

# Design and Implementation of An Environmental Incident Reporting System for Real-time Monitoring and Analytics

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**Abstract**—The stability of ecosystems and public health are seriously threatened by environmental incidents. Timely reaction and analysis are impeded by traditional reporting systems, which frequently experience delays and lack multimedia evidence. In order to enable the real-time submission of event reports, including multimedia attachments, and to offer administrative analytics based on regression trend analysis, this project introduces an automated environmental incident reporting system. The technology, which has a user-friendly dashboard and scalable backend storage, is designed to help environmental authorities make better, more accurate, and data-driven decisions.

**Index Terms**—Environmental Incident Reporting, Real-Time Incident Submission, Multimedia Evidence Upload, Regression Trend Analysis, Analytics Dashboard, Automated Incident Management, Scalable Backend Storage, Environmental Monitoring, Data-Driven Decision Making

## I. INTRODUCTION

Achieving sustainability requires effective environmental monitoring because it makes it easier to identify, report, and handle situations that endanger ecosystems and public health. However, the verification process and the response from responsible authorities are greatly delayed by the tedious, laborious, and human error-prone nature of traditional event reporting techniques, which also lack essential multimedia accompaniment like photos and videos. Automated, easily available, and trustworthy reporting systems are desperately needed as environmental problems worsen as a result of urbanisation, pollution, and climate change. These needs are met by the Environmental Incident Reporting System created for this project, which offers an easy-to-use online platform that enables citizens and environmental organisations to instantly

submit comprehensive incident reports with multimedia supporting documentation. In addition to improving the reports' depth and trustworthiness, the inclusion of rich media facilitates quicker and more accurate evaluations. Additionally, the system detects spatial and temporal trends by integrating sophisticated regression-based analytics, which helps authorities find patterns, foresee reoccurring problems, and more efficiently deploy resources. The gap between antiquated manual reporting workflows and contemporary, data-driven environmental governance frameworks is closed by this combination of real-time, multimedia-enabled reporting with strong data analytics. It significantly reduces the time between an incident occurring and the public being aware of it, enabling timely action that reduces environmental harm and safeguards public health. Furthermore, by streamlining reporting procedures and enhancing transparency via administrative dashboards, the platform promotes increased community involvement and a cooperative approach to environmental stewardship. By providing fast, accurate, and actionable data, this system improves environmental monitoring and governance overall. This helps make well-informed decisions, encourages responsibility, and establishes the groundwork for sustainable environmental management in both urban and rural settings.

## II. LITERATURE SURVEY

*2.1 Investigating the Association Between Air Pollutants' Concentration and Meteorological Parameters: A Statistical Modeling-Based Approach*  
In Siliguri, a rapidly expanding urban centre in West Bengal, India, this study examines the link between air pollutant concentrations (PM2.5, PM10, NO2, SO2, CO, O3, NH3) and climatic factors as

temperature, relative humidity, rainfall, and wind speed between 2018 and 2022. To investigate these relationships, the researchers used linear and nonlinear regression models, Spearman correlation, and Mann-Kendall trend analysis on a large amount of monitoring data. With notable seasonal variation—winter showing more pollution and monsoon seasons showing lower concentrations—the data showed a typically negative connection between climatic factors and pollutant levels. The regression models performed poorly for gaseous pollutants, but they were successful in predicting particulate matter concentrations ( $R^2$  up to 0.67). The investigation emphasised how weather has a significant impact on variations in air quality and the necessity of include other factors like wind direction and sun radiation in future models. The study also emphasised the significance of heightened urban air quality management, including legislative initiatives targeting automobile emissions and construction dust control in Siliguri, and pointed out the rising trend of  $NH_3$  concentration in contrast to the fall of other pollutants. This comprehensive statistical method offers important insights for enhancing the prediction of air pollution and the reduction of health risks in comparable metropolitan settings.

