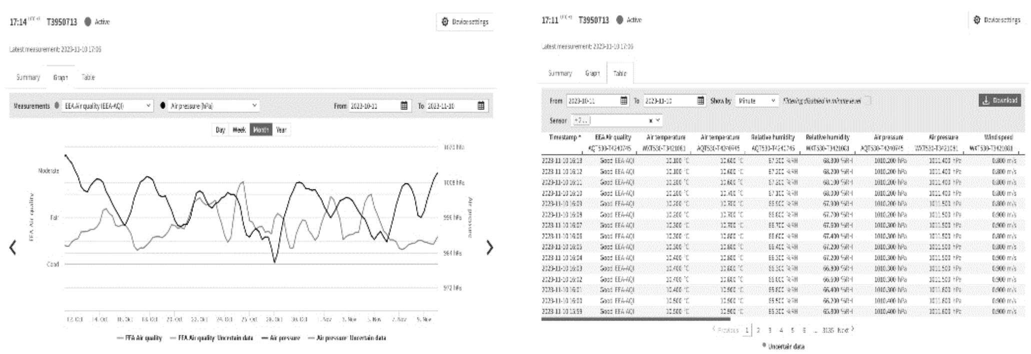


Fig. 1 – The main page of the Vaisala app
Рис. 1 – Головна сторінка програми Vaisala

The Vaisala web application is a tool for effective management and visualization of data from sensors such as AQT530 and WXT530. The user-friendly interface allows users to personalize the data display, choosing measurement units and reviewing consolidated information for the last 24 hours.

1 2



1 – the first figure demonstrates the view of the Vaisala app on the graphs tab; 2 – the second figure shows the tables tab

Fig. 2 – View of two tabs of the Vaisala web application
Рис. 2 – Вигляд двох вкладок веб-додатку Vaisala

Graphs and tables provide detailed information for analyzing changes over time. The application also allows users to download data in CSV format for further analysis. While it is an normal intelligent tool, it may require additional tools for air quality data analysis, which may cost more than the standard subscription plan.

4.2. Improved research architecture

The information-analytical system for air quality monitoring consists of two key components: the website and the database. The website, developed using R and Shiny, provides users with an intuitive interface to interact with the data. The website structure includes pages with tables, graphs, comparison of graphs, air quality diagrams, AQI index, and measurement unit settings. The MySQL database ensures fast access to air quality data. The system components interact to facilitate convenient analysis and visualization of data.

The information-analytical system offers a convenient and efficient tool for collecting, processing, and utilizing air quality data from Vaisala stations. The system's functionality includes automatic data collection, processing, and visualization through graphs and diagrams. Users have access to data export in convenient formats and unit conversion.

The developed system caters to various users, including researchers, private organizations, government bodies, and citizens, providing them access to reliable and understandable information. The system supports scientists in conducting research and policymakers in making informed decisions.

In particular, the system enables cost-effective replacement of expensive subscriptions on the official Vaisala website, reducing costs and enhancing analytical capabilities. The use of the web application is supported by its own server, resulting in significant cost savings compared to using the official resource.

The developed information-analytical system is intended for effective air quality monitoring, reducing costs, and improving analytical capabilities. This approach becomes more accessible to researchers, government authorities, and non-governmental organizations, playing a key role in addressing environmental challenges and ensuring public health.

The system automatically downloads data for the entire time period, ensuring systematic updates. The automated data processing process contributes to the accuracy and efficiency of the results. Innovative visualization tools facilitate data analysis and understanding. The integration of web technologies provides universal access and optimizes data usage, enhancing the functionality of the air quality monitoring system.

4.3. Description of the functionality of the information system web service

Sequence of Application Operation:

1. Data Collection and Transmission: The system initiates by collecting information from the official server where data from Vaisala station sensors are uploaded. These raw measurements are transferred to the system's internal server, enabling the processing and analysis of the collected data.

