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Application of Greenhouse Gas Monitoring System Using General Packet Radio Service on GSM Network

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Abstract. Emissions of carbon dioxide (CO_2) is the greatest influence on the air quality for the largest contribution to global warming is about 50%. These gases absorb and reflect radiation emitted waves of the earth, so that the heat will be stored on the surface of the earth. The absorption capacity on mangrove plants is one of the efforts to reduce CO_2 emissions. In this work, a gas monitoring system was developed to monitor greenhouse gas utilizing GSM network using GPRS service. Based on experiment result, this system can monitor the absorption of CO_2 emissions and the formation of O_2 gas in mangrove plants as one of the efforts to reduce the impact of global warming. The information can be transmitted using SMS service on GSM network in less packet size and data transmission time, and also can be accessed through web-based application. As conclusion, the use of small and portable gas-sensing air pollution monitoring technologies can obtain more spatially and temporally representative air pollution data.

1. Introduction

A major problem in the 21st century is outdoor air pollution which is contributing to approximately 3.7 million deaths globally [1]. Referring to the WHO-specified limits on air pollutants level, today, approximately 92% of the world's population lives in the regions where air pollution levels are categorized as unsafe [2]. However, air pollution is also the cause for global climate change [3] and environmental problems such as acid rain [4], haze [4-5], ozone depletion [6-7] and damage to crop [8-10]. Thus, efforts are needed to resolve the issues [11]. Carbon dioxide (CO_2) is one of the greenhouse gases that cause global warming, with a contribution of 50% [12]. CO_2 gas absorbs and reflects the radiation emitted by the earth, so that the heat will be stored on the surface of the earth. Traditionally, air pollution is monitored by measuring the concentrations of various pollutants such as carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and particulate matter (PM) at fixed sites by using accurate and expensive instrumentation [13-17].

Recent advancements in the field of sensors, wireless communication technology, and digital electronics have raised a new paradigm for air pollution monitoring [18-19]. A low-cost sensor for monitoring real-time concentrations of different air pollutants on a ubiquitous network to gather high-resolution spatio-temporal air pollution data implemented by this paradigm. The air pollution data can be then utilised for a variety of air pollution management tasks. Several articles have already addressed this emerging area of sensor-based air quality monitoring. Generally, previous researchers are focus on the needs, challenges, benefits, and future directions of a sensor-based pollution monitoring for widely applications [20-21].

The main advantage of Global System for Mobile Communication (GSM) is the ability for international roaming. With these capabilities, GSM services can reach remote areas [22]. General Packet Radio Service (GPRS) is a packet-switching technology that enables data transfers through the cellular network's global system for mobile communications (GSM). GPRS can transmit the data in the form of multimedia, e-mail, Wireless Application Protocol (WAP), and World Wide Web (WWW) [23-25]. Previous research related to the measurement of hazardous gases, that concerns the process of carbon dioxide (CO_2) uptake in plants by designing a monitoring and controlling system of CO_2 gas concentration have been carried out by [26-31].

The major objective of this research is to develop a system to gather spatio-temporal air pollution data (CO_2, O_2, etc.) by using a ubiquitous network of low-cost sensors for monitoring real-time concentrations of different air pollutants in mangrove plants area, utilizing GSM network using GPRS service. This paper first gives a brief overview of technological advancements of a sensor-based air pollution monitoring system. Next, the architecture of the implemented system is described in Section 2. Section 3 presents measurement results with discussion, while the last section contains some concluding remarks.

2. Experimental apparatus and procedure

This paper discusses the greenhouse gas monitoring system to monitor the absorption of CO_2 gas emissions and O_2 gas concentration in mangrove plant area. The level of emissions and concentration of both gasses monitored continuously, then the data will be stored based on time interval measurements that can be set on part per million (m) units. Periodically the data are sent to the web server as configured period Short Message Service (SMS) which is used in order to configure the monitoring unit asynchronously. The observation system uses a gas sensor of carbon dioxide (CO_2) and oxygen (O_2) placed around the mangrove plant area. Observation station point spread in Muara Opak Mangrove Forest Area located in Baros Hamlet, Tirtohargo, District of Kretek, Bantul Regency. Figure 1 presents the architecture of the system. The monitoring unit is responsible for detecting gas concentration, initialization, and control of the GPRS/GSM modem. Communication between monitoring unit and web server implemented over the wireless link based on GPRS. Then, the data provided by each monitoring unit interpreted by web-based application.