*2.2 Forecasting Air Pollution Particulate Matter (PM<sub>2.5</sub>) Using Machine Learning Regression Models*

By using data from Taiwan's Air Quality Monitoring Network from 2012 to 2017, *Using Machine Learning Regression Models* explores the application of cutting-edge machine learning techniques to forecast  $PM_{2.5}$  concentrations. The authors apply and contrast a number of models with conventional statistical methods, such as random forest, multilayer perceptron (MLP), decision tree regression, gradient boosting regression (XGBoost), and others. According to the study, ensemble models with  $R^2$  values above 0.88 and reduced errors across a variety of measures, such as random forest and gradient boosting regression, perform better in terms of prediction. The approach places a strong emphasis on preprocessing data, integrating weather and air pollution variables, and addressing missing values with spline and Fourier algorithms. According to experimental results, machine learning models outperform more traditional methods like linear and ridge regression in producing forecasts with high

accuracy and robustness. The study comes to the conclusion that using methods like XGBoost can greatly enhance short-term air quality forecasting, offering prompt alerts to reduce the dangers to public health posed by air pollution.

### 2.3 Identification Framework of Contaminant Spill in Rivers Using Machine Learning with Breakthrough Curve Analysis

The Transient Storage Zone Model (TSM) and machine learning (ML) are used in this research to provide a workable framework for quickly determining the quantity and location of pollutant spills in rivers. The breakthrough curve (BTC) analysis is the primary information source. In order to represent nonFickian transport processes such as advection, dispersion, and storage effects, realistic spill scenarios are first created using TSM simulations that are influenced by hydraulic and geometry data from HEC-RAS. To describe contaminant transport patterns, 21 features—shape, concentration, slope, duration, area, derivative, and phase—are taken from these simulated BTCs. The best feature subsets are chosen using Recursive Feature Elimination Cross-Validation (RFECV), and six machine learning models—Decision Tree (DT), Random Forest (RF), XGBoost (XGB), Ridge regression, and Support Vector Machines (linear/RBF)—are trained independently for spill location (classification) and spill mass (regression). Results from the tracer test validation applied to Gam Creek, South Korea, indicated that RF and XGB had the highest accuracy ( $\sim 0.97$ ) for spill location prediction, with tail slope ( $St$ ) being the most significant parameter. While XGB demonstrated better field performance for spill mass prediction, RF was more noise-robust in field conditions because it relied on fewer, stable characteristics. The strength of the framework is that it can be used for realtime river accident response systems because it only needs an observed BTC from a downstream sensor to produce quick, actionable estimations of the contamination source without complete hydraulic data.

### 2.4 Forest Fire Prediction: A Spatial Machine Learning and Neural Network Approach

The authors of this paper offer a thorough machine learning approach designed specifically for

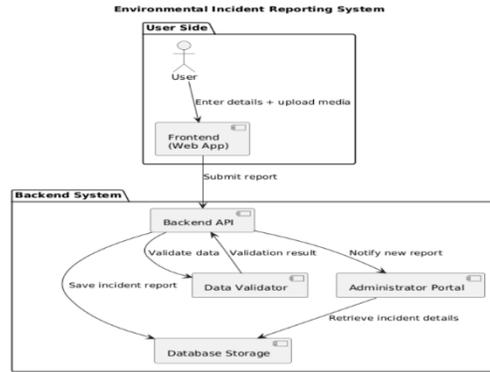
estimating South Carolina's forest fire risk and geographical susceptibility. They assess a range of models, including Decision Tree (DT), Random Forest (RF), Logistic Regression, Support Vector Machine, Artificial Neural Network (ANN), and Convolutional Neural Network (CNN), using data from 2023 on fire incidents, weather, land cover, topography, and human infrastructure. A follow-up investigation revealed that hazard maps created from correlation coefficient-based overlay (as opposed to model-based feature importance) more closely mirrored long-term fire incidence patterns, despite the fact that the DT had the highest predicted accuracy at 90.58%. This finding implies that complicated ensemble models would not necessarily perform better in hazard mapping than correlation-based spatial modelling, underscoring the significance of geographical correlation and the integration of historical fire data with multi-source environmental characteristics. The need of integrating machine learning and geographic analysis for practical environmental management and climate mitigation planning is emphasised in the article.IV.