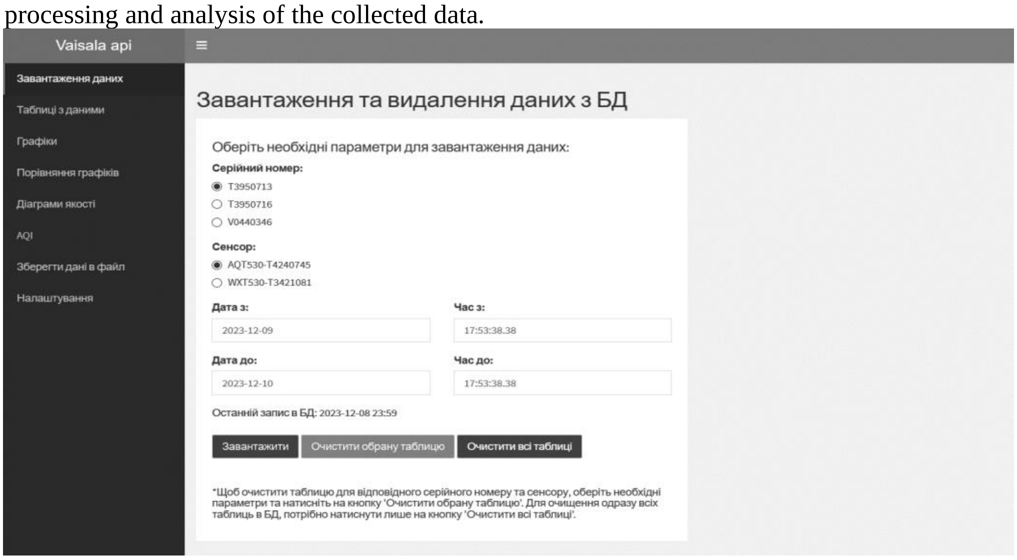


Fig. 3 – The initial tab «Downloading data»
Рис. 3 – Початкова вкладка «Завантаження даних»

The appearance of the data download page from the Vaisala server is depicted in Figure 3.

2. Data Processing and Optimization: The data undergoes a comprehensive processing stage, including the ability to round to established time ranges. This ensures high accuracy and adaptability of the information for a large volume of data and its subsequent use.

3. Data Visualization and Presentation: One of the system's key features is its ability to visualize data in the form of interactive graphs, diagrams, and the AQI index. This not only improves information perception but also allows for in-depth analysis and trend identification.

4. Data Export: The system provides users with the ability to export data in a convenient format, facilitating further use in other systems or programs.

5. Data Conversion: There is an option for unit conversion, making data usage easier in different contexts.

Therefore, the user first lands on the application page and navigates to the «Data Upload» tab, where they can manually upload data if it has not been automatically loaded. Data is automatically updated every 10 minutes. In the upper-left corner is the application name «Vaisala API». Below the name is the navigation menu with tabs: «Data Upload», «Data Tables», «Graphs», «Graph Comparison», «Air Quality Diagrams», «AQI», «Save Data to File», «Clear Data».

On the «Data Upload» tab to the right of the navigation menu are control elements for uploading data. Initially, the user must select the station's serial number and then choose the sensor for the corresponding serial number. Below are fields for entering the start and end date and time for the period for which data needs to be uploaded. Information about the last record in the database for the selected serial number and sensor is displayed below. If the database is empty, a corresponding message will be displayed. Further down, there are buttons «Upload», «Clear Selected Table», and «Clear All Tables».