The CO_2 absorption monitoring system is divided into two separate systems that work in an integrated way:

i. Monitoring unit

Monitoring unit consist of electronic components that work to organize and read the sensors installed in the monitoring unit. This system also equipped with gas sensors of carbon dioxide, oxygen gas, temperature and humidity, and storage media. This system serves to send data to the web server using the HTTP protocol over the Internet network. Monitoring unit is implemented using Arduino Ethernet Shield 3G (SIM5216E). As a gas monitoring unit, O_2 sensor (OOM202), CO_2 sensor (MG811), temperature and humidity (DHT22) were used. As a GPRS modem, we have used SIM900A module. The system will detect the presence of CO_2 and O_2 gas in the air, then read by the gas sensor and produce analogue output stage. The data in the form of stage is then processed by the microcontroller, resulting in a series of numbers. The microcontroller contains a program to calculate the variable stage of the sensor. After the electrical signal is processed to obtain data which is then displayed on the LED screen as an indicator of the value of CO_2 and O_2 gas content contained in air. The last process is to send information of gas concentration using GPRS service automatically.

ii. Web-based application

GPRS modem is responsible for communication with the remote web server that runs web-based application, which is accessible by the standard web browser and presents the results to the end user for the analysis. The usage of pull communication model eliminates the need of public IP address for the monitoring system, which reduces the total cost of the system. Data and configuration parameters are exchanged between monitoring unit and web-based application using HTTP-POST method. Web-based monitoring application functions to receive data from microcontroller via HTTP protocol over the internet network, store the data in web server, then display information of monitoring result in real-time and online. The observed information is transmitted using GPRS service on GSM network, which is visualized on the web page.

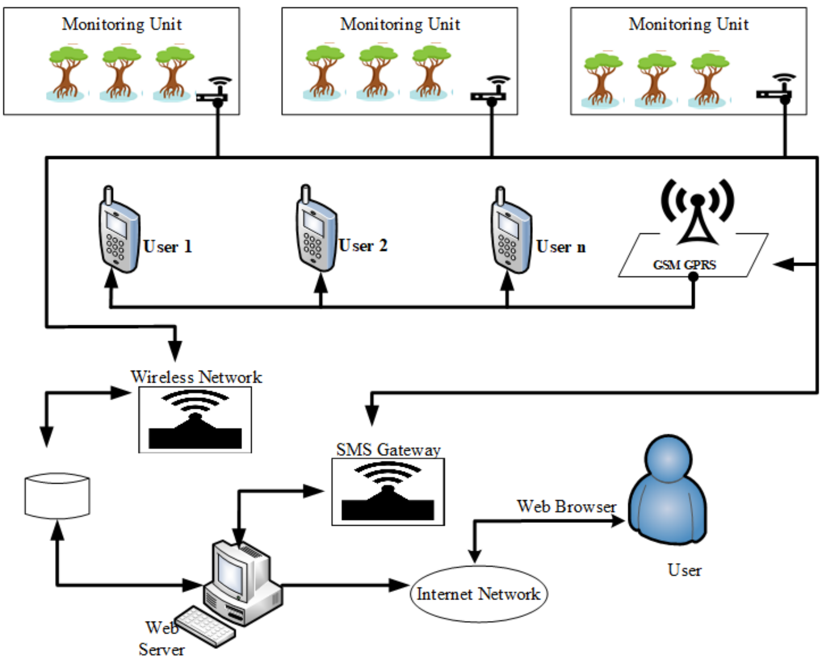

Figure 1. Architecture of the system

3. Results and discussion

In most cases, air pollution is monitored by measuring concentrations of various pollutants such as carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and particulate matter (PM) at fixed sites by using accurate and expensive instrumentation [16-18]. So far, previous research that concerns to the measurement of hazardous gases by designing a monitoring and controlling system of CO_2 gas concentration have been carried out by [26-31]. Traditional approaches for measuring air quality based on fixed measurements are inadequate for personal exposure monitoring. We need the use of small, portable gas-sensing air pollution monitoring technologies employing portable and mobile methods to obtain more spatially and temporally representative air pollution data [32]. In recent years, researchers have investigated a variety of approaches to sensor-based air quality monitoring that focus on the needs, benefits, challenges, and future directions of a sensor-based pollution monitoring paradigm for different applications [20-21].

The proposed system is capable to display online information containing fluctuations in carbon dioxide, oxygen, temperature, and humidity levels. Information from the monitoring unit is transmitted over GSM networks using the GPRS service to the server. Communication between server and monitoring unit using Raw Socket (TCP/UDP) technology. The information stored in the database is displayed on a web page that has been completed with the marker and value of the monitoring results. Web-based applications allow users to access monitoring units located in multiple locations.

