2011 International Conference on Instrumentation, Communication, Information Technology and Biomedical Engineering
8-9 November 2011, Bandung, Indonesia

Measuring Air Pollutant Standard Index (ISPU) with Photonics Crystal Sensor based on Wireless Sensor Network (WSN)

Muhamad Azis[1], Erus Rustami[1], Wenny Maulina[1],
Mamat Rahmat[2], Husin Alatas[3], and KudangBoro Seminar[2]
[1]Department of Physics, Bogor Agricultural University (IPB), Bogor, Indonesia
(Tel : +62 251 - 8625728, Fax. +62 251 - 8625728; E-mail: muhamad.azis@gmail.com)
[2]Department of Agricultural Engineering Science, Bogor Agricultural University (IPB), Bogor, Indonesia
(Tel : +62 251 - 8625728, Fax. +62 251 - 8625728; E-mail: rahmat32@gmail.com)
[3]Theoritical Physics Division , Department of Phyisics, Bogor Agricultural University (IPB), Bogor, Indonesia
(Tel : +62 251 - 8625728, Fax. +62 251 - 8625728; E-mail: s.h.alatas@gmail.com)

Abstract - Information systems of air pollutant standard index (ISPU) with photonics crystal sensor which consist of three primary section viz. station as sensor acquisition of air pollutant, server as collecting and data logging, and graphical user interface (GUI) as user facilitating while data acessed has been built. Each station is equipped with five sensors, each of which serves to read the CO gas, SO_2, NO_2, surface ozone (O_3), and dust particles (PM10)[1] .To optimize the performance of the system to be able to retrieve data from areas that are difficult to reach, then the data transmission from the station to the server using wireless communication. Transmitted data is then stored on the server. The saved data can be displayed either in the form of desktop and web applications in realtime and non-realtime.

Keyword: ISPU, realtime monitoring, crystal photonics sensor, Wireless Sensor Network (WSN), data logging

I. INTRODUCTION

Air pollution is a serious environmental problem in Indonesia today, in line with the increasing number of motor vehicles and the increase in transport economics. Test the feasibility of emissions since the last few years touted by the government and NGO (*National Government Organization*) were also not running as expected. Number of vehicles on the road day after day is increasing. In the Jakarta area was recorded 8.74% increase vehicle per year while increasing the road infrastructure 6:28% per year, adding to the decline of our environmental air. That's because the cause of the increased air pollution. Communities must be aware of this situation because every body is different resistance to certain substances. [3]

Air quality delivered to the community in the form of the Air Pollutant Standards Index (ISPU). ISPU is the air quality report to the community to explain how clean or polluted our air quality and how it impacts our health after breathing air for several hours or several days. Determination ISPU considers the level of air quality on human health, animals, plants, buildings, and aesthetic value. Based on the Decree of the Environmental Impact Management Agency (Bapedal) Number KEP-107/Kabapedal/11/1997, ISPU delivery to the community can be done through mass media and electronic boards and displays in public places. ISPU determined based on five major pollutants, namely: CO, SO_2, NO_2, surface ozone (O_3), and dust particles (PM10). [1]

Information systems of ISPU with photonics crystal sensor which consist of three primary section viz. *station* as sensor acquisition of air pollutant, *server* as collecting and data logging, and *graphicaluser interface* (GUI) as user facilitating while data acessed has been built. Each station is equipped with five sensors, each of which serves to read the CO gas, SO_2, NO_2, surface ozone (O_3), and dust particles (PM10). To optimize the performance of the system to be able to retrieve data from areas that are difficult to reach, then the data transmission from the station to the server using wireless communication. Transmitted data is then stored on the server. The saved data can be displayed either in the form of desktop and web applications in *realtime*and *non-realtime* .[2]

II. THEORETICAL BACKGROUND

Photonic Crystal Sensor

The photonic crystal sensor was referred in this paper is the designation for photonic crystal-based optical sensor who developed by researchers at the Department of Physics, Bogor Agricultural University. Development of optical sensor is started from the study of theoretical physics about the phenomenon of interaction of electromagnetic waves (EM) with a photonic crystal, then the process of fabrication by electron beam evaporation method and its manufacture into a highly sensitive optical sensor.[4]

The basics principle of this sensor is to propagating EM waves in photonic crystals are inserted in the sample material, and then accepted by photodetector transforming it into electrical voltage. To be able to read, the voltage should be amplified by the amplifier circuit. The voltage generated in principle can be converted and calibrated to the required

978-1-4577-1166-4/11/$26.00 ©2011 IEEE

parameters in units, eg grams/liter, molar,% volume or % weight.

