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AIR QUALITY MONITORING USING NANO SENSORS AND REAL TIME ANALYSIS

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Abstract- Air pollution is a serious problem in thickly populated and industrialized areas. Economic growth and industrialization are proceeding at a rapid pace, accompanied by increasing emissions of air polluting sources. Environmental impacts of air pollutants have impact on public health, vegetation, material deterioration etc. To prevent or minimize the damage caused by atmospheric pollution, suitable monitoring systems are urgently needed that can rapidly and reliably detect and quantify polluting sources. Nanotechnology based solid-state gas sensors can overcome this problem. Nanotechnology is the study, design, creation, synthesis, manipulation, and application of functional materials, devices and systems through control of matter at the nanometer scale (10^{9} of a meter), that is, at the atomic and molecular levels, and the exploitation of novel phenomena and properties of matter at that scale. Here we report an application example of studying air quality monitoring based on nanotechnology 'solid state gas sensors'. To carry out air pollution monitoring over an extensive area, a combination of ground measurements through inexpensive sensors and wireless (Geographical Information System) GIS will be used for this purpose. This portable device, compressing solid-state gas sensors integrated to a Personal Digital Assistant (PDA) linked through Bluetooth communication tools and Global Positioning System (GPS), will allow rapid dissemination of information on pollution levels at multiple sites simultaneously. The AQ report generated can be then published using internet GIS to provide a real time information service for the PCD, for increased public awareness and enhanced public participation. The local deterministic and geo-statistical interpolation methods have been used for spatial prediction, and to find out the most suitable method for studying air pollution, based on observations at each monitoring site.

Keywords – Airpollution, Nanotechnology, Nanosensors, GIS, GPS

I. Introduction

In places where the air is thick with toxic air pollutants, increasing emissions are unavoidable due to excessively rapid economic and industrial growth. The cost of establishing and implementing ordinary monitoring systems is extremely high.Use of analytical instruments are time consuming, expensive, and can seldom be applied for real time monitoring in the field, even though these can give a precise analysis. Hence, a new generation of detectors, solid state gas sensors, often an excellent alternative for environmental monitoring due to low cost, light weight, extremely small size and also due to the reason that they can be deployed anywhere so as to receive data that can eventually be transmitted through a wireless GIS network system as a rapid monitoring tool to the general public. The air pollutant measured was NOx. The air sampling points are established at the same locations as the air quality monitoring sites of the PCD, to compare the NOx Concentration values acquired from the solid-state gas sensor devices and PCD's air quality monitoring system.

II. Air Quality Monitoring System

The PCD has been measuring air quality levels through the automatic monitoring system, referred as to "AIRVIRO SYSTEM" and reporting real time air quality levels through the internet as the air quality index (AQI) maps. Air quality monitors comprise 16 permanent stations and are set up at roadside and general sites. Unfortunately, the cost of establishing and implementing traditional monitoring systems is extremely high. In the past, the establishment of air quality monitoring systems in Thailand needed technical assistance from international agencies or governments and the investments made in these systems are extremely high, running to $250,000 US. This air quality monitoring system can measure and report air quality levels in real time nevertheless there is still a huge disadvantages that this monitoring system cannot be implemented at many sites to monitor air pollution over an extensive area because of high costs.

For non automatic monitoring systems used for measuring gases, analytical instruments such as optical spectroscopy or gas chromatography/mass spectrometry, NDIR (Non Dispersive Infrared), chemiluminescence's, and the like can give a precise analysis; however they are time consuming, expensive, and are seldom used in real time in the field. Moreover, they are difficult to transport from place to place being bulky as well. To substitute the typical analytical tools and adapt or extend the air quality monitoring system of PCD with a new generation of

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detectors, nanotechnology based metal oxide semiconductors such as ZnO semiconductors used in the study are a viable alternative. In fact these solid state gas sensors offer an excellent opportunity for implementation in environmental monitoring due to light weight, extremely small size, robustness, low cost and also as they can be installed anywhere to collect data covering extensive areas. The air quality data can eventually be transmitted through a wireless GIS network system to the public.

III.NANOTECHNOLOGY

The nanotechnology realm has traditionally been refined as lying dimensions between 0.1 and 100 nanometers. Nanotechnology has been applied to industry for example in textile, medicine and health, computing, transportation, aeronautics and space exploration, environment, and so on. In the last decade, the specific demand for gas detection and monitoring has emerged especially as the awareness of need to protect the environment has grown. Gas sensors are applied in numerous fields of applications. In the present case, a nanotechnology based gas sensors application for studying air pollution is described. The answer to why use nanotechnology based solid-state gas sensors is that increasing the surface to bulk atom ratio increases grain size dependence, meaning increasing gas adsorption and more sensitivity.