The realized system was installed in the real environment located at Muara Opak Mangrove Forest Area located in Baros Hamlet, Tirtohargo, District of Kretek, Bantul Regency for about 30 days. Data from monitoring unit is recorded every 5 minutes and sent to server every hour. During the testing period, no erratic behaviour was observed in the recording and sending of data in the system.

3.1. Communication between monitoring units and server

Communication between monitoring units and web servers using GPRS data services on GSM networks. The modes contained in the GSM hardware module can work simultaneously between GSM for SMS service for text messaging and GPRS service for data communications. Instructions on the GPRS service to enable internet data communications on the SIMCOM Module which is the user sends an "http on" text message to the GSM number on the monitoring unit, as shown in Figure 2.

```
void kirim_HttpOn(char * NomerHp)
{
DisableTimer();
flagtimer=1;
printf("AT+CMGS=\"%s\"\r\n",NomerHp);
if(wait_karakter('>',5000)==1)Buz_key2=1;
putsf("ID Device: ");kirim_data_eemprom(idAlat);putsf("\nStatus Online");putchar(26);
wait_karakter('+',10000);
wait_Oke();
EnableTimer();
}
```

Figure 2. Program script for communication between monitoring unit and web server

Part of program script to enable GPRS service on GSM module are shown in Figure 3.

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```
HTTPINIT:
r=send_USART(commandHTTP[5],"OK",2000);
if(r==0 && ct <3){ct++;goto HTTPINIT;}r=ct=0;

HTTPPARA1:
r=send_USART(commandHTTP[6],"OK",2000);
if(r==0 && ct <3){ct++;goto HTTPPARA1;}r=ct=0;
HTTPPARA2:
printf("AT+HTTPPARA=\"URL\",\"http://monitoringudara.com/data.php?id=%s&co2=%f&o2=-
%f&v=%d&s=%d\"\r\n",id_buf,karbon,oksigen,suhu,lembab);
r=send_USART(NULL,"OK",2000);
if(r==0 && ct <3){ct++;goto HTTPPARA2;} r=ct=0;

