



(REVIEW ARTICLE)



## Integration of Field Measurements and Digital Analytics in Local Environmental Monitoring: Experience of a Family Laboratory in Ukraine

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### Abstract

Local environmental monitoring—measuring noise, air quality, water, and microclimate directly on-site—has become an important risk management tool for individuals, businesses, and municipalities. The global environmental monitoring solutions market is valued at over USD 20 billion and is projected to grow to USD 41–44 billion by 2034, showing a steady average annual growth of around 6%. At the same time, the air quality monitoring systems market is expected to double by 2034 compared to 2024, exceeding USD 11–12 billion.

Using the example of a family laboratory in Ukraine, which has been serving at least 60 clients per month for over eight years, this article examines the integration of field measurements and digital analytics. It describes approaches to digitizing measurements, using GIS and cloud services, managing large datasets, and creating clear visualizations for clients. The combination of classical measurement methods with digital tools is shown to increase the reliability of assessments, speed up report preparation, promote evidence-based environmental culture, and provide resources for scientific research and regulatory work.

**Keywords:** Local Environmental Monitoring; Ukraine; Digital Analytics; Air Quality; Noise; Microclimate; GIS; Iot Sensors; Private Laboratory

### 1. Introduction

Environmental monitoring has long been considered the responsibility of governments and large industrial enterprises. However, technological advances and stricter environmental requirements have led to a situation where a significant portion of measurements is now conducted at the level of specific sites: apartments, offices, small production facilities, schools, and shopping centers. Global trends reinforce this shift. Analysts estimate that the global market for environmental monitoring solutions may reach USD 41.8 billion by 2034, with an average annual growth rate of around 6.3%. Separately, the air quality monitoring segment is projected to reach USD 11–12 billion by 2034. IoT reports forecast the number of connected environmental monitoring devices to grow from 26.6 million in 2024 to 89.5 million by 2034.

Ukraine faces a complex set of challenges: war consequences, urbanization, and the need to align with EU standards. According to international estimates, in 2024, PM<sub>2.5</sub> concentrations in Ukrainian cities exceeded WHO guidelines on average by 2–3 times. In the European region, according to EEA and WHO data, at least 20% of the population lives under noise levels recognized as harmful to health. Against this backdrop, private laboratories conducting on-site measurements become a crucial link between global trends and the real needs of people.

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The Yakovlev family enterprise, performing environmental measurements for at least 60 clients monthly for over eight years, demonstrates how the integration of field measurements and digital analytics allows solving practical problems while accumulating datasets significant for scientific and regulatory purposes.

The purpose of this article is to describe a practical model for integrating measurements and analytics in local monitoring and to outline key methodological and organizational principles that ensure trust in results.

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## 2. Global Context: From Isolated Measurements to Connected Data

The traditional model of environmental monitoring relied on stationary observation posts and periodic laboratory analyses. Modern practice supplements this with a “cloud” of point and mobile measurements, as well as networks of sensors in buildings and infrastructure. Analytical reports highlight:

- Steady growth in the market for classical solutions (stationary stations, laboratory equipment, software);
- Rapid growth of air quality monitoring systems and IoT sensors integrated into “smart city” projects;
- Expansion of tasks—from “regulatory compliance control” to risk prediction, urban planning support, and assessment of damage from emergencies.

For a local laboratory, this implies a transition:

- From isolated reports on individual sites to the accumulation of a measurement database;
- From paper-based reporting to a digital workflow for storage, processing, and visualization of data;
- From episodic responses to complaints to trend analytics and identification of recurring problem areas.

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## 3. Digital Workflow of the Family Laboratory: From Request to Archive

The experience of the Yakovlev family laboratory shows that digitalization of monitoring starts not with instruments, but with processes.

### 3.1. Data Structure and Standardization of Field Forms

For each site visit, a “site card” is created including:

- Coordinates and address;
- Type of site (residential apartment, office, workshop, school, open area);
- List of tasks (noise, air, water, microclimate);
- Applicable standards for comparison.

During measurements, standardized electronic forms (tablet/laptop) are used to record:

- Exact time and location of measurement;
- Conditions (weather, operating mode of equipment, presence/absence of people);
- Instrument model and calibration number;
- Raw readings with units of measurement.

This reduces the risk of information loss and simplifies subsequent processing.

