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PranaVayu: An AQI-Based Real-Time Air Pollution Monitoring and Health Advisory Web Application

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Abstract

Poor air quality has silently made itself one of the most lethal crises of the present day- it causes approximately 7 million deaths annually in the world, with India contributing a disturbing proportion of it. Such cities as Delhi, Hyderabad, or Kolkata routinely record the readings of AQI that health professionals would call dangerous, yet the apps and portals that most individuals utilize to monitor pollution levels merely display a number and a color. PranaVayu was constructed to transform that. Instead of merely informing you about the Air Quality Index, PranaVayu does not inform you of the Index but will tell you what to do regarding the Index, only that it will tell you differently according to who you are. A grandmother with asthma, who has retired, is at risk at a different level compared to a five-year-old attending school, and a pregnant woman planning to take an outdoor walk, and PranaVayu will identify this fact with specific health guidelines. The system is created on React 18 with Vite, TypeScript, and Tailwind CSS, and uses the OpenWeather API to combine live AQI values with up-to-date weather data to create the contextual advice that the current platforms have not been able to offer. It accepts Telugu in addition to English, functions offline as Progressive Web App, dispatches crisis notices in case of intensified weather, and maps pollution patterns on a 7 and thirty days basis. We have compared PranaVayu to five existing sites and found it was the only one that provided this combination of all features, especially the demographic health advice and regional language support that the Indian users require the most.

Keywords—Air Quality Index (AQI); air pollution monitoring; health advisory system; React; Progressive Web App; demographic health protocols; OpenWeather API; environmental informatics.

I. INTRODUCTION

Any big Indian city, when you take a walk in winter in the morning, the air speaks. There is a grey veil on the roofs, children wear scarves on their faces, and the old population remains at home. The figures provided to support this haze are devastating: the WHO estimates that about 7 million individuals die annually due to outdoor air contamination alone [1]. Unfortunately, India is at the centre of this crisis, fourteen out of the twenty most polluted cities in the world are Indian, as recent air quality reports say.

However, nowadays, most individuals who wish to check the air quality in their city open an app and look at an AQI number, say, 178. What does it actually imply to a sixty five year old man who has a history of bronchitis? Should his grandchild aged ten continue attending school? Should his daughter-in-law, who is pregnant, be allowed to walk in the afternoon as his doctor advised? These are the questions the real users are asking, and the current platforms fail to answer them. Aggregating PM2.5, PM10, CO, NO2, SO2, and O3 into one number, the AQI scale (0 to 500) is still a long way away from the personal health choice a family has to make.

We have found three issues with the state of AQI tools that exist today. To start with, all the major platforms do not divide their health guidance into a specific demographic group. Second, AQI and weather information, despite being closely connected regarding health hazard, is nearly always displayed separately, and users have to draw the lines on their own. Third, platforms targeted at the urban population of India seldom accommodate regional languages, which restricts their utility to the high percentage of users who speak their native language more fluently than English, usually Telugu, Hindi, Tamil, or other Indian languages.

PranaVayu was created to fill all these three gaps. This name is a Sanskrit word, prana, which means life force, and vayu, which means wind or air, and it represents what we were attempting to create an app that was not about abstract information but something that had a direct influence on living, breathing humans. The stack of technology was selected based on performance and maintainability (React 18, Vite, TypeScript, Tailwind CSS

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and the OpenWeather API), whereas the actual design choices were not made on the basis of engineering aesthetics but on the basis of health outcomes.

The remaining part of this paper is organized as follows. Section II scouts what is already out there, ranging between international websites such as IQAir and WAQI to India-specific websites such as CPCB and AQI.in and other related research. Section III takes a tour of PranaVayu. Each of its major features is discussed in Section IV. Section V is the comparison of PranaVayu and the platforms that are in existence. The final section VI is the conclusion and the directions we are going to take next.

II. RELATED WORK

We took a long time to research what had been in the market before we decided to build PranaVayu- both in regards to the live products and the scholarly studies. Our discovery supported the issue we had already established: the tools are effective in gathering and presenting information, but they are not designed to assist regular users and make health-related choices.

A. Global Platforms

The most complete free AQI tool is probably WAQI [2], which gathers data of thousands of official government and EPA-qualified stations in all continents of the world. Its world map is really beneficial to researchers and pollution enthusiasts, though, in terms of health guidance it is skin-deep. It is not personalized with any tailored recommendations, there is no demographic sensitivity, and no activity level advice. It is aware of the fact that the air is unclean; it does not inform you what to do about it.