HTTPACTION:
r=send_USART(commandHTTP[8],"+HTTPACTION:", 2000);
if(r==0 && ct <3){ct++;goto HTTPACTION;}
if(r==1){
    lcd_clear();lcd_gotoxy(0,1);lcd_puts("Transfer: OK");delay_ms(1000);
    }
if(r==0 && ct ==3){lcd_gotoxy(0,1);lcd_puts("Transfer: ERROR");delay_ms(1000);}r=ct=0;
```

Figure 3. Programme script to activate GPRS service on GSM module

3.2. Display the results of monitoring on the web browser

The data sample obtained from the monitoring unit located at the mangrove plant area shows the concentration of CO_2, O_2, temperature, and humidity during the observation period for 24 hours as shown in Table 1. This measurement aims to determine the level of CO_2 gas pollution during the process of photosynthesis of mangroves plant during the day, as well as changes in CO_2 gas concentrations at night.

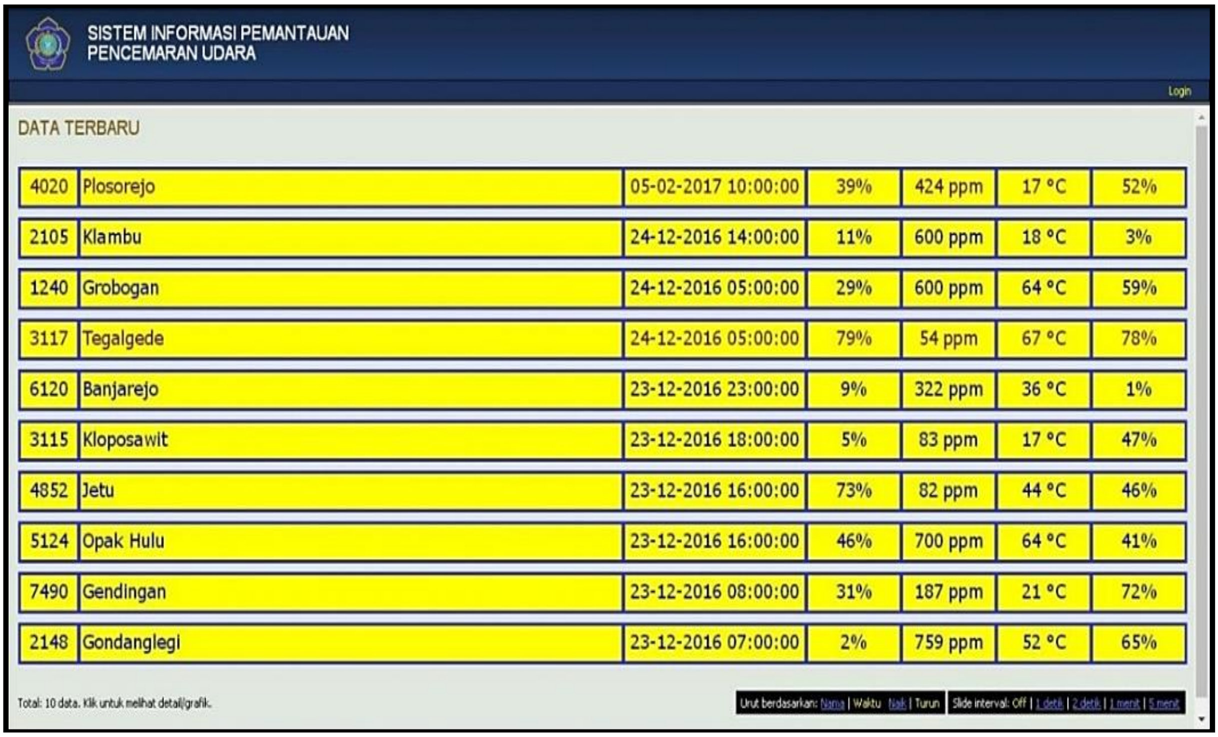
Table 1. Measurement results in the mangrove plant area

No.	Time	CO_2 (m)	O_2 (%)	Temp (^{0}C)	Humidity (%)
1	5:30	280.0	23.8	27.0	85.0
2	5:45	290.0	23.7	28.0	84.5
3	8:00	360.0	22.5	29.7	81.5
4	8:15	366.4	22.4	29.9	81.2
5	10:00	403.0	21.3	31.3	78.7
6	10:15	407.0	21.2	31.5	78.4
7	11:30	420.6	20.4	32.4	76.6
8	11:45	423.4	20.3	32.6	76.3

9	12:00	426.2	20.1	32.8	75.9
10	12:15	429.0	20.0	33.0	75.6
11	13:45	453.8	19.1	34.1	73.5
12	14:00	462.3	18.9	34.3	73.1
13	14:15	469.9	19.1	34.5	72.8
14	17:15	561.1	18.1	36.8	68.6
15	17:30	568.7	18.0	37.0	68.2
16	17:45	576.3	17.9	34.0	67.9
17	18:00	583.9	17.8	35.0	67.5
18	18:15	591.5	17.8	33.0	67.2
19	23:30	751.1	18.2	27.0	68.1
20	23:45	758.7	18.3	28.6	69.3
21	0:00	766.3	18.3	29.0	70.5
22	0:15	773.9	18.4	28.0	71.8
23	2:45	849.9	18.8	25.8	84.0
24	3:00	827.1	18.8	25.6	85.2
25	3:15	834.7	18.7	25.4	86.4

HTTP-POST method is used to exchange the configuration and data between monitoring unit and web-based application. Web-based application functions to receive data from microcontroller via HTTP protocol over the internet network. Communication with the web server that runs web-based application is done by GPRS modem, which is accessible by the standard web browser and display the results to the end user for the analysis. Monitoring data is transmitted using a simple and short package format using GPRS services to minimize packet data transmission time. GPRS transmission rate can be improved to 56Kbps or even 114Kbps, so the connection and transmission become more convenient and easier.

