SNSP 2019

Nov. 19th-22nd, 2019
Hualien, Taiwan

The 2nd International Conference on
Sensor Networks and Signal Processing (SNSP 2019)

National Dong Hwa University

★ Welcome to SNSP 2019!

The 2nd International Conference on Sensor Networks and Signal Processing (SNSP 2019) will be held in Taiwan on November 19th-22nd, 2019. SNSP 2019 is co-organized by National Dong Hwa University, which is committed to providing forum for academic experts and participants to exchange their experiences and share research results about all aspects of Sensor Networks and Signal Processing, and discuss the encountered practical challenges and the adopted solutions. The plenary session of SNSP 2019 will include Keynote Speeches, Invited Speeches, Poster Presentations and Oral Presentations.

Hualien, located on the east coast of Taiwan on the Pacific Ocean, is the largest county by area, yet due to its mountainous terrain, has one of the lowest populations in the county. Hualien is famous for its natural environment, Taroko Gorge, which includes Qingshui Cliff, and Qixingtan Beach. Besides, Hualien retains a rich indigenous culture of Taiwan, which is also the reason why it attracts so many tourists every year.

The meeting time countdown

0 days

Important Dates

Last Round Submission
Submission Deadline: October 8th, 2019

Author Login

Invited Speaker---Assoc. Prof. Evizal Abdul Kadir

Islamic University of Riau, Indonesia

Evizal Abdul Kadir received his Master of Engineering and PhD in Wireless Communication at Faculty of Electrical Engineering, Universiti Teknologi Malaysia in 2008 and 2014 respectively. He is currently as Lecturer and Researcher in Islamic University of Riau (UIR) Indonesia as well as Director of research institute and community services and get promoted to Associate Professor. He has experience and worked in several companies that provide system solution in Wireless Communication and Radio Frequency (RF) as well as Radio Frequency Identification (RFID), currently is continuing his research activities related to the Wireless Communication System, Antenna, Remote Sensing, Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), Wireless and Mobile Monitoring System and IoT.

Speech Title: Remote River Water Pollution Monitoring Use Multiple Sensor System of WSNs and IoT

Abstract: The river is a natural phenomenon that commonly available in the tropical region because of rain intensity. Many peoples and community like to live along the riverside for a few decades ago. The river plays a significant role by the community for transportation and daily activities uses river water. In this research, the objective is to design and develop a new system with multiple sensor system to monitor river water pollution because most of the community use river water in daily activities. Wireless Sensor Networks (WSNs) applied in this design and development because of advantages WSNs system, multiple sensor nodes installed for detection of water pollution such as water temperature, pH, electrical conductivity (EC) and dissolved oxygen (DO). The system designed to be able to monitor river water pollution parameters and send the information to the data center (backend system). Arduino microcontroller used to process and filtering the data before sending to the backend system, only valid and valuable information to collect and keep in the database. Results show system be able to detect polluted water with indicating parameters and shows in a graph. Based on analysis can be concluded that polluted water indicator mostly from residence waste and industry. Furthermore, WSNs sensors will deploy in some area then compare the results each other.

Keywords: Multiple sensor, WSNs, River water, Pollution, Monitoring

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Part Ⅰ Conference Schedule

TUESDAY, NOVEMBER 19, 2019 ***Lobby, DongHwa House, NDHU[1]***	
09:00-17:30	Conference Registration
Note: The Registration desk will be moved to the *3F, Science and Engineering Building 2, NDHU* on November 20 and 21, 2019.	

