

# Personal Pollution Exposure Monitoring using Pollution Sensors and Health Prediction.

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**Abstract**—The aim of this paper is to outline a wearable air pollution mapping system for an individual. For this it incorporates interfacing some pollution related sensors (CO<sub>2</sub>, CO and clean sensor) to the clients body which will continually screen the encompassing air pollution levels and figure the correct measure of dangerous gasses breathed in by the client contingent on the breathing rate of the client. Contingent on these qualities, the client will be alerted continuously by indicating notices where pollution level has outperformed the allowable breaking point. The data will be preserved (on-chip) and later analyzed using graphs and diagrams prepared in Excel using Visual Basic. The data analysis will provide the user with health prediction.

**Keywords**—Air pollution monitoring, Personal pollution mapping, Real time alerts, Data server, Health prediction.

## I. INTRODUCTION

Air pollution has become an intense issue as of late. The issue is more serious in substantial mechanical urban areas. Air pollution has known to have a serious health effects on human body. The World Health Organization (WHO) approximates that around 1.4 billion urban residents worldwide are living in areas with air pollution above recommended air quality guidelines. Chronic exposure to air pollution increases the risk of cardiovascular and respiratory mortality and morbidity, while acute short-term inhalation of pollutants can cause changes in lung function and the cardiovascular system exacerbating existing conditions such as asthma, chronic obstructive pulmonary disease (COPD), and ischemic heart disease. Indeed, it is evaluated worldwide that air pollution kills a greater number of individuals every year than street mishaps. The World Health Organization information demonstrates a few million individuals are being affected via air pollution related sicknesses what's more, pass on rashly because of air pollution instigated sicknesses. In this way, observing and controlling encompassing air pollution is high on general society awareness in both creating and created nations. Hence, it becomes very important for an individual to know the amount of toxic gases his body is being exposed to know the ill effects of air pollution on health. Fortunately we have various destinations checking air pollution record and proportion of poisonous gasses introduce noticeable all around in different parts of the urban communities (Like we do have a site in Shivajinagar area of Pune). But these sites are

fixed at a point and consider aggregates of pollution levels and use coarse data to calculate actual amount of pollution which is not very accurate. Moreover, these sites are located at some distance from the actual polluting machines or vehicles. Hence it can never calculate the amount of pollution to which a particular individual is actually exposed (consider a biker driving behind a polluting lorry). The amount of harmful gases actually consumed by the biker will differ a lot from the amount calculated by the pollution monitoring site. Secondly, the general public does not really understand the seriousness and consequences of pollution data displayed by these sites. They have no means to understand the health effects of the pollution levels they are exposed. Hence, these existing pollution monitoring sites shows only the aggregates of the data and are least useful at the individual level.

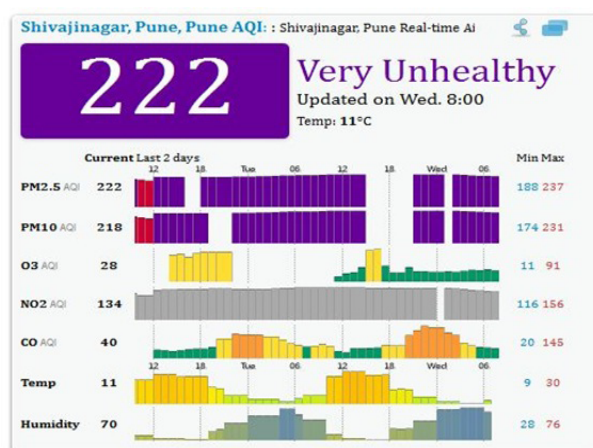


Figure 1.1: The Air Quality Index (AQI) showing status Very Unhealthy for Shivaji nagar area of Pune

The amount of pollutants breath in by an individual also varies from person to person due to difference in body structures and the activity that a person is currently exhibiting. For example, consider two individuals who are both in the same place at the same time, but one is driving while the other is sitting idle. They will experience the impact of air pollution in different ways since they will inhale different amounts of air due to their different breathing rates. Hence, person who is jogging is likely to be more affected than the person who is sitting idle. Also, they may additionally have different medical predispositions to the exposure. When these differences are accumulated over

a long period, they can become significant, leading to different health outcomes. The sites monitoring air pollution never considers the level to which an individual is actually being exposed. Hence, it is almost impossible to calculate and predict the health effects of air pollution on individual health.