Figure 4 shows the data obtained from the monitoring unit, located at 10 locations. Recorded data consist of location, date and time of data transmission, as well as information on temperature, humidity, and concentrations of CO_2 and O_2. Furthermore, the data is processed and displayed in graphical form as shown in Figure 5 to 8.



4020	Plosorejo	05-02-2017 10:00:00	39%	424 ppm	17 °C	52%
2105	Klambu	24-12-2016 14:00:00	11%	600 ppm	18 °C	3%
1240	Grobogan	24-12-2016 05:00:00	29%	600 ppm	64 °C	59%
3117	Tegalgede	24-12-2016 05:00:00	79%	54 ppm	67 °C	78%
6120	Banjarejo	23-12-2016 23:00:00	9%	322 ppm	36 °C	1%
3115	Kloposawit	23-12-2016 18:00:00	5%	83 ppm	17 °C	47%
4852	Jetu	23-12-2016 16:00:00	73%	82 ppm	44 °C	46%
5124	Opak Hulu	23-12-2016 16:00:00	46%	700 ppm	64 °C	41%
7490	Gendingan	23-12-2016 08:00:00	31%	187 ppm	21 °C	72%
2148	Gondanglegi	23-12-2016 07:00:00	2%	759 ppm	52 °C	65%

Figure 4. Web page displayed of CO2, O2, temperature, and humidity levels

Figure 5 to 8 show a graphical display of data recorded from one of the monitoring unit located at Opak. Figure 5 shows the fluctuations of CO_2 levels at the observation location over a 24-hour period with random time interval, while Figure 6 shows the O_2 concentration. Figure 7 displays the temperature, while Figure 8 displays humidity.

Based on the display in Figure 5 to Figure 8 it can be stated that the monitoring unit placed at the observation location can send data properly to the server. Data are exchanged between monitoring unit and web-based application by using HTTP-POST method. Web-based monitoring application functions to receive data from microcontroller via HTTP protocol over the internet network. The data is then processed and displayed through a web-based application.

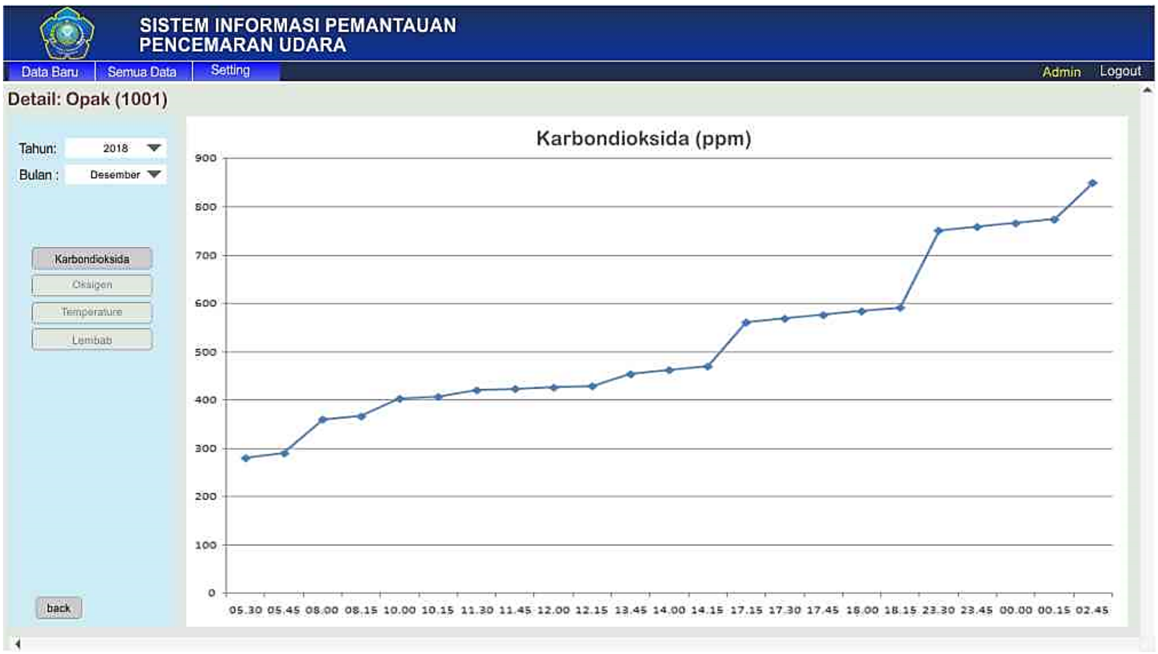