WEDNESDAY MORNING, NOVEMBER 20, 2019 ***C303, Science and Engineering Building 2, NDHU***	
09:00-09:10	WELCOME SPEECH *Speaker: Prof. Han-Chieh Chao*
09:10-09:50	**Keynote Speech 1:** SGO (Social Group Optimization): A New Evolutionary Optimization Techniques and Its Applications in Sensor Networks *Prof. Suresh Chandra Satapathy, School of Computer Engineering, KIIT, India*
09:50-10:30	**Keynote Speech 2:** Short-time Continuous Wavelet Transform of the Response of Time-varying Systems *Dr. Huang Yen-Nun, Distinguished Research Fellow, Research Center for Information Technology Innovation, Taiwan*
10:30-10:40	GROUP PHOTOGRAPH
10:40-11:00	COFFEE BREAK
11:00-11:40	**Keynote Speech 3:** U-Sensors Based Dynamic Model in Wireless Body Area Network *Prof (Dr.) V.R.Singh, Life Fellow-IEEE, National Physical Laboratory, India*
11:40-12:10	POSTER PRESENTATIONS

[1] NDHU (Shoufeng Campus of National Dong Hwa University)

WEDNESDAY AFTERNOON, NOVEMBER 20, 2019

12:10-13:00	BUFFET LUNCH *Lakeside Restaurant, NDHU*
14:00-16:55	**Oral Session 1: Sensor Networks and IoT** *C303, Science and Engineering Building 2, NDHU*
18:30-19:30	BUFFET DINNER *Lakeside Restaurant, NDHU*

THURSDAY, NOVEMBER 21, 2019

09:00-11:40	**Oral Session 2: Signal Processing** *C303, Science and Engineering Building 2, NDHU*
12:00-13:00	BUFFET LUNCH *Lakeside Restaurant, NDHU*
14:00-16:30	**Oral Session 3: Data Processing and Applications** *C303, Science and Engineering Building 2, NDHU*
18:15	Gathering and taking bus to The Promisedland Resort *Gate of Science and Engineering Building 2, NDHU*
18:30-19:00	CLOSING SPEECH & PRIZE AWARDING *Andalusia Ballroom, The Promisedland Resort*
19:00-20:30	AWARDING BANQUET *Andalusia Ballroom, The Promisedland Resort*

THURSDAY, NOVEMBER 22, 2019

08:55-09:00	Gathering and Depart from Donghwa House
09:00-17:00	FIELD VISIT IN HUALIEN

Part II Keynote Speeches

Keynote Speech 1: SGO (Social Group Optimization): A New Evolutionary Optimization Techniques and Its Applications in Sensor Networks

Speaker: Prof. Suresh Chandra Satapathy, School of Computer Engineering, Kalinga Institute of Industrial Technology(KIIT), India

Bio: Suresh Chandra Satapathy is a Ph. D in Computer Science Engineering, currently working as Professor of School of Computer Engineering at KIIT (Deemed to be University), Bhubaneshwar, Odisha, India. He held the position of the National Chairman (Educational and Research) of Computer Society of India and is also a senior Member of IEEE. He has been instrumental in organizing more than 30 International Conferences in India as Organizing Chair and edited more than 40 Book Volumes from Springer LNCS, AISC, LNEE and SIST Series as Corresponding Editor. He is quite active in research in the areas of Swarm Intelligence, Machine Learning, Data Mining. He has developed two new optimization algorithms known as Social Group Optimization (SGO) published in Springer Journal and SELO (Social Evolution and Learning Algorithm) published in Elsevier. He has delivered number of Keynote addresses and Tutorials in his areas of expertise in various events in India and abroad. He has more than 120 publications in reputed journals and conf proceedings. Dr. Suresh is in Editorial board of IGI Global, Inderscience, Growing Science journals and also Guest Editor for Arabian Journal of Science and Engg published by Springer. He is the Editor-in-Chief of IJIDSS from Inderscience and Associate Editor of KES Journal from IOS press.

Abstract of the speech: Nature provides some of the efficient ways to solve problems. Nature inspired algorithms imitating processes in nature/inspired from nature for solving complex optimization problems. In this talk the use of recently developed new efficient optimization algorithm Social Group Optimization (SGO) which is inspired by the social behavior of human for solving complex problems would be discussed. To judge the effectiveness of SGO, extensive experiments have been conducted on number of different unconstrained benchmark functions and performance comparisons are made with recently proposed state-of-art optimization techniques as well as 30 standard numerical benchmark functions taken from ICSI 2014 Competition on Single Objective Optimization and compared with the performance of six selected algorithms of that competition. In the later part of the talk, a case study of application of SGO to Sensor Networks would be delivered.