As the report has demonstrated, nanotechnology is widely regarded as a 'new' and exciting branch of science and technology. This belief has contributed to the massive period of growth that this high profile and wide-ranging field is currently enjoying.

IV. Solid State Gas Sensors For Air Pollution

Gas sensors for detecting air pollutants must be able to operate stably under deleterious conditions, including chemical and/or thermal attack. Therefore, solid-state gas sensors appear to be the most appropriate in terms of their practical robustness. The sensors used for detecting air pollutants are usually produced simply by coating a sensing (metal oxide) layer and a substrate with two electrodes. Typical materials are tin oxide (SnO_2), zinc oxide (ZnO), titanium oxide (TiO_2) and tungsten oxide (WO_3) with typical operating temperatures of 200 to 400ºC.

The general mechanism for a metal oxide sensor is a change in the resistance (or conductance) of the sensor when it is exposed to pollutant gas, relative to the sensor resistance in background air. The sensor resistance is the best-known sensor output signal and is in most cases determined at constant operation temperature and by DC measurement. AC measurements have also been reported but are more frequently used in impedance spectroscopy at a modeling level.

The figure explains how metal oxide semiconductor detects the pollutant gases.

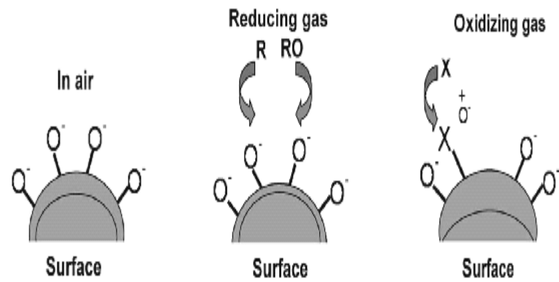

Figure :Detection of pollutant gases using Metal oxide semi conductors

The depletion zone at the surface of metal oxide sensor is due to the absorption of atmospheric oxygen. When the metal oxide sensor absorbs a reducing gas (CO, H_2), depletion area at the surface will be decreased, meaning increasing conductivity. On the other hand, if a metal oxide sensor absorbs an oxidizing gas (NO_2), the depletion zone at the surface will be increased, meaning decreasing conductivity. In conclusion, a change of conductivity/resistance is related to gas concentration. In the case of a ZnO sensor, the conductivity decreases that means the resistance increases when the sensor absorbs NOx, dependent on NOx concentration.

V. Internet GIS

Internet GIS is a relationship between GIS and internet. Users will be able to access GIS applications without purchasing GIS software by using a web browser. Detailed maps can be generated from huge databases of spatial information and distributed all over the world. The web is a cost effective to share or provide public access to data world wide on the internet. As shown in figure, the wireless GIS Data Logging System being developed in this study is composed of two parts, it is hardware and software.

On the hardware side, a Mandrake 9.1 server provides the back end support. A user has a PDA operated on pocket PC. To be complete, a Global Position Receiver (GPS) and digital camera can be also integrated through proper extensions.

On the software side, a Minnesota Map server 4.4.0 ensures Web Map Service (WMS), which is an Open Source Common Gateway Interface (CGI) based development environment for building spatially enabled internet applications. The server setup is made up of PostgreSQL, PostGIS and PHP, configured with each other to execute the client's request and manage the database. The client setup is composed of interfaces, developed using JavaScript and Hyper Text Markup Language (HTML).

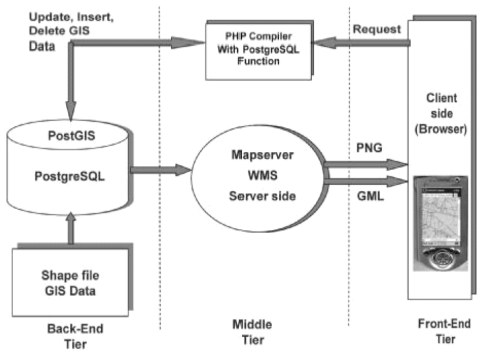

Figure 1. GIS Interface

For wireless Data Updating System, it is composed of three tiers, including Front-End Tier, Middle-Tier and Back-End Tier which is shown in figure 1. On the Front-Tier is the client, making a request, Minnesota Map Server in the Middle Tier passes the CGI-request over to the Back-End Tier where PHP and PostgreSQL with PostGIS read the data and execute the request.