Figure 5. Graphic display of CO2 concentration

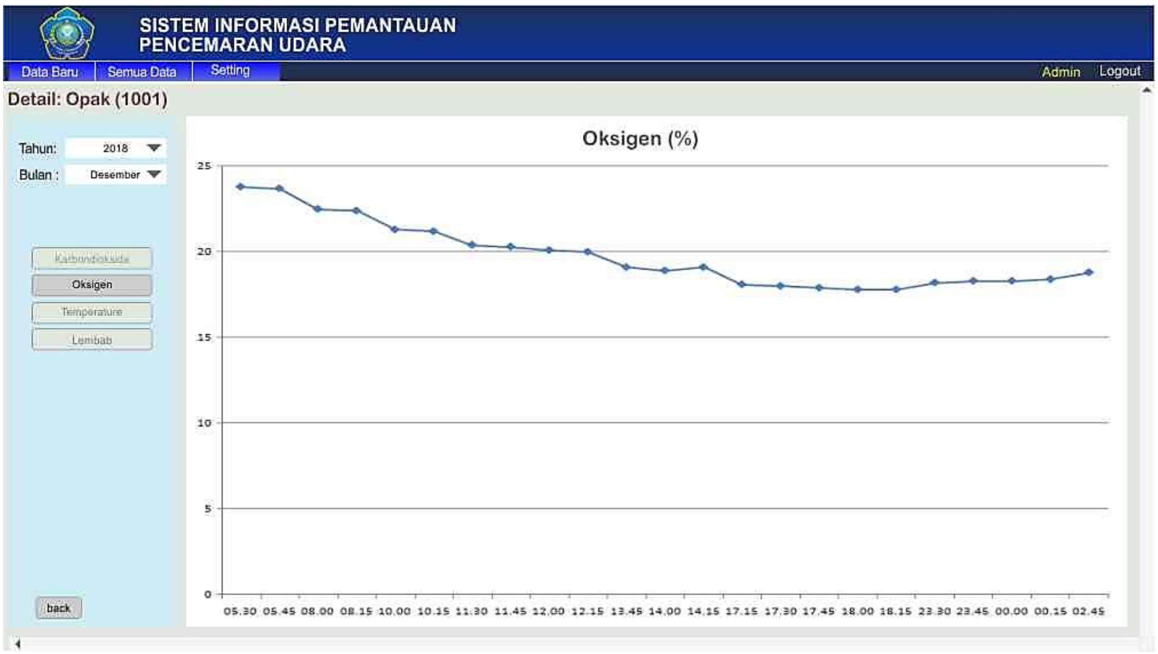


Figure 6. Graphic display of O2 concentration

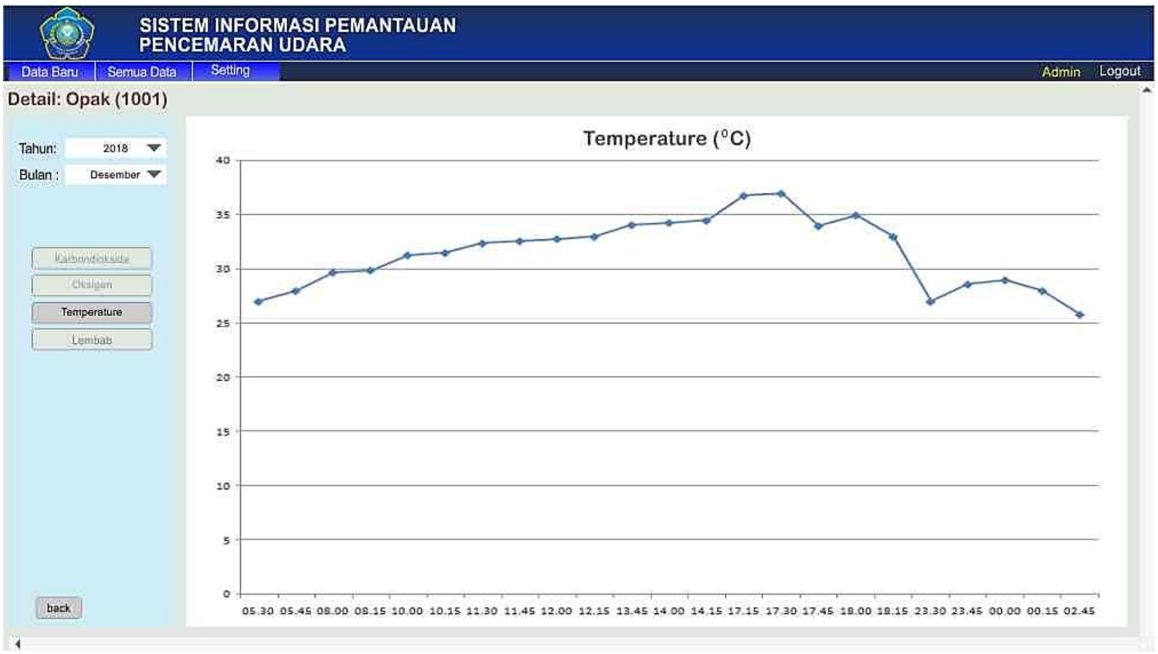


Figure 7. Graphic display of temperature

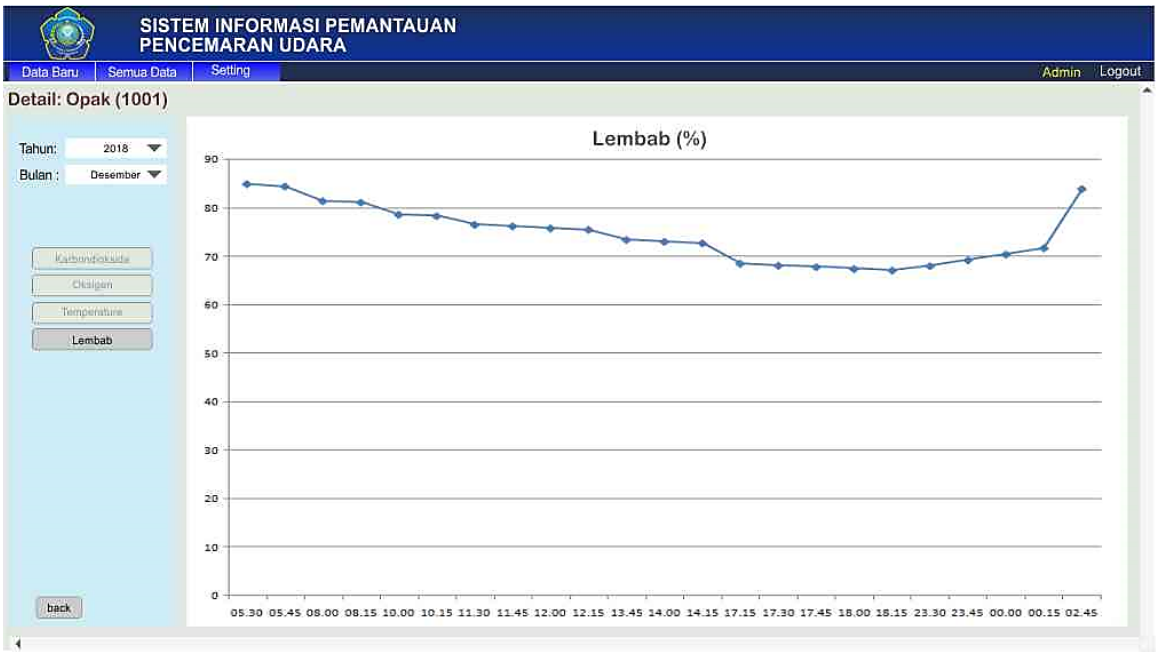


Figure 8. Graphic display of humidity

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4. Conclusion

A low-cost architecture of gas monitoring system based on GPRS communication was described and implemented. The system was installed in the real environment at mangrove plant area during the period of 30 days and we have noticed no erratic behaviour during its exploitation. Based on experiment result, this system can monitor the absorption of CO_2 emissions and the formation of O_2 gas in mangrove plants as one of the efforts to reduce the impact of global warming. The information can be transmitted using SMS service on GSM network in less packet size and data transmission time, and also can be accessed through web-based application. As conclusion, the use of small, portable gas-sensing air pollution monitoring technologies employing portable and mobile methods can obtain more spatially and temporally representative air pollution data. In future, the advancement of the system can be improved to provide accurate information about the spatial distribution of pollutants or identify pollution hotspots.

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References

[1] Ramanathan V and Feng Y 2009 Air pollution, greenhouse gases and climate change: global and regional perspectives *Atmos Environ* **43** 37–50
[2] Menz FC and Seip H M 2004 Acid rain in Europe and the United States: an update *Environ Sci Pol* **7** 253–65
[3] Xu P Chen Y and Ye X 2013 Haze, air pollution, and health in China *Lancet* **382** 2067
[4] Solomon S 1999 Stratospheric ozone depletion: a review of concepts and history *Rev Geophys* **37** 275–316
[5] Solomon S Garcia R R Rowland F S Wuebbles D J 1986 On the depletion of Antarctic ozone J. *Nature* **321** 755–58
