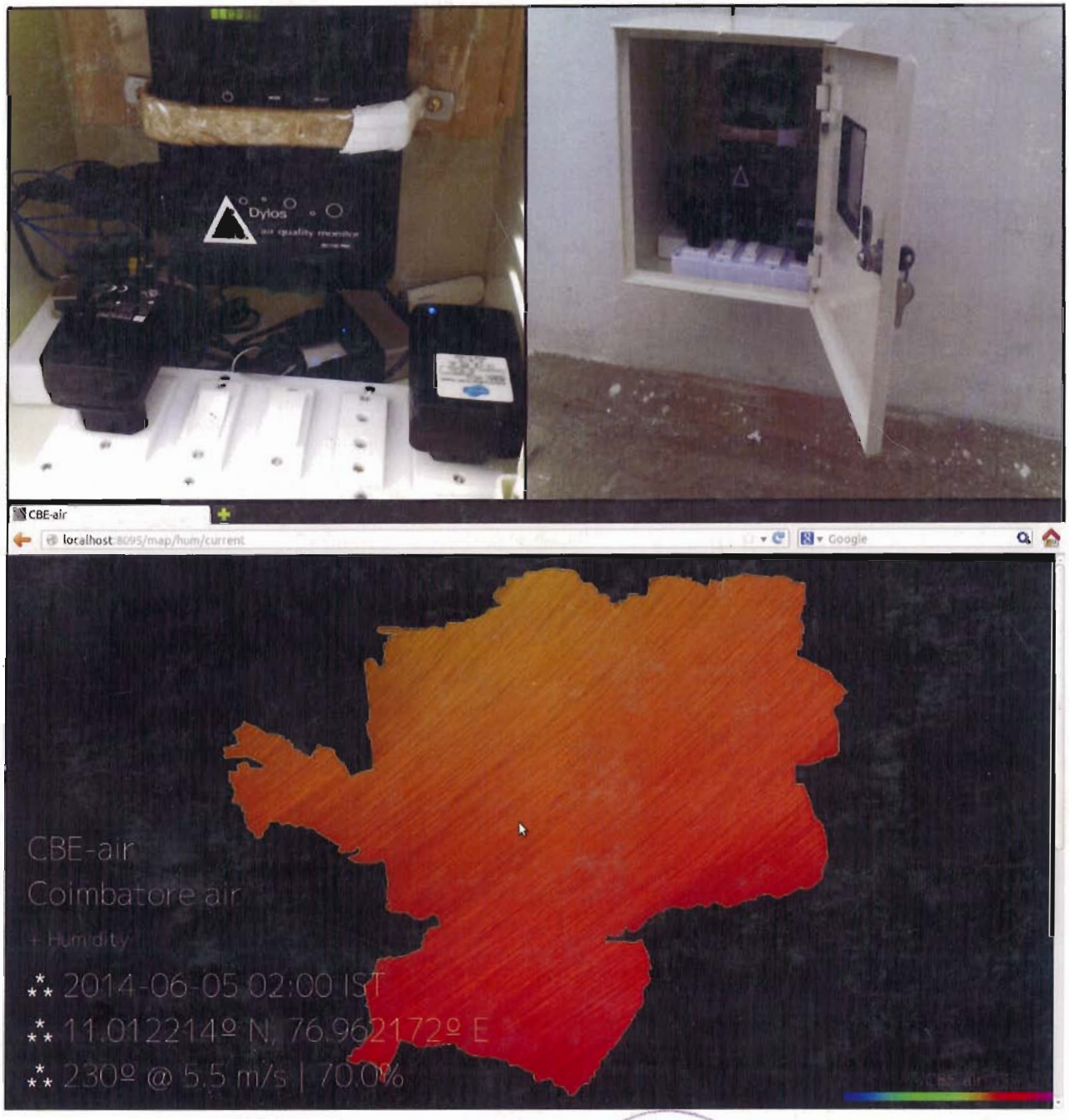
Real time air pollution modeling and dissemination of location based information using mobile devices



Final report submitted to

Natural Resource Data ManagmentSystem

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SACON

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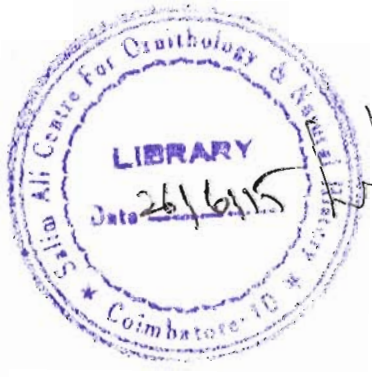