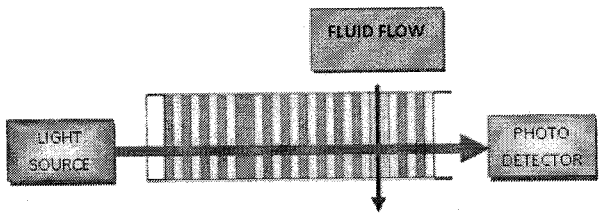

Figure 1. Photonics crystal sensor

Characterization is done by using the spectrophotometer method for testing conformance Olympus USPM fabrication results with the results of simulations and UV-VIS Spectrophotometer Ocean Optics USB 1000 for measuring the transmittance of the photonic crystal with a refractive index of the receptor defect. Here is the schematic implementation of experiments in which samples were subjected to the defect using a solution of reagent that has reacted with the gas sample.[4]

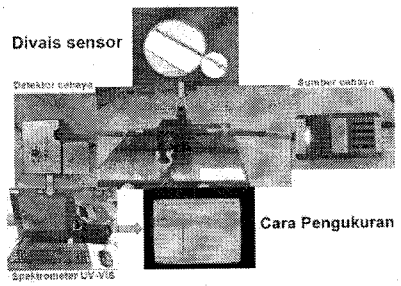

Figure 2. Photonics crystal sensor characterization

DFRduino Mega 1280

DFRduino Mega is 100% same as the original Arduino Mega. The Arduino Mega is a microcontroller board based on the ATmega1280(datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

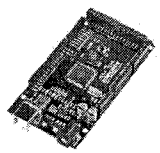

Figure 3.DFRduino Mega 1280 architecture

(http://www.dfrobot.com)

DFRduino I/O Expansion Shield

The IO Expansion shield is designed for those who are familiar with the electronic circuits or universal board with bread board module, it helps in building a simple circuit effortlessly, but for those who are not familiar with the circuit or the slightly more complex circuit it doesn't seem so easy. This sensor expansion board is able to easily connect a number of commonly used sensors. For interactive works, the focus should not be on the specific circuit configuration, but on what features needs to be implemented. So for some of the specific function of the sensor module to connect to this sensor expansion board, we need to consider how to use the Arduino.

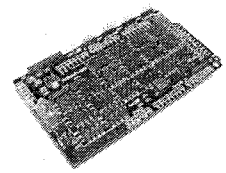

Figure 4.DFRduino I/O Expansion Shield

(http://www.dfrobot.com)

XBee Pro Wireless Module

The Digi XBee 802.15.4 modules are the easiest-to-use, most reliable and cost-effective RF devices we've experienced. The 802.15.4 XBee modules provide two friendly modes of communication – a simple serial method of transmit/receive or a framed mode providing advanced features. XBees are ready to use out of the package, or they can be configured through the X-CTU utility or from microcontroller. These modules can communicate point to point, from one point to a PC, or in a mesh network.

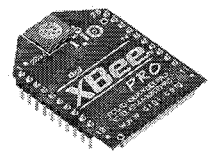

Figure 5.XBee pro module

(http://www.dfrobot.com)

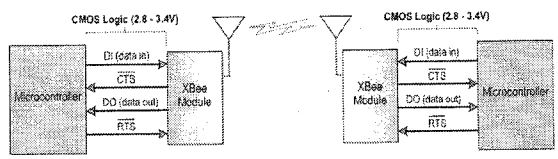

Figure 6. System data flow diagram in a UART-interfaced environment

(http://www.digi.com)

III. METHODOLOGY

Information systems of air pollutant standard index (ISPU) with photonics crystal sensor which consist of three primary section viz. station as sensor acquisition of air pollutant, server as collecting and data logging, and graphical user interface (GUI) as user facilitating while data acessed has been built. Each station is equipped with five sensors, each of which serves to read the CO gas, SO_2, NO_2, surface ozone (O_3), and dust particles (PM10)[1].

Analog data read by the sensor is then processed by DFRduino and then transmitted wirelessly to the server to the next are stored in the database server. The process of data storage performed by the Visual Basic 6.0 licensed. Tests performed on each block of data systems.

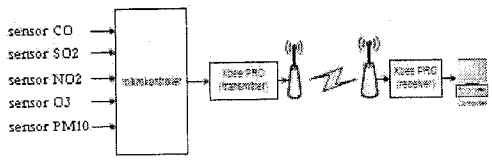

Figure 7. Block Diagram

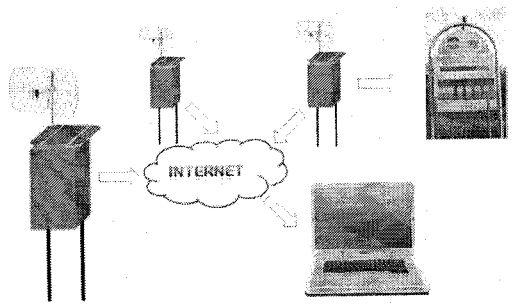

Figure 8.overall system of ISPU monitoring

Through when the incoming data will be directly recorded and stored on a database. The saved data can be displayed either in the form of desktop and web applications in *realtime* and *nonrealtime*.