Keynote Speech 2: Short-time Continuous Wavelet Transform of the Response of Time-varying Systems

Speaker: Dr. Huang Yen-Nun, Distinguished Research Fellow, Research Center for Information Technology Innovation, Taiwan

Bio: Dr. Huang received his PhD in Computer Science from University of Maryland. He Joined AT&T Bell Labs in 1989. His work on Software Implemented Fault Tolerance (SwiFT) tools was applied to tens of telecommunication systems in AT&T and was named one of the ten major technology breakthroughs in Bell Laboratories in 1992. Because of the SwiFT work, Dr. Huang was a recipient of Lucent Commemorating Stock Certificate and Computerworld Smithsonian Award in 1998 on the SwiFT technology. He became a Distinguished Member of Technical Staff of Bell Labs in 1996. He started the Dependable Computing Research Department in AT&T in 1999 and was the department head of the organization to ensure the high dependability of all AT&T services. Dr. Huang became the VP of Engineering of PreCache Inc, a Sony subsidiary, in 2001 to create a multi-media content delivery platform. In late 2004, Dr. Huang returned to AT&T and became the Executive Director of Dependable Distributed Computing and Communication Research Department to lead AT&T Digital Content Management and IPTV research programs. In 2007, Dr. Huang became the Executive Vice President of Institute for Information Industry, a government funded R&D organization with more than 1800 employees. From 2008 to 2011, Dr. Huang was the President of VeeTIME Co. to build quadruple-play telecom services including cable TV, FTTx, NGN and 4G Wimax using an all-IP network in central and south Taiwan. With his leadership in R&D and in management, VeeTIME service availability was improved from 95% to 99.96% in a year. Dr. Huang has more than 20 US patents awarded, and more than 100 papers published in well-known journals and conferences. His patents have generated millions of US dollars license income for AT&T and Lucent and created two telecom products. His 1995 Software rejuvenation paper initiated software fault avoidance and prevention research area. Dr. Huang was the Deputy Executive Secretary of Science and Technology Advisory Group of Executive Yuan, helping Premier of Executive Yuan in Taiwan on the Information and Communication Technology (ICT) development policy and funding allocation between 2010 and 2015. Dr. Huang was elected as a 2012 IEEE Fellow. His research areas include Dependable Computing, security and privacy, fault tolerance, innovative multimedia services, mobile communication, IoT.

Abstract of the speech: This study provides the first report on the formulation of short-time continuous wavelet transform and its signal reconstruction. This new development is motivated by the needs for adjustable frequency resolution over time in analyzing time-varying systems. An analytical signal with time-dependent frequency components is first used to characterize the behavior of the new transform in terms of time and frequency resolution distribution in time-frequency domain. The dynamic responses of time-varying systems such as a softening Duffing oscillator are next used as an example to demonstrate the effectiveness of the proposed transform and reconstruction. Finally, the developed short-time continuous wavelet transform is applied to develop an adaptive wavelet transform and identify the characteristic frequencies of reinforced concrete slabs with embedded delamination defects from impact-echo testing. The proposed new transform can detect and locate the embedded defects more accurately than the conventional continuous wavelet transform. In engineering applications, synchro-squeezed adaptive wavelet transform gives even more accurate results than the conventional adaptive wavelet.