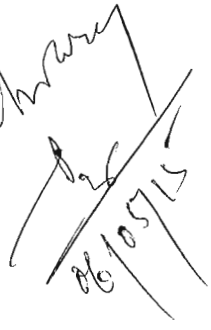

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Executive summary

Particulate matter (dust) air pollution is a serious environmental and health concern in the fast growing urban areas of India. It involves multi level interacting components of emission sources, dynamism of atmosphere and implications on public health and environment. Mitigation or management of this problem requires information, realistic models and predictability on the levels of pollution with adequate temporal and spatial resolution. Establishment of urban area real time monitoring and modeling system is inevitability and it is being recognized as a vital infrastructure for addressing the problem in various locations of the country. However, with ever-increasing necessity for sensor networks, huge capital and recurring expenditure for the real time modeling system in terms of computational resources are hampering wider installation of such systems. Technical hurdles such as inherent variability and lack of an appropriate bridge system that is interoperable and facilitates optimal usage with access of real-time data are further hampering efficiency and robustness of these systems in deriving information and its dissemination. On the other hand, there is a growing realization that a low cost monitoring network with modeling environment would be an important enabler for high spatial resolution air pollution observations and related applications. There are evidences from field trails, showing that low cost sensors with advanced calibration techniques would be an important asset for real time air pollution monitoring. However, it involves a huge challenge in terms of fine-tuning the sensing technology, data management, networks sustenance and derivation of suitable application from the collected information.

The project in Coimbatore, a fast growing urban conglomerate in the state of Tamil Nadu (India), intended to address the question of how disparate and meager sensor resource's real time data can be better organized, modeled and disseminated for integrated management of particulate matter air pollution. The project applied Open Geospatial Consortium (OGC) Sensor Web Enablement (SWL) specifications. The specifications such as Sensor Observation Services (SOS), Web Processing Services (WPS) and GeoSMS were approached for organizing sensor resources, real time air quality modeling and its data dissemination. The main objective of the project was to

i) Develop Sensor Observation Service for spatially distributed air quality sensors and real time meteorological data website. ii) Develop Real time air quality modeling web processing service using the SOS, validate and compare it with similar other models. iii) Develop a Geo-SMS based android application to disseminate the modeling result.

To address the objective one, the project developed a low cost real time particulate matter monitor by combining Dylos™pro, a commodity indoor air quality monitor, single board computer and real time data communication system. Field trials of the developed monitors was tested in four locations of the Coimbatore urban area and found its suitability in real time particulate pollution monitoring. To test the robustness of data communication, two mode of data transfer through SMS and REST API were tested and found to have satisfactory functionality. The Sensor observation service was enabled for these established monitors using istSOS, a python based implementation of OGC SOS. To demonstrate the functionality of the SOS implementation, a web application was devel-

oped which consume the SOS as data back-end. Data download in different interoperable formats, visualization of time series data from the real time monitor in chart and table view are some of the functionalities enabled along with the web application.

To address the objective two, WRF-CHEM based real time particulate pollution modeling system was developed. A python based automatic execution script was developed to make the modeling system to execute in real time. To address the high computational requirement of WRF-CHEM simulation in real time, different computer processor intercomparison was carried out. Thus, we found satisfactory usability of cloud computer clusters in time bound simulation of the WRF-CHEM for Coimbatore urban domain. As alternative to cloud computers, the project also experimented with low cost, low energy demand single board computer cluster such as ARM processor based Cubietruck cluster. It was found that although the WRF-CHEM can be made into effective functioning system using this computer processor, the time required for the simulation is considerably higher than other computer systems. To enable the Web Processing Services (WPS) for the model output, a web application was developed to visualize WRF-CHEM output in interoperable interface with functionality similar to the OGC standard WPS. For addressing basic requirements of WRF CHEM simulation, a high resolution emission inventory (1X1 km) for anthropogenic particulate pollutants PM2.5 and PM10 was developed covering 3000 sq.km of Coimbatore and its adjacent regions. Secondary information from multiple government agencies and sources were also used for estimating the particulate pollution emission from Coimbatore region considering 2012 as base year. In validating the WRF-CHEM output, it is found that the simulation results are not akin to the observations and need further sensitivity study with various micro physics and other atmospheric chemistry options of WRF CHEM for Coimbatore domain.

To address the objective three of the project a GeoSMS backed Android mobile application was developed. The application was developed based on an offline map that had functionality to send an SMS containing user's current location coordinates on touch map clicking. To provide the server side functionality for the mobile application, a SMS gateway was setup in the server side backed with nearest neighbourhood algorithm KD-tree. The algorithm access the WRF-CHEM model output and provides the location based information according to the received GeoSMS bearing location coordinates of the user.

By adopting open source specification implementation the study intends to develop "best practice" to organize real time data on particulate pollution in Coimbatore urban area. The project foresees better management of real time particulate pollution data from monitoring and modeling output with extensible and interoperable data format. The main output of the project is successful demonstrations of time and space relevant data provision for solving the particulate pollution problems of Coimbatore, as an example replicable elsewhere.