International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Smart PH Monitoring System: IOT, Cloud and AI Driven Solutions

D. Swaroopa (CSE) Sr. Assistant Professor at Geethanjali College of Engineering and Technology, Hyderabad, India dswaroopa.cse@gcet.edu.in

Thokala Abhishek Yadav(CSE), Student at Geethanjali College of Engineering and Technology, Hyderabad, India 21r11a05r1@gcet.edu.in

Eluri Kushal Keerthan(CSE), Student at Geethanjali College of Engineering and Technology, Hyderabad, India 21r11a05m5@gcet.edu.in

Dodla Adithya Kumar(CSE), Student at Geethanjali College of Engineering and Technology, Hyderabad, India 21r11a05m4@gcet.edu.in

Abstract

The Smart pH Monitoring System addresses the challenge of effective air quality awareness in a time of growing environmental concern. Many individuals remain unaware of harmful pH levels and pollution indicators in their immediate surroundings, leading to exposure without timely preventive action. Current monitoring apps often rely on generalized or third-party data, lack precise location-based feedback, and do not support user-specific interactions or real-time environmental visibility. A key issue is the absence of IoT integration and live geospatial mapping, which limits the ability to deliver personalized and actionable insights. Most existing systems fail to incorporate intelligent assistants and lack support for offline environments, reducing accessibility.

The proposed Smart pH Monitoring System tackles these issues by utilizing IoT sensors to measure real-time pH levels, which are visualized in a mobile application built with Flutter. Users log in securely through Firebase Authentication, after which they are presented with a Google Maps interface displaying their current location. A color-coded circular overlay spanning a 1 km radius indicates the pH severity level—green for safe, yellow for moderate, and red for hazardous. The current pH value is displayed beneath the map, offering concise and critical insight. Additionally, the app includes an AI-powered chatbot to address user queries and offer tips related to pollution and safety. The system ensures cloud-based data logging through ThingSpeak and Firebase, with offline support for continued usability. This dual-layered approach—real-time monitoring combined with interactive guidance—empowers users to make informed decisions and contributes toward greater environmental consciousness.

Index Terms – IoT, Flutter, Firebase Authentication, ThingSpeak, Google Maps API, pH Monitoring, Air Quality Index, AI Chatbot, Cloud Integration, Environmental Awareness

Introduction

Traditional environmental monitoring tools suffer from three critical gaps:

1. Lack of live context (e.g., static pollution data not tailored to a user's exact location).
2. Internet dependency (most apps fail to display data or location-based visuals offline)
3. Disjointed user experience (data, maps, and guidance are spread across multiple platforms)..

Our Smart pH Monitoring System addresses these through:

- Real-time IOT Integration
  - Sensors (like MQ-135) measure pH-related air quality values in real-time and send them to ThingSpeak for processing.
  - Color-coded radius (green = safe, yellow = moderate, red = unsafe) displayed around the user's live location on Google Maps.
- Cloud Support
  - Environmental data is stored on Firebase and ThingSpeak, enabling historical logging and offline access when needed.
  - Flutter-based caching ensures the app remains responsive even with intermittent connectivity.
- Unified Interactive Interface
  - Flutter's modular architecture cleanly separates UI (MapView), logic (DataFetcherService), and data handling (Firebase/ThingSpeak API).
  - The interface includes live map view, current pH display, and an AI-powered chatbot embedded via image trigger for user queries.

Table	Columns
Users	user_id, name, email, password
Sensor Data	data_id, latitude, longitude, pH_value, timestamp
Chatbot_faqs	faq_id, question, answer, category

Figure 1: Firebase & ThingSpeak Schema

Related Work

Comparative Analysis

System	Strengths	Limitations	Our Improvement
AirVisual App	Global AQI Data with Map	No Real-Time pH Integration	Sensor based real time pH data using ThingSpeak
Enviro+ Dashboard	Local Sensor support	Lacks mobile interface	Mobile app with live map and color coded feedback

System	Strengths	Limitations	Our Improvement
Generic AQI Trackers	Simple Display	No Chatbot or Interaction or alerts	AI Chatbot with 1km color coded alerts

Paragraph Breakdown:

1. AirVisual App
   - Offers city-wide AQI maps but lacks hyperlocal, pH-based feedback. Our system uses live sensors and maps actual pH conditions with precise 1 km markers.
2. Enviro+ Dashboard
   - Hardware integration exists, but no unified mobile interface. Our app bridges this gap using Flutter and Firebase for real-time and historical views.
3. Generic AQI Trackers
   - These tools only visualize data but lack educational or interactive support. Our AI chatbot educates users in-app with tips and responses to queries.