Keynote Speech 3: U-sensors Based Dynamic Model in Wireless Body Area Network

Speaker: Prof (Dr.) V.R.Singh, Life Fellow-IEEE, National Physical Laboratory, India

Bio: Prof. (Dr) V.R.Singh, Ph.D. (Electrical Engg), IIT-Delhi and Life Fellow-IEEE and LF-IETE, LF-IE-I, LF-ASI/USI and LF-IFUMB/WFUMB, has over 37 years of research-cum-teaching experience in India and abroad (Univ of Toronto-Canada, KU Leuven- Belgium, Korea Univ, South Korea, TU-Delft, Netherlands, Univ of Surrey, UK, and others). He has been at National Physical Laboratory (NPL), New Delhi, as a Director-grade-Scientist/Head of Instrumentation, Sensors & Biomedical Measurements and Standards, as well as lately Distinguished Professor. He has over 350 papers, 250 talks, 260 conf papers, 4 books, 14 patents and 30 consultancies to his credit. Under his guidance, 35 PhD scholars have earned PhD degree while others are working with him. He is the Mentor/Advisor of PDM University. Dr. Singh has been the Associate Editor of IEEE Int Sensor Journal (2010-2016), and is Associate Editor of IEEE Transactions on Instrumentation and Measurements and Regional Editor of Int Journal of Biomedical Engineering and Technology (IJBET). Apart from this, he is on Editorial/Reviwer Boards of other journals. like Sensors & Actuators (Switzerland), IEEE Trans on Engg in Med and Biology, J Computers in Electrical Engg (USA), J.Instn Electr Telecom Engrs, J.Instn Engrs -India, Ind J Pure & Appl Physics, J.of Instrm Soc Ind, J. Pure & Appl Ultrasonics, J. Life Science Engg, etc. He is the recipient of awards by INSA (Ind Natnl Sci Academy)1974, NPL 1973, Thapar Trust 1983, ICMR (Ind Council of Med Res) 1984; Japan Soc. Ultr in Medicine 1985, Asian Federation of Societies of Ultasound in Medicine & Biology 1987, IE-I(Institution of Engineers- India) 1988/1991, IEEE-EMBS 1999 and IEEE-2010/2011/2014, Sir CV Raman Award by Acoustical Society of India /2018, for his outstanding contributions. Presently, he is IEEE-EMBS-DL (Distinguished Lecturer), IEEE-NanoTechnology Council-DL and INSA-DL. He has served as Guest Editor of Special Issues of JASI on Physical Acoustics and Utrasonics (2016-17) and Medical Acoustics (2017-18) as well as on IETE Technical Review journal on Transducers (2002). He is the Chair of IEEE-EMBS/IMS-Delhi Chapter, President of Acoustical Society of India and Vice President of Ultrasonic Society of India and has been theVice President of Instrumentation Soc of India, Vice-President of IFSUMB, Secretary of IEEE India Council and the Chairman of IEEE-Delhi Section. Dr. Singh is a Member of IEEE Standards Association. He was also Council Member of WFUMB (Australia) Ultrasound Safety and Standards. He has served as the Chair or a Member of BIS Committee on Elctro-Medical Committee in the past and presently, he is the Chairman of BIS-MHD-15 Committee. He has been the session chair,plenary/keynote/ invited speaker and on advisory boards of world congresses and nationa/international conferences, world over. He has been the Conf Organiser of WESPAC-2018, Nov 10 to 15, New Delhi. His main areas of interest are biomedical instrumentation, biomedical standards, computer modeling and simulation, sensors and transducers, biomedical ultrasonics/medical acoustics, POCT devices, neuro-sensors/implants, nano-cancer-technology, cancer hyperthermia, tissue characterisation, lithotripsy, WSN and u-health care engineering.

Abstract of the speech: As is aware, the main resource constraint in the wireless body area network is the energy. The energy consumption may be reduced by maintaining the state of a sensor. Generally, the senor node consumes less energy in the sleep state as compared to the active state. This paper develops a dynamic model by using ubiquitous sensors to select the state of the sensor node using the mutual information within the nodes. U-sensors based dynamic model is developed for effective use in wireless body area network to change the state of the sensor node. This model can use different routing mechanisms for comparative study. The simulation results are given for better performance than that of the current MAC. The work is applied in health care applications.

Nature of the Award

- This award consists of free registration to the next conference and a certificate;
- The awards will be given during the Awarding Banquet November 21.