### 3.2. Cloud Storage and Backup

Measurement data and reports are stored in a secure cloud with backup. For sensitive cases (conflict-prone sites, legal disputes), separate storage and restricted access are applied based on a “minimum required rights” principle. This approach allows:

- Protection of data from loss and unauthorized access;
- Quick retrieval of archival measurements for reanalysis;
- Anonymization of datasets for analytics and scientific purposes.

### 3.3. GIS and Visualization

For sites related to urban locations, a geoinformation approach is applied:

- Measurement points are mapped;
- Heatmaps can be generated for noise and air quality;
- With sufficient observations, problem area maps are created (e.g., locations with systematic exceedances of noise or PM2.5 levels).

Even simple GIS solutions on open platforms allow clients to better understand spatial distribution of issues and the laboratory to identify recurring patterns.



**Figure 1** Global Indoor Air Quality Monitoring System Market Size Forecast (2024–2034, USD Billion)

## 4. Integration of Field Measurements with Sensors and “Citizen Science”

The development of low-cost sensors and user applications has created a “surface layer” of environmental data: building-installed stations, school sensors, and citizen initiatives. For a family laboratory, this environment presents both opportunities and risks.

### 4.1. Verification and Calibration of Amateur Data

Some clients approach the laboratory after observing “poor” readings from a sensor app in their apartment or office. Professional measurements allow:

- Verification of readings accuracy (especially for CO<sub>2</sub>, PM2.5, VOCs);
- Explanation of limitations of low-cost sensors (drift, sensitivity to conditions);
- Calibration or replacement of equipment if needed.

Thus, professional measurements act as a “reference point” for the citizen observation network.

### 4.2. Use of Continuous Sensor Data in Interpretation

Where permanent sensors are installed in a site, their data can complement the picture:

- Daily/weekly averages are compared with one-time professional measurements;
- Peaks associated with specific activities (equipment operation, rush hours, nighttime noise) are identified.

Combining field measurements with continuous monitoring allows more accurate description of exposure patterns and targeted recommendations.

#### **4.3. Potential for Scientific Research**

Experience in Ukraine shows that citizen and local initiative data are already used in scientific publications—including for analyzing sharp PM<sub>2.5</sub> spikes during missile and drone attacks. Having a structured measurement database at the level of a private laboratory enables participation in such research:

- Providing anonymized data;
- Organizing joint measurements with universities;
- Testing new methodologies on real sites.

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### **5. Interpretation and Communication: From Numbers to Decisions**

Digital analytics are meaningful only when results are understandable to decision-makers.

#### **5.1. Visualization for Different Audiences**

Experience shows that for private clients, the following are particularly useful:

- Simple “before/after” graphs (e.g., noise levels with open vs. closed windows);
- Comparison charts with standards (scale: “WHO guideline – national norm – actual value”);
- Color-coded air quality or noise scales with explanations of associated risks.

For businesses and legal professionals, structured tables, references to standards, and clearly formulated conclusions for each parameter are more important.

#### **5.2. Accounting for Uncertainty and Transparency of Limitations**

Digital formats can tempt one to present “perfectly precise” numbers. For trust, it is crucial to clearly indicate:

- Instrument error ranges;
- Factors that could influence results (temporary work, anomalous events);
- Proximity of values to regulatory thresholds, when conclusions require caution.

This transparency reduces the risk of inflated expectations and strengthens trust in the laboratory as an independent expert.

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### **6. Challenges and Prospects for Local Monitoring in Ukraine**

Integration of field measurements and digital analytics in Ukraine occurs against the background of:

- Absence of national standards for several parameters (notably PM<sub>2.5</sub> and PM<sub>10</sub>), while WHO guidelines are exceeded;
- High proportion of population exposed to noise pollution, comparable to European levels;
- Need to account for war-related consequences, which have changed the structure of pollution sources.