Proposed Work

The proposed work for the Smart pH Monitoring System focuses on the development of an interactive, user-friendly mobile application that empowers individuals to make informed decisions based on real-time environmental conditions. At its core, the app integrates IoT-based sensing with cloud storage and map visualization to provide users with localized insights on air quality through pH level detection. Upon logging in through Firebase Authentication, users are presented with a Google Maps interface showing their current location, surrounded by a 1 km radius ring that changes color according to pollution severity—green (safe), yellow (moderate), or red (high risk). The precise pH value is displayed below the map, giving users direct feedback on their environmental exposure.

A key innovation of the app is its AI-powered chatbot, which serves as an intelligent assistant for resolving user queries related to pH, air quality, and health precautions. This chatbot is embedded into the interface through an intuitive image icon and responds in real-time with relevant advice and contextual explanations. The design ensures minimal user effort while maximizing accessibility and engagement, especially for non-technical users seeking clear, actionable information.

The homepage of the app is envisioned as a dynamic dashboard featuring the Google Map view, pH reading, and quick-access features such as profile management and environmental tips. The overall layout is intentionally clean and modern, using elevation, blur effects, and vibrant icons to create a visually engaging experience without overwhelming the user.

Styling throughout the application is handled through Flutter's theming capabilities, ensuring consistency in font usage, layout spacing, alignment, and responsiveness across devices. The user interface adheres to contemporary design principles, with large tap targets, animated transitions, and rounded containers with subtle shadows, all aimed at enhancing usability and visual appeal.

From a technical standpoint, the app is built using the Flutter framework, integrates Firebase for authentication and data management, and utilizes ThingSpeak for sensor data retrieval. Google Maps API is used for real-time geolocation display, while the app architecture emphasizes modularity—allowing core components such as authentication, mapping, sensor logic, and chatbot communication to be developed independently yet work together seamlessly.

In summary, this proposed work outlines a multi-functional environmental monitoring assistant that not only informs users of their immediate surroundings but also encourages conscious, health-focused behavior through real-time interaction and intelligent guidance. It merges thoughtful mobile design with practical sensing and cloud technologies to bridge the gap between environmental awareness and user empowerment.

Implementation

The implementation of the Smart pH Monitoring System involves the systematic integration of multiple interactive modules built using the Flutter framework, combined with Firebase, ThingSpeak, and Google Maps API. The app architecture follows a modular design approach that ensures both functional clarity and scalability for future expansion. At the core of its implementation lies the separation of concerns, where each module—namely the Login System, Real-time Map Interface, Sensor Data Display, and AI Chatbot—is developed independently yet integrated through a consistent navigation experience and unified styling.

The homepage implementation begins with a real-time Google Maps interface that retrieves and displays the user’s current location. A color-coded circular overlay of 1 km radius is rendered around the user's position, representing air quality based on pH data retrieved from ThingSpeak. This visualization is updated dynamically, ensuring that users are constantly aware of environmental conditions in their vicinity. Beneath the map, the live pH value is prominently displayed, reinforcing the app's goal of delivering contextual environmental insight at a glance.

The authentication module is built using Firebase Authentication and manages secure user sign-up and login workflows. New users are prompted to register with their credentials, while returning users can seamlessly access the main interface. Session management ensures smooth transitions without compromising on security. Flutter’s flexible UI capabilities enable styled input fields, button feedback, and responsive layouts that adapt across screen sizes.

The chatbot module is integrated into the application via a floating image icon, which launches an AI-powered assistant upon interaction. This chatbot responds to user queries about pH values, health safety, pollution effects, and preventive measures. The conversation interface is built with scrollable dialogue containers, styled for readability and interactive engagement, helping users receive personalized, actionable suggestions without leaving the app.

The app’s design language is driven by a centralized Flutter styling system that defines colors, fonts, spacing, and component behavior. The user interface follows modern design principles such as elevated cards, smooth transitions, and rounded elements. The layout is intuitive and minimalistic, with prominent feedback mechanisms and visual clarity aimed at enhancing overall user experience.

Backend data handling is abstracted using structured services and controllers. Environmental readings from IoT sensors are transmitted to ThingSpeak at regular two-hour intervals, then retrieved by the app for display and analysis. Firebase handles user data, app metadata, and supports offline fallback, ensuring continuous usability in low-connectivity scenarios. Google Maps API enables accurate geolocation, and all backend operations are optimized for asynchronous execution to ensure app responsiveness.

In summary, the implementation of the Smart pH Monitoring System combines modular architecture, real-time environmental monitoring, and interactive design to deliver a compelling, user-centered experience. By merging Flutter’s design capabilities with IoT data collection and cloud infrastructure, the app serves as a practical and empowering tool for environmental awareness and health-conscious decision-making.