Oral Session_1: Sensor Networks and IoT

Session Chair: Assoc. Prof. Evizal Abdul Kadir, Islamic University of Riau, Indonesia

Time: 14:00-16:55, Wednesday Afternoon, November 20
Location: C303, Science and Engineering Building 2, NDHU

14:00-14:30	SNSP1204 *(Invited Talk)*	Automatic Irrigation System Based on Soil Moisture Detection Using IoT *Assoc. Prof. Shashi Mehrotra, Department of Computer Science and Engineering, KL University, India*
14:30-15:00	SNSP1205 *(Invited Talk)*	Battery-less Device Operation and Wireless Power Transfer for Sensor Networks and IoT *Prof. Yasushi Takemura, Yokohama National University, Japan*
15:00-15:30	SNSP1248 *(Invited Talk)*	Remote River Water Pollution Monitoring Use Multiple Sensor System of WSNs and IoT *Assoc. Prof. Evizal Abdul Kadir, Islamic University of Riau, Indonesia*
15:15-15:45	**COFFEE BREAK**	
15:45-16:15	SNSP1256 *(Invited Talk)*	Recent Advances in Fiber-optic-based Structural Health Monitoring (SHM) *Prof. Moshe Tur, Tel-Aviv University, Israel*
16:15-16:35	SNSP1196	Acetone and IPA Bio-sniffers in Breath Analysis for Early Screening of Diabetes *Dr. Po-Jen Chien, Tokyo Medical and Dental University, Japan*
16:35-16:55	SNSP1224	Use Accelerometer to Monitoring the Exercise Status: Held the Push-ups Movement as an Example *Dr. Yi-yang Chen, National Taiwan Normal University, Taiwan*

Remote Monitoring of River Water Pollution Using Multiple Sensor System of WSNs and IoT

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Abstract — Rivers are commonly found in the tropical regions because of high rain intensity. Many people and communities like to live along the riverside since decades ago. Rivers play significant role in communities for transportation and daily activities. This research was aimed to design and develop a system with multiple sensors to monitor river water pollution because most of the community members use river water in their daily activities. In this design and development of system, Wireless Sensor Networks (WSNs) was applied because of the many advantages that can enjoyed. Multiple sensor nodes were installed for the detection of water pollution parameters such as temperature, Electrical Conductivity (EC), water pH, and Dissolved Oxygen (DO). The system was designed to monitor river water pollution parameters and send the information to the data center (backend system). Arduino microcontroller was used to process and filter the data before sending to the backend system. Only valuable information was collected and kept in the database. Results show that the system was able to detect polluted water by showing the parameters of interest in a graph. Based on the analysis, it can be concluded that polluted water indicators were mostly contributed from residence waste and industries. Furthermore, WSNs sensors will be deployed in some areas, the results will be compared to each other. Furthermore, the Internet of Things (IoT) technology will be used for data sharing and communication.

Keywords—Multiple sensor, WSNs, River water, Pollution, Monitoring

I. Introduction

Water pollution is one of the issues that has been raised in some of the areas in Indonesia. This research focussed on Siak River located in Riau Province because of the issue of river pollution since a few years and until now no significant solution by the respective authorities had been taken. Riau province is located in central Sumatera Island in Indonesia. This province has 5 long and deep rivers, one of the rivers is the deepest in Indonesia. Along the Siak rivers, many companies are operating, the big company being pulp and paper beside other small companies. Sometimes the companies emit pollution to the river, this contaminates the river. Contamination of the river water may be contributed by various sources such as industrial waste, chemical spill, community and residence waste. Flooding and others disaster might also to pollution of the river. This research aims to introduce a monitoring system with incorporates 4 basic sensing system which include temperature, dissolved oxygen (DO), water pH, and electrical conductivity.

The conventional techniques to measure the quality of water using several methods had been ~~as~~ discussed [1-4]. The methods collect river water and information regarding the the water quality were conducted in the laboratory including biological, chemical and physical parameters of the water. It is time consuming and expensive to get full information along the river as many samples need to be sampled. Real-time water quality monitoring system using WSNs are popular in recent year because of the advantages of technology to collect data and information through the sensor node. The requirement for continuous data monitoring for water quality in a real-time system to establish trend and predict behavior from the history are discussed in [5-9].