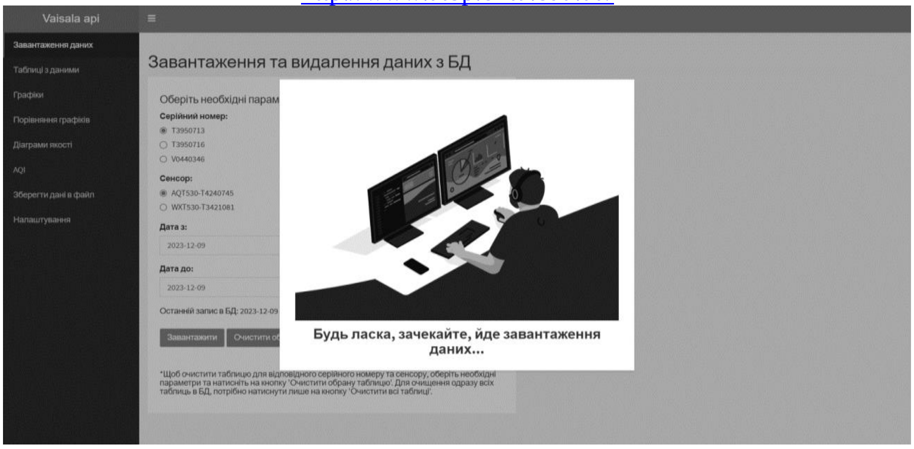


Fig. 4 – Viewing the page while loading data
Рис. 4 – Перегляд сторінки під час завантаження даних

The «Upload» button initiates the verification of the data entered by the user. If the date or time is incorrectly input, the user will receive a notification. Additionally, if the Vaisala server does not respond, the user will also be notified.

If everything is entered correctly, the data will begin to be uploaded to the database. The user cannot navigate or click anything while the data is being uploaded. After the data is successfully uploaded, the user will receive a pop-up window providing information about the upload results.

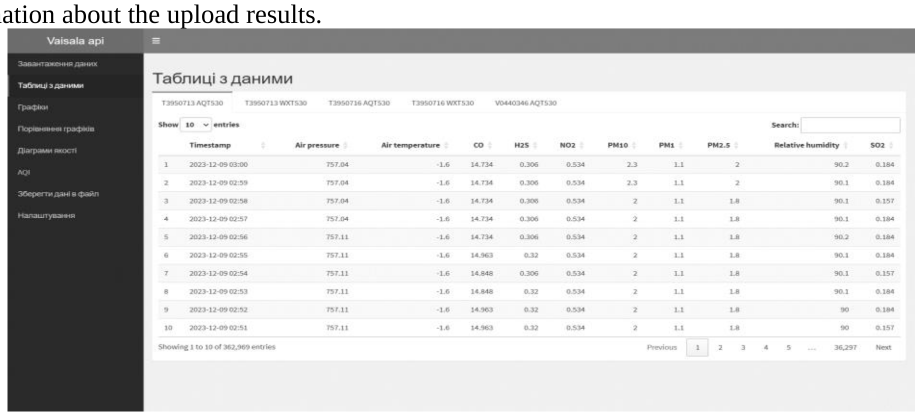


Fig. 5 – Tab «Tables with data»
Рис. 5 – Вкладка «Таблиці з даними»

The second tab, «Data Tables», consists of five tabs, each corresponding to a specific sensor. Each table displays all the data from the database for the respective sensor.

The tables have the following functions:

− A field for searching data;
− Sorting data from largest to smallest and vice versa;
− Highlighting the necessary row;
− Displaying 10, 25, 50, or 100 values on a single page;
− Buttons for navigating through data pages.

In the bottom left corner of each table, the total amount of data is indicated, along with the range of values being displayed.

Fig. 6 – Tab «Graphs»
Рис. 6 – Вкладка «Графіки»

The third tab, «Graphs» consists of five tabs for each sensor. On this tab, the data can be rounded to the required time interval. The possible rounding options include: «No rounding», «20 minutes», «1 hour», «4 hours», «day», «week», «month», «quarter» or «year».

The second dropdown list allows displaying data for the selected time range. The possible display options include: «All data», «Last hour», «Last 4 hours», «Last 12 hours», «Last day», «Last 3 days», «Last week», «Last month», «Last quarter» or «Last year».

In each tab, a chart is generated with the corresponding parameters. The charts automatically update when changing values in the dropdown lists. All charts are interactive, and each data point provides all the necessary information upon hovering: date, time, and value.