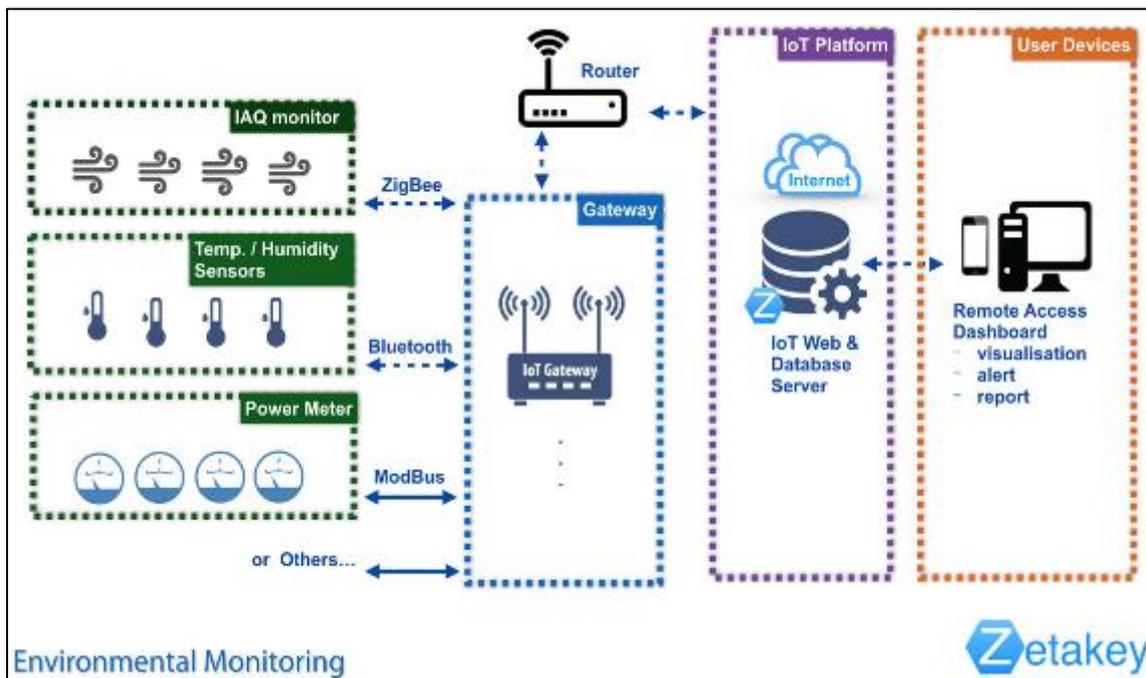
For family laboratories, this implies:

- Expansion of service scope (generator noise, impact assessment of temporary fuel storage, air quality analysis in shelters, etc.);
- Increasing role of independent data in public debates and court proceedings;
- Potential integration with state and international monitoring programs.

A promising direction is participation of private laboratories in networked projects:

- Creating consortia with universities and NGOs;

- Sharing anonymized data through common platforms;
- Developing a “catalog” of local issues to support environmental policy at city and regional levels.



**Figure 2** Conceptual Architecture of an IoT-Based Environmental Monitoring and Data Visualization System

## 7. Conclusion

The integration of field measurements and digital analytics is radically transforming the role of local environmental monitoring. The example of a family laboratory in Ukraine demonstrates that:

- Digitalization of processes—from request to archive—allows the accumulation of structured data rather than producing one-off reports;
- Use of GIS, cloud services, and visualization makes results understandable to diverse audiences and facilitates decision-making;
- Combining professional measurements with data from permanent sensors and “citizen science” provides a more complete picture of environmental conditions;
- Careful handling of uncertainty and methodological transparency strengthen trust in local laboratories as independent experts.

In the context of Ukraine, where environmental challenges are exacerbated by the consequences of war and the process of European integration, such laboratories serve not only as service providers for individual clients but also as potential participants in broader monitoring and research ecosystems. Developing a digital workflow, standardizing data, and collaborating with the scientific community allow local measurements to become a meaningful resource for managing environmental quality at the city and national levels.

## References

- [1] Expert Market Research. Environmental Monitoring Market Report 2024–2034.
- [2] Polaris Market Research. Environmental Monitoring Market Size, Share & Forecast 2024–2034.
- [3] Precedence Research. Air Quality Monitoring System Market Size and Forecast 2025–2034.
- [4] Polaris Market Research. Air Quality Monitoring System Market Size, Share & Forecast 2024–2034.
- [5] IMARC Group. Air Quality Monitoring Market Report 2025–2034.
- [6] Transforma Insights. Environment Monitoring: 89.5 Million Connected Devices by 2034.

- [7] Belis C.A. et al. Status of Environment and Climate in Ukraine. JRC Technical Report, 2025.
- [8] EcoPolitic / IQAir. In 2024, the air of only 7 countries met WHO quality standards: what about Ukraine? 2025.
- [9] Bondar K. et al. Monitoring Air Pollution in Wartime Kyiv (Ukraine): PM2.5 and Related Indicators. Urban Science / MDPI, 2025.
- [10] European Environment Agency (EEA). Noise pollution and health / Environmental noise and health impacts. 2022–2025. 11