A biological sensing system for detection water quality is a method to detect bacteria using a computer vision system in analysis, and chemical analysis of the pollutant is discussed [10-12]. The use of multi-sensors for the water pollutant detection system for the basic parameters are not limited to a few parameters. The use of locals for the collection of the data to support the monitoring system that has limited access are elaborated [13-16]. Image processing contributed to the remote sensor in analyzing and monitoring with long-distance of water quality. In the previous research, the maximum distance was 10 meters for the image analysis [17, 18]. In deep waters or river, the use of robotic system for water quality detection has several advantages. Another scenario is in the ocean where mobile communication can assist in the detection of water quality. In others research conducted uses the method for polluted water detection but ineffective way to the permanent solution system, furthermore the case of the area as discussed [19-22].

In this research, multiple sensors are proposed to study water quality or polluted water. Multiple sensors are able to achieve better analysis of the samples compared to the detection using a single sensor. The basic parameters proposed are temperature, water pH, electrical conductivity and DO. Output gained from this approach will contribute to valuable knowledge for the monitoring of water quality in rivers. The transfer of data between WSNs nodes to a node sink for smooth data communication is also a part of the objective in this work. Siak River, being one of the longest and deepest rivers in Riau Province, Indonesia was chosen for the studies.

II. Multiple Sensor System of WSNs

The proposed design multiple sensor systems for water quality monitoring using WSNs was based on a case study at Siak river in Riau Province Indonesia. The river is very long (more than 200 km). Most of the community and rural residents live along the riverside and do their daily activities using river water. A preliminary survey on the river and geographical information was used to design the sensing system for the detection of pollutants in the river. Figure 1 shows the geographical location of Siak river in Riau Province, Indonesia. The river water was polluted from housing wastes as well as unhealthy community practices. Furthermore, in the rainy season the situation become worst because of the flooding and all the rubbish and wastes find their way into the river through the canals.