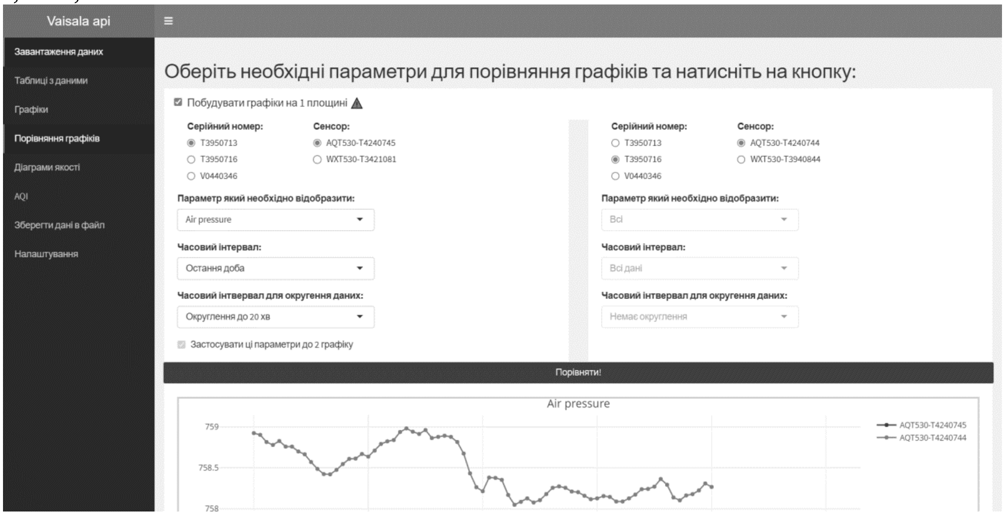


Fig. 7 – Tab «Graph comparison»
Рис. 7 – Вкладка «Порівняння графіків»

On the «Comparison of Graphs» tab, the user can create charts for two different sensors on one plane or side by side on two planes. To do this, it is necessary to select the appropriate option in the top-left corner.

If the data is plotted on one plane, then all parameters and time intervals of the first sensor will be automatically set for the second sensor. Next, the user selects the serial number and sensor for the first and second graphs, sets a parameter from the dropdown list, and specifies time intervals.

Time intervals are the same as for regular charts. The parameter has options that are stored in the database for the respective sensor. After clicking the «Compare!» button, charts will be generated below based on the specified parameters.

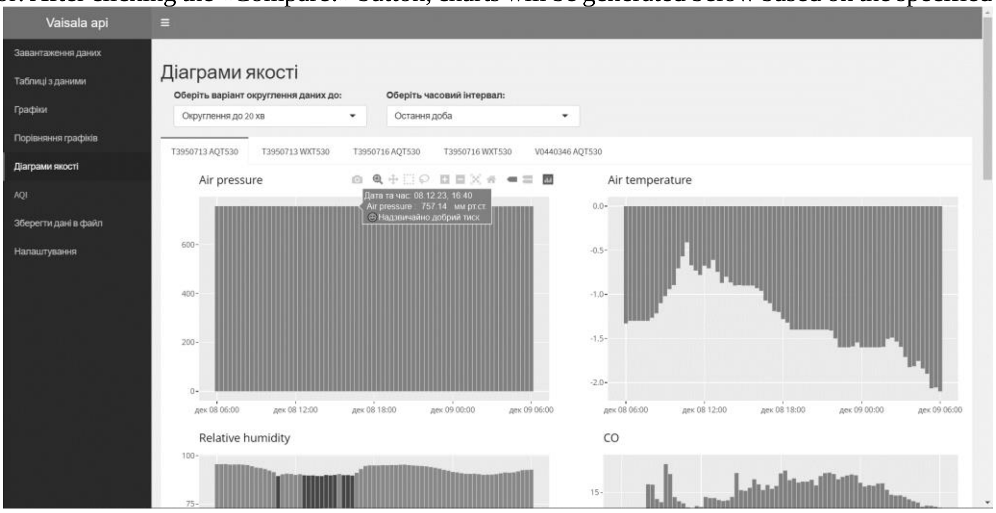


Fig. 8 – Tab «Quality charts»
Рис. 8 – Вкладка «Діаграми якості»

The «Quality Charts» tab has two dropdown lists and five tabs for each sensor. On the bar charts, the columns are colored with the corresponding color. All charts are interactive. Hovering over a column shows the date, time, parameter value, and a brief analysis. Figure 8 demonstrates pressure analytics.