AQI Mark	AQI Colours	Category	Description of AQI effects
—	Maroon	Hazardous	-
■	Maroon	Hazardous	The entire population is more likely to be affected.
■	Purple	Very Unhealthy	Everyone may experience more serious health effects
■	Red	Unhealthy	Everyone may begin to experience health effects.
■	Orange	Unhealthy for Sensitive Groups	People likely to be affected at lower levels than the general public
■	Yellow	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people.
■	Green	Good	Air quality is considered satisfactory, and air pollution poses little or no risk

Figure 1.2: Various levels of Air Quality Index (AQI) and corresponding health concerns

## II. LITERATURE SURVEY

Air pollution is a serious concern worldwide and several projects have emerged over the past few years to develop and effective system to measure and monitor air pollution and study its effects on human health. This chapter discusses few of the previous works done on air pollution monitoring. Over the past few years several projects have emerged that attempt to crowdsource data from low-cost portable mobile sensors to obtain air pollution approximates of high spatial granularity. Notable ones include the MESSAGE [10] (Mobile Environmental Sensing System Across Grid Environments) project in the UK, the MAQUMON project from Vanderbilt University, the Common Sense project supported by Intel, and the Open Sense project ongoing at EPFL Switzerland. Another notable project called HazeWatch [2] that monitors and maps Sydney air pollution in real time via vehicle mounted pollution sensors using both custom-built and off-the-shelf hardware. All these frameworks concentrate on social occasion the pollution information, and less on utilization of information by people personalizedly. From Cambridge University and partners in the UK, the most appreciated projects in this domain is the MESSAGE (Mobile Environmental Sensing System Across Grid Environments) project, which aims to develop fixed and portable devices for high-density measurement of concentrations of carbon monoxide and nitrogen oxides in urban areas. They have very recently reported their development and deployment experience in the Cambridge area, and demonstrated that the use of low-cost fixed and portable devices deployed in high densities can give a much more accurate picture of the spatial and temporal structure of air quality in the urban environment. The scale and

scope of this project is commendable, and the contributions in building the devices, deploying them city-wide, and modeling the collected data are noteworthy; however, these portable devices are relatively expensive and bulky for regular use by pedestrians/bicyclists, and personalized tools for estimating and managing exposure remain under-explored. Vanderbilt University, supported by Microsoft, embarked upon a similar project, called MAQUMON that developed portable wireless sensor units for measuring ozone, nitrogen dioxide and carbon monoxide.

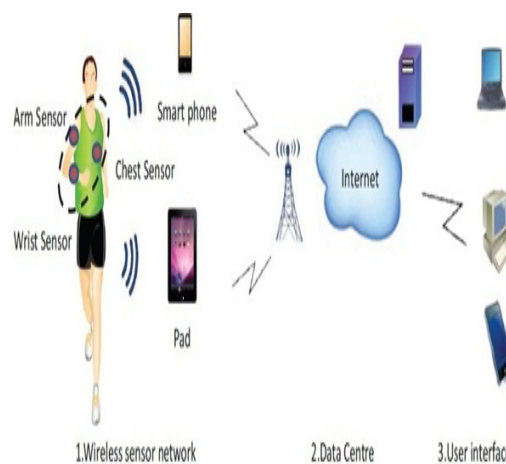


Figure 2.1: System architecture of Project Hazewatch.

Their units are autonomous, having onboard ash (for storage), GPS (for location) and GSM (for communication) capabilities, making them much more bulky and expensive. Innovative web-based visualization (e.g. contour maps) and personalization (e.g. route-planning) tools have also developed by making it more accessible for lay users. But, this project did experiments has not undertaken any long-term deployments. Intel has also been developing as part of the Common Sense project [3] a prototype that is a portable handheld device capable of measuring various air pollutants. This data can be uploaded in real time and viewed on Google Maps. The Common Sense project is currently running trials with these devices attached to the rooftops of street cleaners in the city of San Francisco. Several other projects, such as Sensaris, iSniff, etc. have similar goals, but probably the most noteworthy is the well-funded OpenSense project [2] that is ongoing at EPFL Switzerland. Ontop of public buses several air monitoring units have successfully deployed by them. In spite of the replication of effort across these several projects, they are all worthwhile efforts since they collectively explore different deployment scenarios (e.g. buses versus private cars) in different regions of the world. There also exist studies in the literature that try to associate human activity levels with pollution exposure concentrations. Few studies use physical activity times to estimate personal exposure, and its effect on Ischemic Heart Disease Mortality. However, these studies only use the users