IV. RESULT AND DISCUSSION

ISPU data obtained from stations that have been built and then transmitted wirelessly to the server to the next are stored in the database server. The process of data storage performed by the Visual Basic 6.0 licensed. Data storage interval can be set via the menu on the graphic display software interface has been created. In addition to data storage, data can be displayed in realtime. The following display interface that has been made,

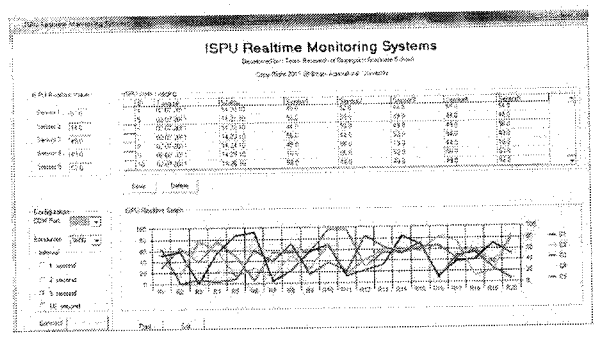

Figure 9. ISPU realtime monitoring systems based on desktop applications

Through when the incoming data will be directly recorded and stored on a database in Microsoft Access data_ispu.mdb. *DataGrid* component on the Visual Basic 6.0 will display the data recorded on database via ADODC connection. The data also can log in the form of an Excel (. Xlsx).

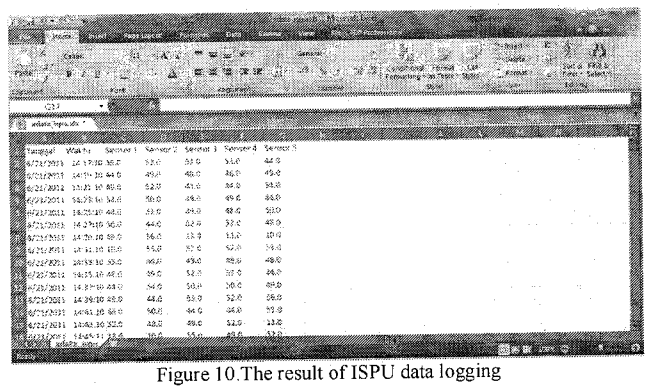

Figure 10.The result of ISPU data logging

The data log results are then displayed in a web browser by a website monitoring are built using the PHP (*Hypertext Preprocessor*) and JQuery techniques. As for displaying graphics in real time is used fusionchart free edition combined with PHP and AJAX (*Asynchronous JavaScript and XML*). The following example display the graph,

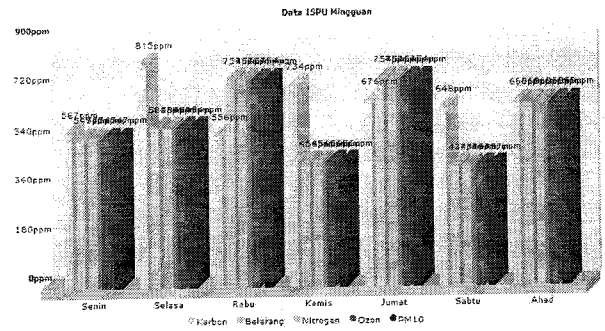

Figure 11. ISPU weekly monitoring based on website

V. SUMMARY

Information systems of air pollutant standard index (ISPU) with photonics crystal sensor which consist of three primary section viz. *station* as sensor acquisition of air pollutant, *server* as collecting and saving of data, and *graphicaluser interface* (GUI) as user facilitating while data acessed has been built. Data acquisition was develoved by wireless communication. The saved data can be displayed either in the form of desktop and web applications in *realtime* and *non-realtime*.

ACKNOWLEDGMENT

This research is supported by Beasiswa Unggulan Terpadu - Education Ministry of Republic of Indonesia, Environmental Research Center IPB (PPLH-IPB), Department of Physics, Department of Civil and Enviromental Engineering, Department of Mechanical Engineering and Bio System in Bogor Agricultural University (IPB), West Java, Indonesia.

REFERENCES

[1] Badan Pengendalian Dampak Lingkungan (BAPEDAL). "*Pedoman Teknis Perhitungan dan Pelaporan Serta Informasi Indeks Standar Pencemar Udara (ISPU).*" Jakarta : BAPEDAL,1998.

[2] Fawziyyah, A. Harmoko, C. Imawan. *Sistem Informasi Data Kualitas Udara Berbasis Web.*PekanBaru : SimposiumFisikaNasional, 2009.

[3] Kementerian Lingkungan Hidup. "*Status Lingkungan Hidup DKI Jakarta*". Jakarta : Kementerian Lingkungan Hidup, 2002.

[4] M. Rahmat.*Tesis : "Design and Fabrication of One Dimensional Photonic Crystal as A Real Time Optical Sensor for Sugar Solution Concentration Detection"*. Bogor :InstitutPertanian Bogor, 2009.