IQAir [3] is even further. It includes more than half a million locations, has 48 hour predictions, and has some general health recommendations based on AQI categories. But it is all the same, both a healthy young athlete and an asthmatic elder can get the same advice. It does not have any offline functionality, and does not support the local Indian languages. It is a refined product, but it was obviously designed with an international, English speaking and mostly healthy customer in mind.

U.S. EPA official platform is AirNow [4] and has established the gold standard of data reliability in the North American background. In fact, many other sites in the world, such as PranaVayu, have their AQI formula and definition of health categories. But it was made to suit the American conditions and American audiences. It does not provide any demographic segmentation and is not related to the Indian regulatory and linguistic environment.

OpenAQ [5] is a very different solution, being an open-source data harmonization system that integrates measurements of government monitoring systems around the world and exposes them to a publicly accessible API. Researchers love it. Regular users cannot really use it. It lacks any advisory layer, no non technical interface and has no health recommendations whatsoever.

B. India-Specific Platforms

The most likely popular air quality app used by the Indian audience is AQI.in [10], which is quite reasonable in its core purpose and displays real-time AQI and pollution levels of hundreds of Indian cities. The thing is that it ends there. There is little health advice and generic advice. Still, there are no recommendations related to the activity, no emergency alert system, and no support of other than English Indian languages.

The official government site on Indian air quality is the CPCB portal [6]. Its readings are certified monitoring stations and are applied in legal and regulatory matters. However, it looks like a government database, not a health tool. It is rather limited in interaction and does not have any personalization, and its design is clearly focused on data publication rather than user guidance.

C. What the Research Tells us.

A similar yet slightly different issue was addressed by Dhingra et al. [7]: they developed a mobile system of pollution monitoring with IoT-based on an Arduino gas sensor as an input and an Android application as an interface to data. Their input demonstrated that citizen-grade sensors are capable of making a significant addition to government surveillance networks. Yet, their work was directed on the sensing and data collection - the health advisory side was not touched to a great extent.

Gupta et al. [8] considered the prediction angle, where multiple machine learning models, which included SVR, LSTM, KNN, and Random Forest were used to predict the AQI of Indian cities. The fact that LSTM performed better than the rest when it comes to time-series prediction is applicable to the PranaVayu roadmap; we intend to introduce a similar forecasting module into the further development. However, once again, their work did not address the question of translation of predictions into individual user instructions.

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Combined, both the literature and the available platforms lead to the same conclusion: the tools available are capable of measuring and reporting air quality, but there has been an evident and mostly unmet demand of a system that is capable of personalizing that data, i.e., by demographic group, by language and in conjunction with the weather conditions. Exactly that is the space that PranaVayu occupies.

III. PROPOSED SYSTEM ARCHITECTURE

PranaVayu is a web based Progressive Web Application. The reason is that we intentionally did not use a heavy backend to ensure low latency and minimal hosting costs in case the application is later to be scaled to application all over the cities in India with different network infrastructures. The architecture is four-layered with each layer having a defined and narrow purpose.

A. Data Ingestion Layer

The OpenWeather platform has two endpoints that feed all the environmental data into the system: Air Pollution API and Current Weather API [9]. Air Pollution API provides the concentrations of PM2.5, PM10, CO, NO2, O3 and SO2 at any given latitude-longitude. The Weather API will include temperature, humidity, wind speed, as well as a condition code, the same code that allows us to know whether a city is undergoing a thunderstorm or some dust event. These raw concentration values are converted into a single AQI integer on a 0 500 scale using a custom module named aqiUtils that applies the standard breakpoint interpolation formula by EPA [13] to these raw values. This calculated AQI is made the input of all the things below.

B. Diagnostic Engine

This is the core of the difference of PranaVayu. After calculations of the AQI have been made, diagnostic engine is involved. It consists of three parallel elements. The AQI Classifier uses the calculated integer and classifies it into one of six health categories. The Demographic Protocol Generator then verifies what user profile is present - child, elderly, pregnant, asthmatic, or a general adult - and finds the correct health protocol in that combination of category and profile. Lastly, the Weather-AQI Correlator examines the weather information and the AQI. A rise in the humidity to over 80 percent and PM2.5 already at a moderate level, such as the one found in the case of the correlator, raises a red flag in the risk department and increases the advisory to a new level. The combination of these three outputs forms the advisory which is displayed to the user.