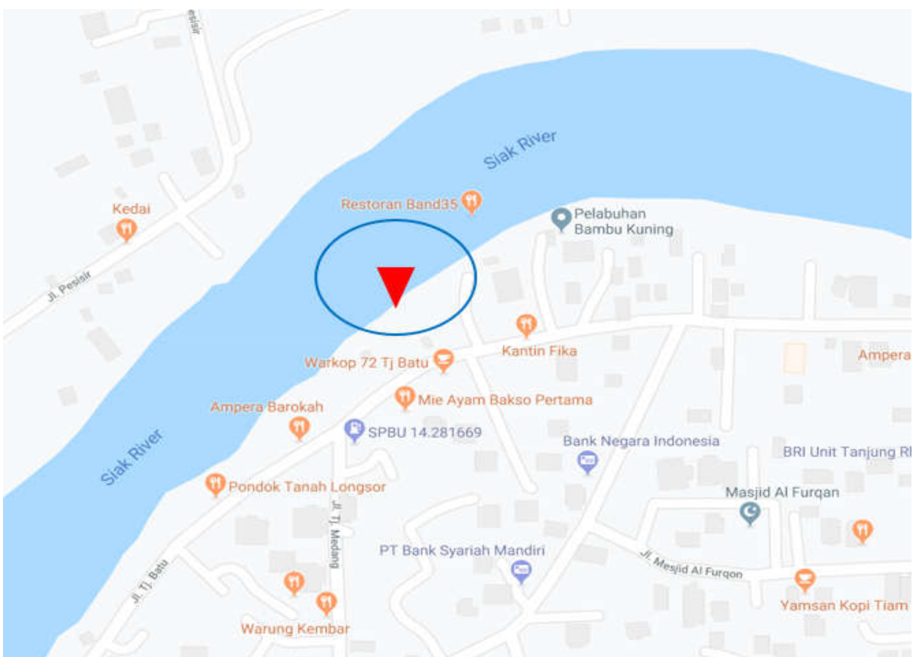

Fig. 1. Geographical location of Siak river and the testing location

Based on an early survey, the river is highly polluted because the river is not only used for the residents living along the riverside but also for transportation where many vessels and wooden ship ply through the river carrying various material including people using high-speed boats. Furthermore, many companies operate along the river because of easy transportation and water supply. Some of the companies spilled chemical wastes and other materials into the river. In figure 2 shows a scene of the polluted river water as indicated by the colored water sensors are required for the detection of water contaminant in the river. This information will be used to decide the type of sensors that need to installed to the system for detection such as temperature, DO, pH and electrical conductivity as well as other parameters for the future.

Fig. 2. Actual scene of Siak river in Riau, Indonesia

Multiple sensors system was designed to incorporate four parameters for the establishment of river water pollutant index, results for all the sensors provide information how pollutant the water was. A complete block diagram of WSNs system is shown in figure 3. The Arduino Uno was used as sensor signal conditioning as well has ability to serve analog and digital input with internal Analog to Digital Converter (ADC), Raspberry Pi3 for Microcontroller Unit (MCU) as data processing and Radio Frequency (RF) transceiver was Texas Instrument module CC1310 for RF communication among the sensor nodes. In the last step of the system block diagram, an antenna was used to transmit the signal and information to the other sensor node and send the information to the data center.

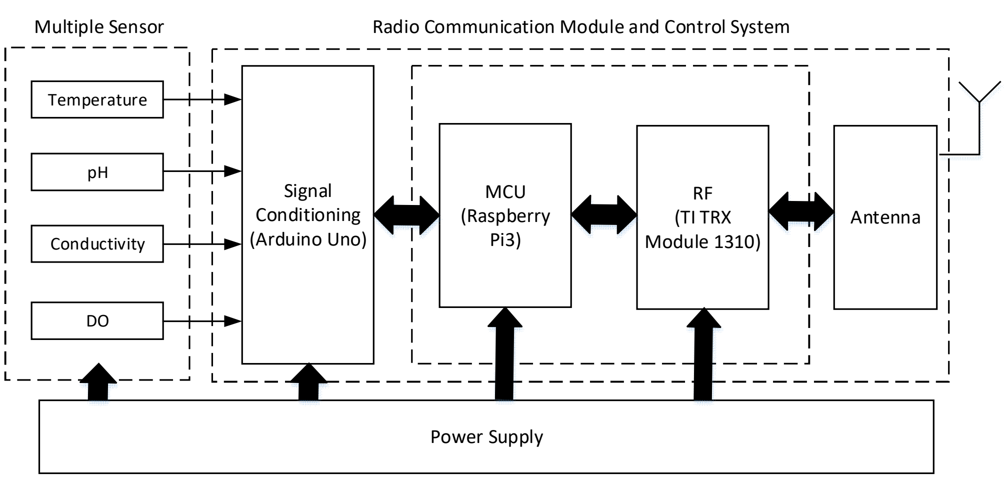

Fig. 3. Block diagram of multiple sensor system

The complete expected indicator of measurement and range of the results in the unit as well as the accuracy is shown in table 1.

Table 1. Design Specification of the multiple sensor system

Parameter	Range	Accuracy	Method
pH	0 to 14	± 0.1	Glass Electrode
Temperature	0 to 16 ° C	± 0.5 ° C	Thermistor
DO	0 to 20 mg/L	± 0.5 mg/L	Polarography
Electrical Conductivity	0 to 50	± 0.5	Conductivity Measurement

III. System Design for Polluted Water Detection

In the proposed design of the multiple sensing systems for polluted water using four parameters as mentioned earlier, every sensor contributed to the collection of data and perform the analyses in the system. To detect common polluted water in real time, the sensing system must be deployed to the river. Solar system is required to supply power to the system because of its remote location with no electricity available. In this case, a set of solar panel with backup battery was provided based on the capacity of sensing system that have been tested. In the monitoring of polluted river water, there are several external factors that need consideration such as environmental, whether, temperature, etc. Based on the earlier testing, some parameters increase abnormal with exponential curve. This is because some of the sensing surface was covered by foreign materials that registers high signal but fortunately this takes place for short time.