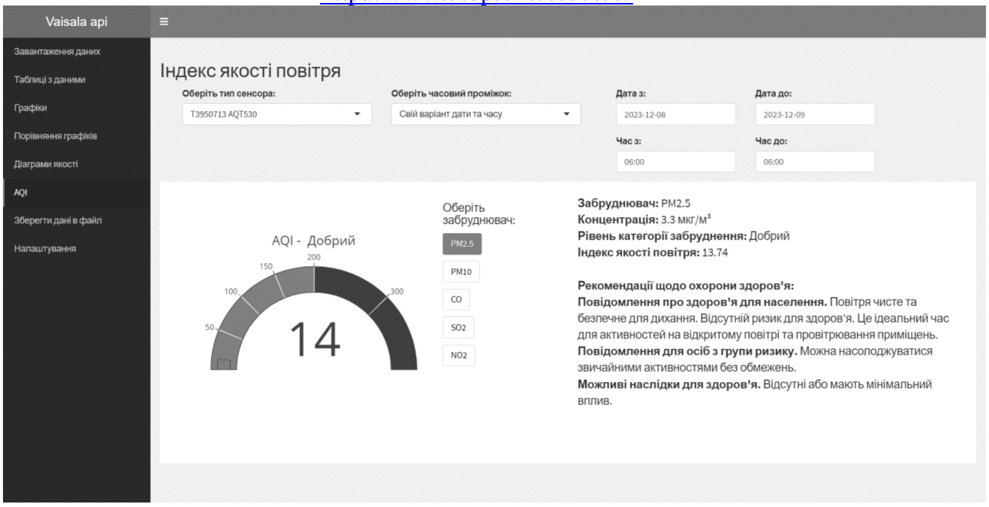


Fig. 9 – Tab «AQI»
Рис. 9 – Вкладка «AQI»

The «AQI» tab contains a measurement diagram, which is a key tool for determining air quality. It assesses 5 pollution parameters and displays the results in the form of color-coded classification. Users can quickly determine air quality from «good» to «hazardous».

O_3 (ppb)	O_3 (ppb)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	SO_2 (ppb)	NO_2 (ppb)	AQI	AQI
$C_{low} - C_{high}$ (avg)							$I_{low} - I_{high}$	Category
0–54 (8-hr)	—	0.0–12.0 (24-hr)	0–54 (24-hr)	0.0–4.4 (8-hr)	0–35 (1-hr)	0–53 (1-hr)	0–50	Good
55–70 (8-hr)	—	12.1–35.4 (24-hr)	55–154 (24-hr)	4.5–9.4 (8-hr)	36–75 (1-hr)	54–100 (1-hr)	51–100	Moderate
71–85 (8-hr)	125–164 (1-hr)	35.5–55.4 (24-hr)	155–254 (24-hr)	9.5–12.4 (8-hr)	76–185 (1-hr)	101–360 (1-hr)	101–150	Unhealthy for sensitive groups
86–105 (8-hr)	165–204 (1-hr)	55.5–150.4 (24-hr)	255–354 (24-hr)	12.5–15.4 (8-hr)	186–304 (1-hr)	361–649 (1-hr)	151–200	Unhealthy
106–200 (8-hr)	205–404 (1-hr)	150.5–250.4 (24-hr)	355–424 (24-hr)	15.5–30.4 (8-hr)	305–604 (24-hr)	650–1249 (1-hr)	201–300	Very unhealthy
—	405–504 (1-hr)	250.5–350.4 (24-hr)	425–504 (24-hr)	30.5–40.4 (8-hr)	605–804 (24-hr)	1250–1649 (1-hr)	301–400	Hazardous
—	505–604 (1-hr)	350.5–500.4 (24-hr)	505–604 (24-hr)	40.5–50.4 (8-hr)	805–1004 (24-hr)	1650–2049 (1-hr)	401–500	