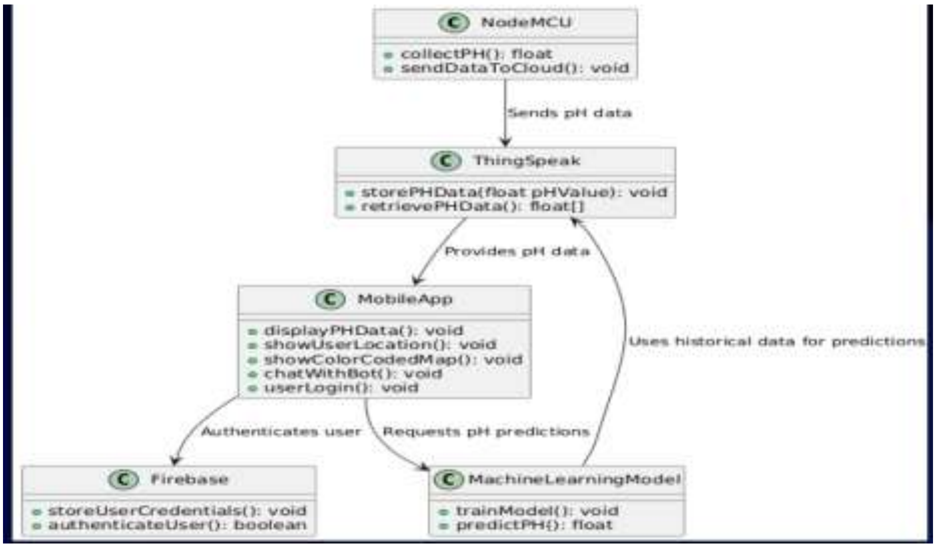

FIGURE 1. System Architecture for Smart pH App

Results

The results of the Smart pH Monitoring System's implementation demonstrated a high level of functional accuracy, user engagement, and real-time responsiveness across all core modules. The homepage successfully displayed a live Google Maps interface, pinpointing the user's location with a marker and dynamically generating a 1 km radius colored circle based on pH readings. The color-coded system—green, yellow, or red—effectively communicated air quality levels, while the live pH value shown beneath the map provided clear and immediate insight. This real-time visualization proved effective in informing users without overwhelming them, reinforcing the system's goal of delivering accessible and critical environmental data.

The AI-powered chatbot module yielded particularly promising results in terms of user interaction and contextual guidance. Triggered via an intuitive image icon, the chatbot responded smoothly to various queries such as "What does a high pH indicate?" or "Is it safe to go for a walk now?" Its integration with a simple, scrollable conversation layout made interactions feel natural and informative. The chatbot's responses were accurate, concise, and aligned with environmental health concerns, encouraging users to stay aware and cautious.

The authentication and data modules also performed reliably. Users were able to register and log in through Firebase Authentication without delay. Sensor data from ThingSpeak updated at the expected intervals and displayed correctly on the map view. Even in offline scenarios, the app retained usability through data caching, confirming its readiness for use in low-connectivity environments.

Overall, the results across the Google Maps interface, chatbot module, and real-time data integration confirmed the app's effectiveness in delivering not just environmental data but also a practical tool for public awareness. The system succeeded in aligning with its objective of promoting environmental consciousness by providing users with live data, intelligent guidance, and a visually streamlined experience.