C. Alert and Notification Engine

The alert engine is a background service, which monitors two types of triggers. The former is AQI boundary crossing - the computed index goes out of one category of health to the next, an alert is triggered. The second one is a weather event: heatwave, heavy rain, storm, dust event condition codes will all activate emergency banners in the UI and, with permission granted by the user, push notifications through the Web Notifications API. In development, we discovered that such meteorological alerts are of great value, such as, a dust storm can push PM10 up to a dangerous level in a few hours, and the user requires such a warning in time.

D. Presentation Layer

The frontend is managed by React 18 [11] and Vite [12]. TypeScript was not a choice with us, as we had several readings of pollutant, several demographics, and several advisory levels running through the same elements, a good type system was critical to prevent bugs. The visual design is built on Tailwind CSS and the shadcn/ui glassmorphism aesthetic which we found to be fitting in an application about something as airy and atmospheric as, well, air. Recharts are used to create charts and Leaflet.js is used on top of OpenStreetMap tiles to create maps. The entire application is also encased as a PWA that has a Service Worker, which also stores the last-fetched information even when the user is offline.

IV. MAJOR CHARACTERISTICS AND TECHNICAL DEPLOYMENT

A. Demographic-Specific Health Protocols

This was the direct result of a mere observation: at 160 AQI, quite different things happen to a healthy 25-year-old and an eight-year-old asthmatic child. PranaVayu supports four profiles that include children below 14 years, adults above 60 years, pregnant women, and those with asthma or COPD in addition to the default general-adult profile. Given any profile-category combination, the system produces four outputs: a plain-language risk assessment, a list of specific precautions (such as Keep school windows closed or Avoid walking to the market between 11 AM and 4 PM), recommended indoor options and a clear point beyond which professional medical help is needed. We have not found any such degree of specialization in any of the platforms we have reviewed in Section II.

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B. Weather-Integrated Health Advisory

This concept was stolen by the way physicians do think of respiratory health. A pulmonologist cannot merely observe pollution levels- he/she questions about humidity, as high moisture in the air causes a change in the behaviour of fine particles in the lungs. The Weather-AQI Correlator of PranaVayu uses a similar logic in a calculating manner. The correlator raises the advisory when the humidity is above 80 percent and the PM2.5 is already high even when the raw AQI has not reached a category limit. Equally, a vigorous wind at low AQI may in fact mean that dispersion is taking place and outdoor activity can be considered safe than normal- the system picks up that subtlety as well.

C. Pollution Trend Analysis

We wanted the users to know not only the current state of air quality, but also the direction in which it is moving. The trend module shows the history of AQI in 7-day and 30-day rolling windows in Recharts line graphs. More to the point, it produces human-understandable messages of insight, such as PM2.5 is 23 percent above this time last week or Air quality has been improving steadily over the past four days, so that a user does not have to make a graph out of it to get the idea. To a parent who has to make a decision whether to allow his child to walk to school or not, this context is more important than the raw reading today.

D. Multilingual Support: English and Telugu

This project was constructed in Hyderabad, and we felt it quite natural to make a health application that is to be used in Hyderabad speak Telugu. We introduced a complete i18n framework, not only of UI labels but of all health advices, recommendations of activities and alert messages. The alternate between Telugu and English is abrupt and incessant. We designed the language files in such a way that adding a new language such as Hindi, Tamil, Kannada, is only a matter of translating the map of the JSON strings, with no logic layer modification. That is important to long-term maintainability.

E. Progressive Web App and Offline Mode

The fact that PranaVayu was installable and offline enabled was not an extra feature, but a useful one considering the unpredictability of mobile internet connectivity in Indian cities, especially in older neighbourhoods and during the monsoon when networks become overloaded. A Service Worker manages caching: a cache-first approach is taken to static assets (code, styles, fonts), whereas a network-first approach is taken with a cache fallback. The consequence is that the user who has checked AQI one hour ago and has lost connectivity will not get a blank error screen, but AQI reading.