[6] Avnery S Mauzerall D L Liu J and Horowitz LW 2011 Global crop yield reductions due to surface ozone exposure: 2. Year 2030 potential crop production losses and economic damage under two scenarios of O_3 pollution *Atmos Environ* **45** 2297–309
[7] Van Dingenen R Dentener F J Raes F Krol M C Emberson L and Cofala J 2009 The global impact of ozone on agricultural crop yields under current and future air quality legislation *J. Atmos Environ* **43** 604–18
[8] Fenger J 2009 Air pollution in the last 50 years–from local to global *J. Atmos Environ* **43** 13–22
[9] Kumar P Morawska L Birmili W Paasonen P Hu M Kulmala M Harrison R M Norford L and Britter R 2014 Ultrafine particles in cities *Environ Int* **66** 1–10
[10] Mouzourides P Kumar P and Neophytou M K A 2015 Assessment of long-term measurements of particulate matter and gaseous pollutants in South-East Mediterranean *Atmos Environ* **107** 148–165
[11] Hidayati R 2012 Masalah Perubahan Iklim di Indonesia Beberapa Contoh Kasus *Makalah Falsafah Sains*
[12] Sharma P Jain S and Kumar P 2013 An integrated statistical aroach for evaluating the exceedence of criteria pollutants in the ambient air of megacity Delhi *Atmos Environ* **70** 7-17

[13] Holmes N S and Morawska L 2006 A review of dispersion modelling and its application to the dispersion of particles: An overview of different dispersion models available.
[14] Sudarsono M A Novianta and Purnawan 2018 Development of SMS Gateway Information System for Detecting Air Quality *IOP Conf. Series: Materials Science and Engineering* **434** 1 1–6
[15] Sudarsono M A Novianta and Purnawan 2018 Performance of AVR Microcontroller-SMS Gateway for Detecting SO2 and NO2 *The 3rd Intl. Conf. of Energy, Environmental and Information System* **73** 1–5
[16] Kumar P, Ketzel M,Vardoulakis S, Pirjola L and Britter R 2011 Dynamics and dispersion modelling of nanoparticles from road traffic in the urban atmospheric environment: A review *J. Aerosol Science* **42** 580–603
[17] Castell N Viana M Minguillón M C Guerreiro C and Querol X 2013 Real-world alication of new sensor technologies for air quality monitoring *ETC/ACM Technical Paper*