UNITS

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary units (in parentheses). This applies to papers in data storage. For example, write —15 Gb/cm<sup>2</sup> (100 Gb/in<sup>2</sup>).| An exception is when English units are used as identifiers in trade, such as —3½ in disk drive.| Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as μ0H. Use the center dot to separate compound units, e.g., —A·m<sup>2</sup>.|

III. ARCHITECTURE



This diagram illustrates an Environmental Incident Reporting System architecture divided into two main parts: the User Side and the Backend System. In order to upload relevant media and enter information about an environmental occurrence, the user interacts with a front-end web application. The data is sent to the Backend System after submission. After receiving the report, the Backend API in the Backend System forwards the data to a Data Validator for verification. The incident report is saved into Database Storage using the Backend API based on the validation results. The updated report is simultaneously sent to the Administrator Portal, which may then access the incident data from the Database Storage for examination and subsequent action.

IV. METHODOLOGY

The methodology adopted in this project follows a structured and systematic approach to develop an automated environmental incident reporting system with real-time multimedia support, optimized for accuracy, scalability, and usability. The entire process is divided into the following key phases:

1. Incident Data Acquisition: Users submit comprehensive environmental incident reports through a web interface, including multimedia evidence such as photos and videos, along with critical metadata like date, time, and geographic location. This ensures detailed documentation of each event for thorough analysis.
2. Data Validation: Submitted reports undergo rigorous validation to ensure completeness of textual information and correctness of multimedia files. File

formats and sizes are checked to maintain data quality and system stability.

3. **Data Storage and Management:** Validated incident reports and multimedia files are stored securely in a scalable backend database system. Data indexing and structured storage allow quick retrieval and easy management of large datasets.

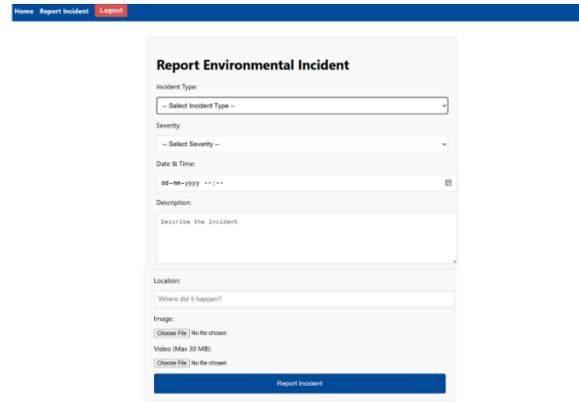
4. **Administrative Dashboard:** An intuitive dashboard was developed for administrators to review, filter, and manage incoming incident reports. The dashboard supports multimedia display alongside incident details to facilitate accurate verification and prioritization.

5. **Trend Analysis via Regression:** Time-stamped incident data is analyzed using regression algorithms to detect temporal patterns, including trends and seasonal variations in incident occurrences. These analytics aid environmental authorities in decision-making and resource allocation.

6. **System Testing and Validation:** The complete system underwent functionality and performance testing under typical operating conditions to verify data integrity, multimedia handling, responsiveness, and analytics accuracy.

### V. RESULTS

To assess its efficacy in real-time data collecting, validation, storage, and management of environmental incidents, the Environmental Incident Reporting System was created and put through a rigorous testing process. Functional testing verified that the system securely saves incident data with low latency, processes multimedia uploads effectively, and validates user inputs accurately. The system's capacity to facilitate timely reporting was demonstrated by the average response time for incident submission and confirmation, which was less than 5 seconds. Data retrieval speeds were consistently less than 10 seconds, allowing administrators to quickly retrieve and assess incident details and make prompt decisions. Using linear regression, the integrated analytics module effectively found temporal trends in event occurrences, offering insightful information for evaluating environmental risk.