Fig. 10 – Categories of the air quality index
Рис. 10 – Категорії індексу якості повітря

The colors of the air quality diagram have the following meanings:
– Green: air quality is within the norm, good;
– Yellow: air quality is satisfactory;
– Orange: air quality is unacceptable, harmful for vulnerable groups;
– Red: air quality is harmful;
– Purple: air quality is very harmful;
– Dark red: air quality is dangerous.

The user selects the type of sensor for analyzing the air in the dropdown list in the upper left corner of the diagram. To the right is the second dropdown list where the user can choose the time period for analysis: «Last hour», «Last 4 hours», «Last 12 hours», «Last day», «Last 3 days», «Last week», «Last month».

If the user chooses «Custom date range», then fields for entering the start and end dates for air analysis will appear.

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

(If multiple pollutants are measured, the calculated AQI is the highest value calculated from the above equation applied for each pollutant.)

where:

I = the (Air Quality) index,
C = the pollutant concentration,
C_{low} = the concentration breakpoint that is ≤ C,
C_{high} = the concentration breakpoint that is ≥ C,
I_{low} = the index breakpoint corresponding to C_{low},
I_{high} = the index breakpoint corresponding to C_{high}.

Fig. 11 – Formula for calculating the air quality index
Рис. 11 – Формула для розрахунку індексу якості повітря

On the AQI tab, the user can interact with the diagram, switching between parameters. The data are calculated according to the formula depicted in Figure 11. The calculated data are analyzed based on the categories of the air quality index, as shown in Figure 10.

The diagram displays the index values, and above it is the textual representation. To the right of the diagram are buttons for switching between pollutants, and further to the right is a field for obtaining more detailed information about a specific pollutant and recommendations.

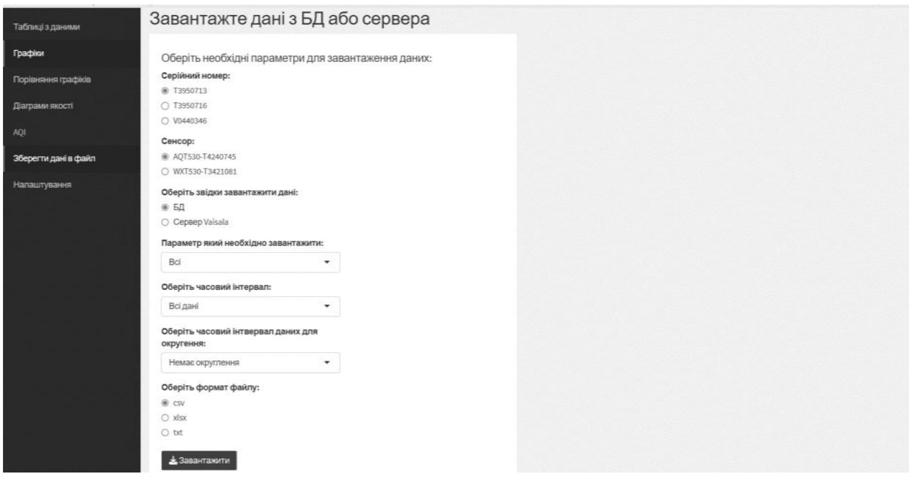


Fig. 12 – The «Save data to file» tab
Рис. 12 – Вкладка «Зберегти дані у файл».

On the «Save data to file» tab, the user must select the necessary serial number, choose the required sensor parameters, time intervals, and the file format for download. Then, the user can download data from the web application's database or from the Vaisala server.