[18] Snyder E G, Watkins T H, Solomon P A, Thomas E D, Williams R W, Hagler G S, Shelow D, Hindin D A, Kilaru V J and Preuss P W 2013 The changing paradigm of air pollution monitoring *Environ Sci Technol* **47** 11369–77
[19] White R M, Paprotny I, Doering F, Cascio W E, Solomon P A and Gundel L A 2012 Sensors for community-based atmospheric monitoring *EM: Air and Waste Management Association's Magazine for Environmental Managers* **5** 36–40
[20] Murota K and Hirade K 2001 GMSK Modulation for Digital Mobile Radio Telephony, *IEEE Transactions on Communications*-**29** 7 1044-50.
[21] Mladen K, Zeljko I, and Branko D 2012 GPRS-Based Electrical Energy Monitoring System *Symp. Ind. Elec.* 282-284
[22] Raul I, Gabriel V and Septimiu M 2012 GPRS Based Data Acquisition and Analysis System with Mobile Phone Control *Measurement* **45** 6 1462-70
[23] Susilo Y S, Pranjoto H and Gunadhi A 2014 Sistem Pelacakan Dan Pengamanan Kendaraan Berbasis GPS Menggunakan Komunikasi GPRS *Jurnal Ilmiah Widya Teknik* **13** 1
[24] Zhang H 2012 A self-adaptive greenhouse CO_2 concentration monitoring system based on ZigBee, cloud computing and intelligent systems (CCIS), *IEEE:The 2nd Intl. Conf.* 1137–40
[25] Gour P 2014 Application of fuel cell in power plant to reduce the carbon-dioxide emission *Intl. J. of Core Engineering & Management* **1** 5
[26] Løkke M M, Seefeldt H F, Edwards G and Green O 2011 Novel wireless sensor system for monitoring oxygen, temperature and respiration rate of horticultural crops post-harvest *Sensors* **11** 845-864
[27] Hagler G S, W Solomon P A and Hunt S W 2013 New Technology for Low-cost, Real-time Air Monitoring *EM Magazine Air & Waste Management Association*
[28] Kumar P, Morawska L, Martani C, Biskos G, Neophytou M, Di Sabatino S, Bell M, Norford L and Britter R 2015 The rise of low-cost sensing for managing air pollution in cities. *Environ Int* **75** 199–205
[29] White R M, Paprotny I, Doering F, Cascio W E, Solomon P A and Gundel L A 2012 Sensors for community-based atmospheric monitoring. *EM: Air and Waste Management Association's Magazine for Environmental Managers* **5** 36–40