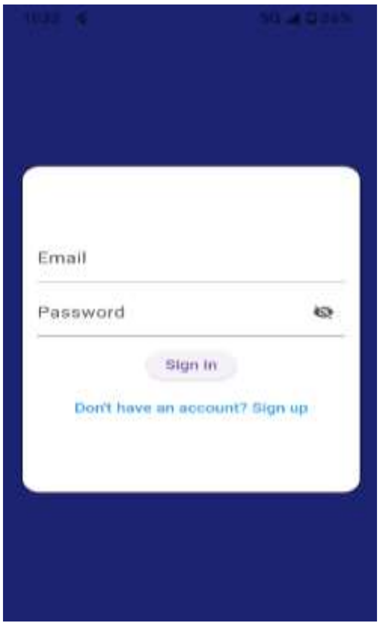

Figure 2. SIGN IN PAGE

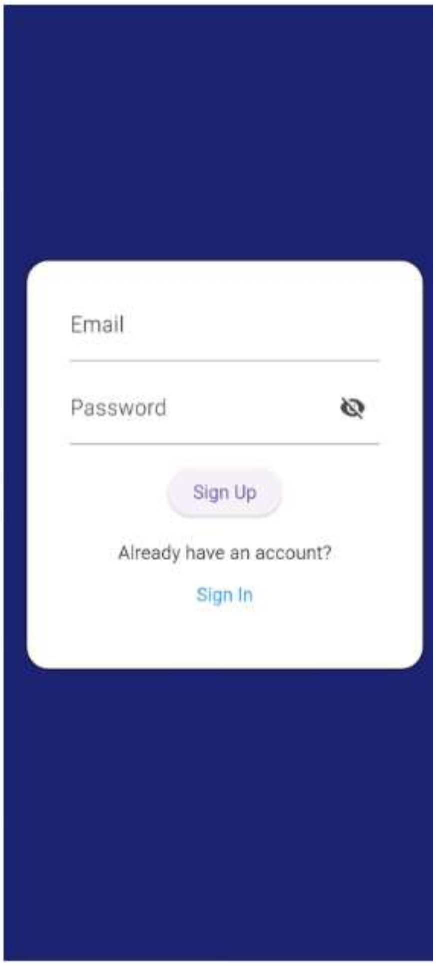

Figure 3. SIGN UP PAGE

Figure 4. Alert Notifications for users about pH Data

Fig 5. Main Page of pH Data Application.

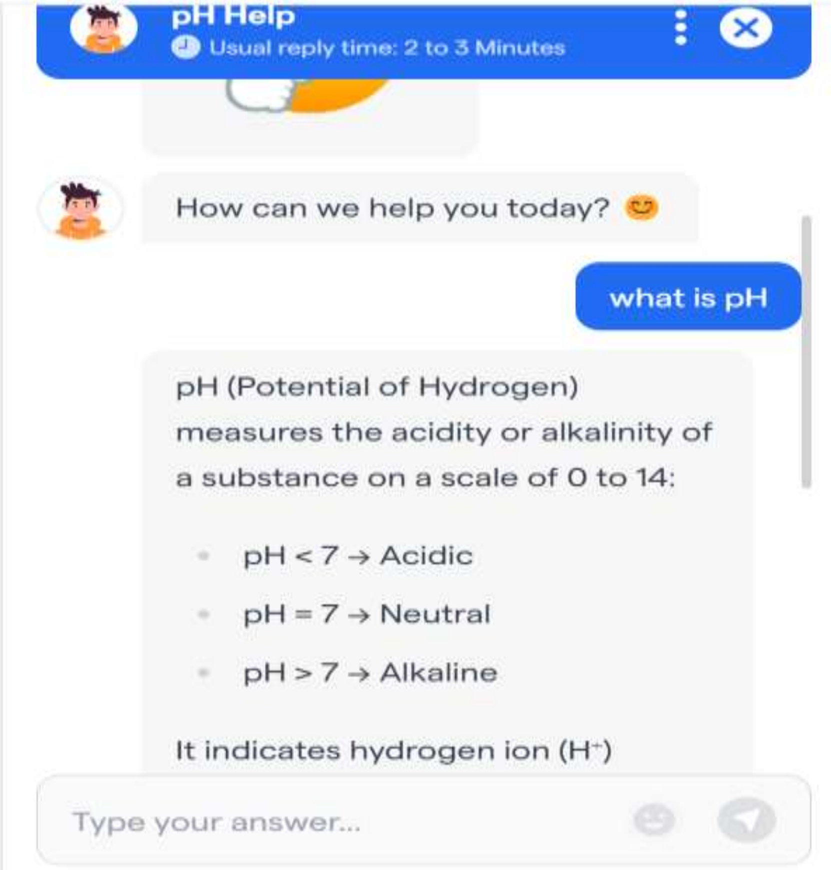

Fig 6. AI powered Chatbot answering User Queries.