VI. NOX Observation Using ZnO sensor

The data used for this study are composed of measured NOx concentration from twelve stationary air quality-monitoring sites as shown in figure. A limited number of observation sites were taken to rest the method at locations, which are critical for automobile pollution. The data were collected every hour from 7:00 hours until 19:00 hours, which were fed to GIS for further processing. It is supposed that more air sampling points are needed for more accurate interpolation techniques, or interpolation by creating a buffer at each point is supposed to be more suitable method for this study.

VII.Integrating GIS With Nanosensors

As shown in figure 2, the solid-state gas sensor gives out electric signals, related to NOx concentration.

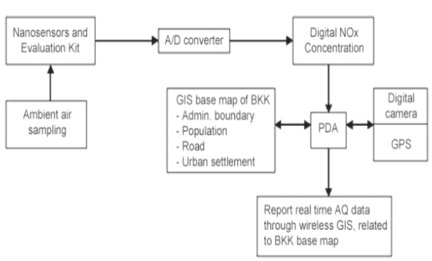

Figure 2. Block diagram of Airpollution sensing

An A/D circuit converter converts the NOx concentration values from an analog to digital signal. NOx concentration levels, acquired from monitoring sites, GIS base maps and attributes were input into PDA linked with GPS. The results were utilized for air quality level modeling of the study area. The model developed were used for acquiring and monitoring real time air quality levels and also updating information through wireless GIS using WMS. The information on the resulting air quality levels can operate as a monitoring system and be displayed in the form of GIS database.

The air quality levels were categorized into five classes. The five classes of air quality level reported include hazardous, very unhealthy, unhealthy, moderate and good. Hence, the internet users can browse and query air quality interpolated maps, relating to geographic information, including districts, roads, urban settlement, historical air quality level, population. The internet based GIS is useful real time interaction on air quality levels and increases public awareness and participation.

VIII.Future Trends

Several developing countries have launched nanotechnology initiatives in order to strengthen their capacity and sustain economic growth.. Panacea Biotech, New Delhi is conducting novel drug delivery research using mucoadhesive Nanoparticles, and Dabur Research Foundation, Ghaziabad is participating in Phase-1 clinical trials of nanoparticle delivery of the anti-cancer drug paclitaxel.

Some of the major nano-materials currently in research are as follows:

- Quantum dot -In the field of telecommunication and optics.
- Polymers - In the filed of computing and energy conversion.
- Nanocapsules -As dry lubricant.
- Catalytic Nanoparticles - In fuel and food production, health and agriculture.
- Carbon nanotubes Space and aircraft manufacture, automobiles and construction.
- Nanoparticulate coatings Liquid crystal manufacturing, molecular wires and anti-corrosion coatings.
- Nanocomposites -In the field of microelectronics.
- Textiles -Military and lifestyle.
- Invisible Nanofibers Conducts electricity and repel with oil

IX.Conclusion

Current air quality of most polluted places is better than a decade ago. However, Bangkok still has been facing serious air pollution problems. Some of the problems such as black and white smoke from truck and public bus exhaust still occur. This is attributed to the rapid economic and industrial growth, combined with a lack of strict implementation of air quality and requires the PCD to adapt or extend the current PCD's air quality monitoring systems and facilitate the problem of analyzing and monitoring air pollution in those places.

The traditional air quality monitoring system, controlled by a PCD, is extremely expensive. Analytical measuring equipment is costly and time consuming, and can seldom be used for air quality reporting in real time. The PCD has been forecasting and reporting real time air quality levels through the internet in the form of maps. However, the air quality index of each monitoring site is just shown by rather coarse levels; good, moderate, unhealthy, very unhealthy and hazardous. The air quality report should be more in detail, including information such as air quality interpolated maps, relating to other information for better understanding the air quality level.

For these reasons, this work is aimed to build up an easy monitoring system using low cost portable gas sensing systems "**solid state gas sensors**" to carry out air pollution monitoring over an extensive area and to be able to report real time air quality data through wireless internet GIS. Later all this modeling can be referred to as an air pollution monitoring system, which will be able to support the PCD to adapt or extend the current PCD's air quality monitoring systems, to facilitate the problem of analyzing and monitoring air pollution, and also to assist in establishing priorities and measurements of air pollution in the polluted areas.

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