F. Emergency Meteorological Alerts

Standard AQI alerts are convenient but they fail to record all that can make a day hazardous to breathe. A dust storm will not reflect in an AQI reading until the particles have spread throughout the city. Even moderate pollution is increased by the stresses of a heatwave on the respiratory system. PranaVayu monitors the OpenWeather condition codes of fifteen weather extremes and displays an emergency banner when it finds one- the banner is highly visible and cannot be overlooked- to the user in the city he/she is monitoring. Push notifications relay the notification to those users who are not actively viewing the app.

G. Geospatial Pollution Visualization

The interactive map created through Leaflet.js offers a user a spatial view of the pollution that cannot be offered by the figures alone. The map is covered with colour-coded AQI indicators in key cities of India that are displayed in the conventional six-colour scale of green to maroon on a dark background so that the gradient is visible at a glance. Users are able to zoom in on their neighbourhood or pan over an area to determine whether the haze on their city is isolated or a wider pattern. This local situation sometimes reverses the recommendations: a city that might appear clean now but with polluted neighbours that are numerous may have its AQI skyrocket tomorrow.

V. COMPARATIVE ANALYSIS

PranaVayu is compared with the five platforms reviewed in Section II on eleven features as seen in Table I. The features were selected to directly indicate the three gaps that were determined in the literature and motivation sections.

TABLE I. Feature Comparison of AQI Monitoring Platforms

Feature	WAQI	IQAir	CPCB	AQI.in	PranaVayu
Real-time AQI	Yes	Yes	Yes	Yes	Yes
Pollutant Details	Yes	Yes	Yes	Yes	Yes
Health Advisory	Basic	Basic	None	Limited	Advanced

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Feature	WAQI	IQAir	CPCB	AQI.in	PranaVayu
Demographic Profiles	No	No	No	No	Yes
Activity Recommendations	No	Limited	No	No	Yes
Weather Integration	No	Yes	No	No	Yes
Trend Analysis	Yes	Yes	Limited	No	Yes
Emergency Alerts	No	No	No	No	Yes
Regional Language	No	No	No	No	Telugu
PWA / Offline Mode	No	No	No	No	Yes
India-Focused	Partial	Partial	Yes	Yes	Yes

The gaps can be seen very clearly in the table. Each of the platforms in the comparison is capable of showing the AQI levels and the distribution of the pollutants - that is the baseline. Beyond that the depth of health advisory declines steeply. WAQI and CPCB provide no more than a colour category. IQAir and AQI.in handle simple messages, yet none of them differentiates between a toddler and a 70-year-old. PranaVayu is the only platform in the line of providing high-level demographic-specific health guidelines, emergency meteorological warnings, and Telugu language concurrently.

What is also missing in the IQAir comparison is also the fact that although the product is the most commercially polished one in the group, IQAir lacks offline mode, does not add weather conditions to its health advisory logic, and lacks emergency alert functionality. These do not constitute minor omissions to an Indian user base. Weather events make the matters of pollution more dangerous than the pollution itself, and this is what is dangerous in India, and a warning system that does not take the weather into account is not complete by definition.

CONCLUSION AND FUTURE WORK

PranaVayu began with a simple query: why do air quality applications tell us so little about what we should actually do? The response, as we could find out, is that the majority of them were constructed as data tools and not health tools. PranaVayu was our attempt to bridge that divide, to create something that uses the same publicly available AQI and weather data, and transforms it into specific, personalised, contextually relevant advice, to which users can respond.

The comparative analysis proves that PranaVayu occupies a niche that none of the existing platforms cover completely. The joint demographic-health procedures, weather-linked alerts, Telugu language assistance, offline functionality, as well as emergency meteorological warnings, are not found in any single competitive product. The utility of that combination remains to be determined by the users, but the fact that those features are not available in the current landscape implies that they were not introduced on purpose but as a result of intentional omission.

Future development can be focused on three areas. The technically most interesting one is predictive modelling: by combining an LSTM network that has been trained on past AQI and weather data, such as what Gupta et al. [8] had shown, PranaVayu would be able to send alerts to its users to be aware of an air quality issue before it happens, not after it happens. Second, we would like to discuss the IoT sensors integration in the vein of the work by Dhingra et al. [7]: a cheap indoor sensor module that feeds directly onto PranaVayu would allow the application to not only provide advice on outdoor conditions but also on whether the air in your home is actually better or worse than outside, which is the question that many users surprisingly ask. Third, the i18n framework can be extended, Hindi and Tamil assistance is a short-term priority due to the number of users in these language communities.

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