If the user chooses the option to download from the Vaisala server, additional input of the start and end date and time for the download is required. After pressing the button to download the data, the user will be prompted to save them to the desired directory.

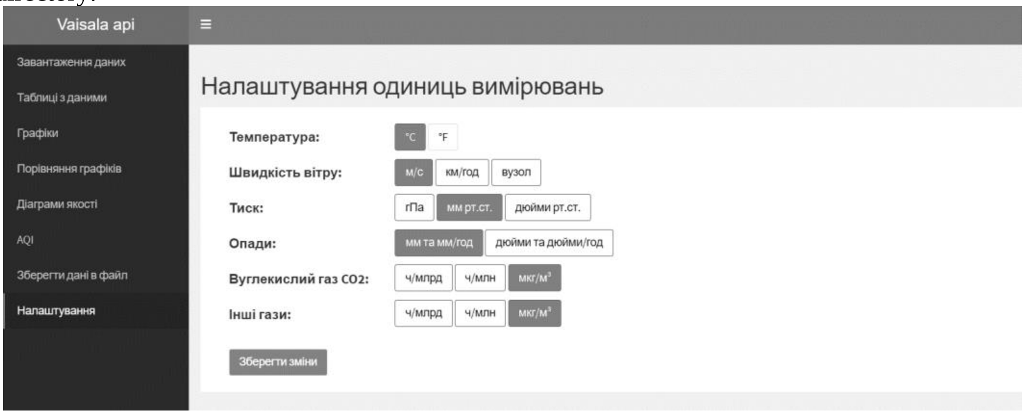


Fig. 13 – Tab «Settings»
Рис. 13 – Вкладка «Налаштування»

The last tab «Settings» provides the option to configure units of measurement for the necessary data.

The user can choose the required units of measurement for specific parameters. Afterward, all data, whether already loaded into the database or to be loaded in the future, will be adjusted according to the selected units of measurement.

The described system represents a significant advancement in the field of air quality analysis and monitoring. It enables users to receive the most comprehensible and accessible information for making informed decisions in the field of ecology and environmental conservation.

V. CONCLUSIONS

The developed web application for collecting, processing, and analyzing data from Vaisala monitoring stations aligns with the technical task and boasts a set of unique features that make it valuable for various purposes, including:

– The application enables the evaluation of air pollution levels in different locations and at different times. This is crucial for decision-making regarding air quality improvement and public health protection.

– Users can explore the causes of air pollution, such as industrial activities, transportation, and other factors. This is essential for devising measures to enhance air quality.

– The application allows the formulation of measures to improve air quality, such as reducing emissions of pollutants, enhancing transportation infrastructure, and other initiatives.

The application possesses unique features that enhance its utility:

1. The application is a web-based tool, providing accessibility from any internet-connected device. Users can access information about air pollution from anywhere.

2. Users can visualize data through interactive graphs and diagrams. This facilitates easy data analysis and trend identification.

3. The application allows data analysis based on various parameters, including time, location, and other factors. This provides users with a deeper understanding of the state of air pollution.

4. The application is designed to interact with various ecosystem elements, including air monitoring stations, researchers, and authorities. This versatility allows the application to serve different purposes, from improving air quality to safeguarding public health.

Additionally, the cost of the developed application is $2000. The official service for one station costs $1200 per year, but the application enables cost savings by opting for a lower tariff of $300 per year, providing data through an API. There is ongoing testing of the possibility of abandoning official services and manually reading data to one's server, resulting in more substantial savings.

The total expenses for renting a private server and obtaining data for one station amount to $445 per year in this scenario, which is $755 cheaper than the official service. Therefore, the project can pay off within three years, especially with the use of only one station, and even quicker with manual data reading.

In conclusion, the developed web application is a crucial tool for improving the accessibility and utilization of air quality data. The application encompasses unique features making it valuable for various purposes, including the assessment of air pollution, detailed investigation of its causes, and the development of measures to enhance air quality.

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