home location to estimate their exposure, without regard to the mobility pattern of the individual. A group of researchers from Europe developed a tool called CalFit [7] that records the individuals location and activity information. However, their study did not use participatory sensor networks, and instead relied on historical data from fixed monitor sites and derived exposure estimates based on an Atmospheric Dispersion Modeling System (ADMS). One can say that using data with such low spatial density can lead to incorrect exposure estimates and hence biased medical inferences. Several studies have involved volunteers carrying portable pollution monitors. A group of researchers from USA designed a study to end out the impact of time-activity patterns on personal exposure. They followed sixteen participants, obtaining their temporal-spatial information with a PDA, and black carbon concentrations with a portable monitor. Their results showed that transportation contributed the highest black carbon concentrations. Nevertheless, their study ignored the human activity levels and only estimated the pollution concentration around the participants rather than their personal inhaled dosage. A research group in Barcelona, Spain designed a survey that tried to compare the exposures with different travel modes. They asked commuters to use different transport modes going along the same route to find out their relative inhalation dose. The inhalation rate algorithm they used was developed by other researchers, which assumed that inhalation rate ratio between different travel modes were constants. The referenced inhaled dose calculated by them can be neither real-time nor sufficiently accurate. Another group of researchers discussed how to combine individual time-activity patterns and air pollution concentrations, and gave a model to integrate the data. They designed a system called Exposure Sense which can combine smart phone accelerometer, external air quality data and pluggable sensors for personal pollution exposure estimation. In these projects, only personal location and acceleration information were considered as activity data, which can estimate the ambient air pollution concentrations, instead of personal real-time inhaled dose. The system developed by researchers in [1] from Sydney, Australia is very much similar with the objectives of this project. In this study [1] they have combined ambient pollution levels taken from participatory system( i.e. a mobile node user is carrying) with an individuals activity levels to estimate the personal inhalation dosage, which can then be used to make further medical inferences for that individual. They developed a system for estimating personal air pollution inhalation dosage. The system comprises a mobile app that interfaces with wearable personal activity sensors to determine breathing rate, and combines it with ambient pollution concentration determined from participatory pollution monitoring system. The group also conducted field trials with the system in Sydney, and obtained real-time pollution inhalation dosage estimates showing that different levels of activity (driving, cycling, and jogging) entail very different levels of exposure.

The improved estimates obtained from the system compared to earlier systems that do not include personal activity information allow for more accurate medical inference. This system is one of the most appreciated among the systems discussed till now as far as calculating the individuals exposure to air pollution is considered.

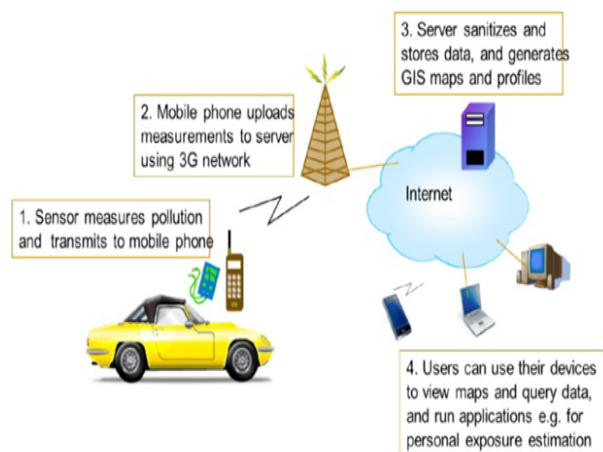


Figure 2.2: System Architecture of [1]

But this system does not have any continuous real time display or warning mechanism to provide the user with real time alerts about the hazardous levels of surrounding pollution levels. Hence, the user is not aware of the levels of pollutants he is consuming in real time. Secondly, the system carries out data analysis and provides the user with the levels of pollution the user was exposed and the also the amount of pollutants entered into users body. But it does provide the user any information about the related health risks the user is subject to as there is no mechanism to provide any kind of health related analysis of the user with the given pollutant consumption of the user. Hence, as the lay user has no idea about the serious health ill-effects of the air pollutants, the user is left no choice to carry the data to the expert and take advice about the health risks which is another costly and time consuming for the user

### III.SYSTEM COMPONENTS AND METHODS

1. Air pollution Monitoring: The air pollution monitoring node consists of hardware and pollution sensors such as carbon dioxide, carbon monoxide and dust sensor. These sensors are used to check the pollution levels in the surrounding area. Also pollution reading is noted along with time for further analysis.
2. Activity Monitoring: The body temperature and pulse rate/ respiration rate of the user will be monitored to calculate the breathing rate of the user so as to calculate the exact amount harmful gases consumed by the user.
3. Real Time Alerts: The recorded data will be analyzed in real time also displayed on LCD attached to the users module. The alerts and warnings is provided to alert the user in case the user is exposed to high levels of harmful gases more than the permissible limits and inhaled by the user. The

real time alerts given can prompt the user to manage alternatives to avoid dangerous levels of pollution which can be really unhealthy.

4. Information record: The data obtained from sensors and user activities will be stored on the device memory along with time. The data will consist of exact amount of toxic gases consumed by the user which is necessary for health analysis.

5. VB server: The information saved money on the gadget can be exchanged by the client by the day's end to the database utilizing serial correspondence. The database will store every one of the information of the client and furnishes the client with information changed over to exceed expectations sheet alongside charts and pie graphs for itemized investigation.

6. Health Analysis: The data saved on the device can be transferred by the user at the end of the day to the database using serial communication. The database will store all the data of the user and provides the user with data converted to excel sheet along with graphs and pie charts for detailed analysis.

#### IV. CONCLUSION

In this paper we have presented a novel system for monitoring personal air pollution Exposure. In this article, system design does not consider any aggregates of data but calculate the exact amount of polluted air inhaled and correspondingly calculate the concentration of each pollutant in the air (CO<sub>2</sub>, CO and dust). The system senses the amount of pollution levels using onboard pollution sensors, stores the data and provides the user with detailed health effects of the consumed pollution levels. The system to be designed should be light weight and battery operated. The system should require less power and must be robust. The cost of the system must be in the affordable limits for common man.

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