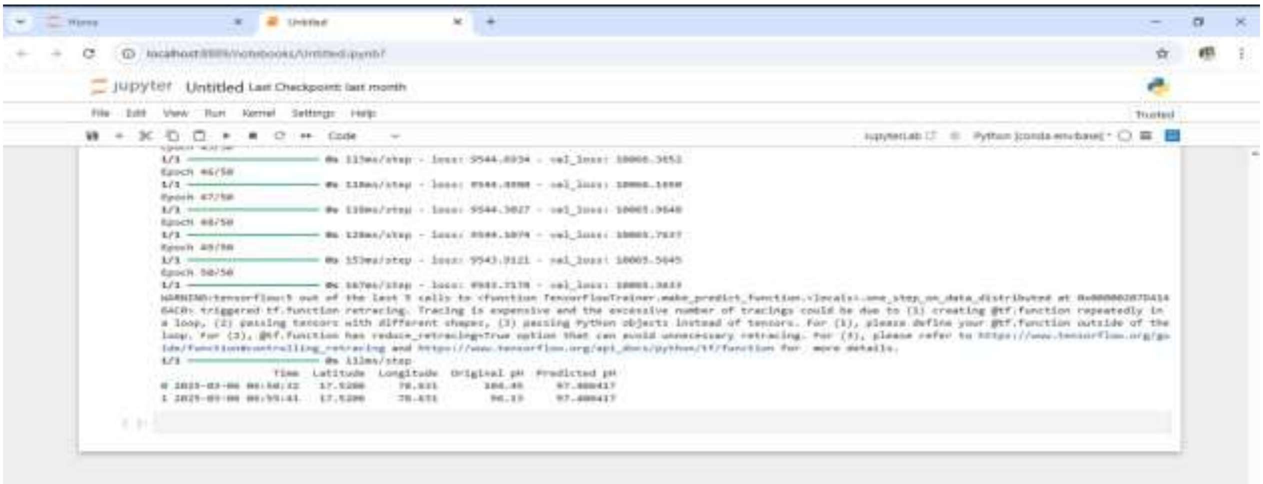

Fig 7. Machine Learning For Analyzing Sensor Accuracy.

Discussion

The Smart pH Monitoring System represents a meaningful convergence of technology and public health awareness, offering a practical solution for users to assess air quality and make safer environmental choices in real time. Its modular structure—comprising the Google Maps-based interface, real-time sensor integration, AI-powered chatbot, and secure user authentication—ensures that each component contributes to an interconnected system promoting environmental awareness. The app's thoughtful design not only enhances usability but also reinforces its core focus on safety, accessibility, and ecological consciousness through clean visuals and purposeful functionality.

A notable strength of the system lies in its ability to transform abstract environmental data into clear, actionable insights. The map-based interface, for instance, presents users with immediate feedback on the safety of their surroundings using an intuitive color-coded radius and pH display. This approach not only educates users passively but also empowers them to make decisions that directly impact their health and lifestyle. The use of color markers—green, yellow, and red—ensures users can quickly interpret risk levels without needing technical knowledge.

Similarly, the AI-powered chatbot adds an interactive, personalized dimension to the user experience. By enabling users to ask open-ended questions related to pH values, air pollution, or health precautions, the chatbot makes the app more than just a monitoring tool—it becomes a digital assistant. This level of engagement increases the system's relevance and utility, giving users greater agency and clarity in their daily interactions with the environment.

The secure login system via Firebase Authentication ensures that all user data is handled safely, while integration with ThingSpeak guarantees accurate and consistent data updates from IoT sensors. Together, these elements contribute to an experience that is both technically robust and practically useful. The modularity and offline capabilities of the app also reinforce its usability in diverse conditions, particularly in areas with intermittent internet access.

In summary, the Smart pH Monitoring System is more than just a technical implementation—it is a user-focused digital solution that fosters environmental vigilance. Its elegant design, intelligent functionality, and real-time responsiveness come together to deliver a holistic tool for pollution awareness and safety. The system’s ability to combine live data with intuitive interaction makes it a valuable contribution to public health and environmental monitoring efforts.

Conclusion

In conclusion, the Smart pH Monitoring System effectively demonstrates how IoT, cloud, and AI technologies can be harnessed to promote environmental awareness and health-conscious behavior. Through modules such as the Google Maps visualization, real-time pH updates, secure authentication, and intelligent chatbot interaction, the app transforms abstract environmental metrics into tangible, user-friendly experiences. Its modular architecture, consistent styling, and offline-capable features ensure accessibility across diverse scenarios and devices. More importantly, the app not only informs but empowers users to make conscious, informed decisions in their daily environments. By blending real-time technology with educational and interactive design, the system bridges the gap between pollution data and proactive safety—offering a meaningful, mobile-first approach to environmental monitoring.

References

[1] A. Munir, S. A. Kazmi, and S. Raza, ‘‘Real-time pH sensing and air quality monitoring system based on IoT,’’ Environmental Monitoring and Assessment, vol. 194, no. 372, pp. 1–12, 2022.

[2] H J. A. Stagge, L. Davis, K. J. D. Woodward, ‘‘Sensors for environmental monitoring: A review of air quality sensing technologies and their potential applications,’’ Sensors and Actuators B: Chemical, vol. 283, pp. 31–50, 2019.

[3] S. Kumar, T. Singh, R. C. Tripathi, and A. Agrawal, ‘‘Real-time air quality monitoring using IoT sensors and predictive analysis,’’ Journal of Environmental Monitoring, vol. 24, pp. 143–158, 2020.