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**Admin Dashboard**

**Reported Incidents**

View Incident Analytics

No.	Type	Severity	Description	Location	Date/Time	Photo	Video
1	Water Pollution	High	Garbage dumped into lake which is causing foul smell	Bangalore	2/8/2025, 4:08:00 pm		No video
2	Oil Spills	High	Oil spills into oceans	Bangalore	2/8/2025, 2:03:00 pm		
3	Deforestation and illegal logging	High	Some people cutting trees on the forest.	Bangalore	2/8/2025, 9:38:00 am		No video
4	Air Pollution	Medium	Smoke from chimneys affecting health.	Bangalore	1/6/2025, 4:40:00 pm		



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### VI. CONCLUSION

An integrated environmental incident reporting system was successfully created as a result of this project, allowing for the correct and timely input and management of environmental incident data. The system tackles important issues in environmental monitoring and response by fusing user-friendly frontend interfaces with a strong backend, thorough validation, and effective data storage. The quality and speed of incident verification and escalation are improved with the addition of multimedia support and automated alerts. Through trend analysis, the deployed analytics module supports proactive environmental stewardship by offering actionable insights. All things considered, the system exhibits excellent usability, dependability, and scalability,

making it a useful instrument for authorities and communities to work together to manage and protect the environment. To further improve incident reporting and environmental decision-making procedures, future research might focus on increasing predictive analytics and improving mobile accessibility.

#### REFERENCES

- [1] S. Kwon, H. Noh, I. W. Seo, S. H. Jung, and D. Baek, "Identification framework of contaminant spill in rivers using machine learning with breakthrough curve analysis," *International Journal of Environmental Research and Public Health*, vol. 18, no. 3, p. 1023, Jan. 2021, doi: 10.3390/ijerph18031023.
- [2] A. Bose and I. R. Chowdhury, "Investigating the association between air pollutants' concentration and meteorological parameters in a rapidly growing urban center of West Bengal, India: a statistical modeling-based approach," *Modeling Earth Systems and Environment*, vol. 9, pp. 2877–2892, Jan. 2023, doi: 10.1007/s40808-022-01670-6.
- [3] S. Sharma and P. Khanal, "Forest fire prediction: A spatial machine learning and neural network approach," *Fire*, vol. 7, no. 6, p. 205, Jun. 2024, doi: 10.3390/fire7060205.
- [4] Doreswamy, H. K. S. Harishkumar, Y. KM, and I. Gad, "Forecasting air pollution particulate matter (PM<sub>2.5</sub>) using machine learning regression models," *Procedia Computer Science*, vol. 171, pp. 2057–2066, 2020, doi: 10.1016/j.procs.2020.04.221.
- [5] A. K. Kadam, V. M. Wagh, A. A. Muley, B. N. Umrikar, and R. N. Sankhua, Prediction of water quality index using artificial neural network and multiple linear regression modelling approach in Shivganga River basin, India, *Modeling Earth Systems and Environment*, vol. 5, pp. 951–962, 2019, doi: 10.1007/s40808-019-00581-3.
- [6] O. Kisi, K. S. Parmar, K. Soni, and V. Demir, Modeling of air pollutants using least square support vector regression, multivariate adaptive regression spline, and M5 model tree models, *Air Quality, Atmosphere & Health*, vol. 10, pp. 873–883, 2017, doi: 10.1007/s11869-017-0477-9.
- [7] S. Wa, X. Lu, and M. Wang, Regression model and method settings for air pollution status analysis based on air quality data in Beijing (2017–2021), *Research Square*, Oct. 2022, doi: 10.21203/rs.3.rs-2157074/v1.
- [8] P. K. Parida, M. I. Alam, D. Gogoi, A. K. Pradhan, and M. K. Pandit, Natural Luffa Fiber Composite: A Path to Sustainable Resource Deployment, in *Pollution Control for Clean Environment—Volume 2: Proceedings of ICPCCE 2023, Lecture Notes in Civil Engineering*, vol. 416, Singapore: Springer, 2025, pp. 243–254, doi: 10.1007/978-981-97-7846-1\_20.
- [9] J. Awewomom, F. Dzeble, Y. D. Takyi, W. B. Ashie, E. N. Y. Osei Ettey, P. E. Afua, L. N. A. Sackey, F. Opoku, and O. Akoto, addressing global environmental pollution using environmental control techniques: a focus on environmental policy and preventive environmental management, *Discover Environment*, vol. 2, no. 8, 2024, doi: 10.1007/s44274-024-00033-5.
- [10] H. Xu, J. Yang, Z. Sun, J. Su, et al., Environmental Pollution, A Hidden Culprit for Health Issues, *Eco-Environment & Health*, May 2022, doi: 10.1016/j.eehl.2022.04.003.