Design of multiple sensors use several modes of sensing and one of it is temperature sensor which contributed to thermistor with non-linear parameter between temperature and internal resistance. The range of temperature sensor was from 0°C to 40°C. The scale of temperature was selected based on early measurement and average temperature of Siak river water as well as environmental conditions in Pekanbaru city in Riau Province. In common use, the thermistor is valid for high temperature which is more than 300°C, thus low range of temperature is better in detection to avoid the nonlinearity. The resistance of sensor can be scaled using general formula as invented in Steinhart-Hart thermistor third order approximation and can be written as in equation (1) [2]:

$$\frac{1}{T} = \mathrm{A} + \mathrm{B} \,.\ln(R) + C \,.\, (\ln(R))^3 \qquad (1)$$

where T indicate the temperature of water detected in degree kelvin and R is the measured resistance in Ohm. The parameters *A, B,* and *C* are standard constants that were obtained from the manufacturer. These parameters determine the accuracy reading of the sensor. When the sensor was powered voltage was induced across the thermistor at the fed point and go into the operational amplifier to gain and fine-tune the off-set signal. Value of voltage output from the sensor is in analog which must be converted to digital to match with the WSNs system which used Arduino microcontroller. The value of thermistor internal resistance is very much dependent on manufacturer. The resistance for room temperature (for example 25°C) with 20k ohm then the characteristics can be written as in equation (2):

$$R_T = |R_0 \,.\, e^{\beta.\,\frac{1}{T} - \frac{1}{T_0}} \tag{2}$$

where *RT* is the resistance of the thermistor at *T* and the temperature is in Kelvin. The value of T_0 is 298.15°K (or 25°C) and the value of beta based on manufacturer's datasheet and specification. Equation 3 was used to calculate the temperature based on manufacturer datasheet as a comparison to the actual value detected during testing. The results of temperature based on the analysis using equation (3) are required for the calibration of the temperature as detected by the sensor.

$$T = \frac{\beta}{\ln \frac{R}{r_\infty}} \tag{3}$$

where:

$$r_\infty = R_0 \,.\, e^{-\beta/T_0} \tag{4}$$

The flow of process in the system is started with establishment of connection from WSNs node to sink in order to conform all the nodes connected. Water sensors may in sleep mode to save the power then to achieve sensor data have to on the sensor (wake up) follow by reading all the sensor data. All the data obtain send to sensor node sink as gate way to monitoring system, in the gate way has memory to record all the data before sending to backend system (server), in the screen monitored data shows while abnormal data occur will send an alert to respective department or authority. Figure 4 shows the flowchart of the process in the sensing system for water pollution.

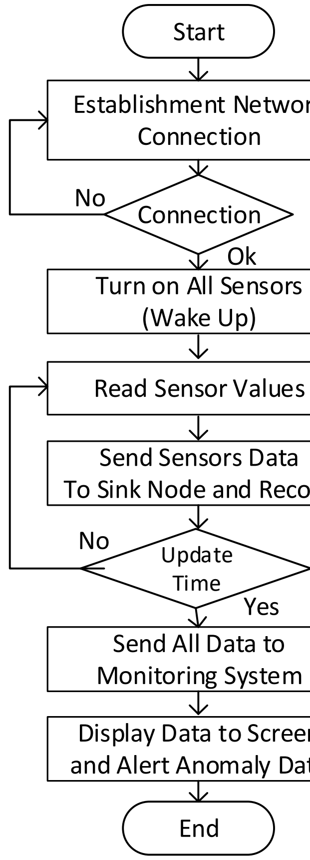

Fig. 4. A flowchart of the process in WSNs system.

A. Multiple Sensor System

The multiple sensors system has been done on a prototype as well as tested in the laboratory. Sensors for the detection of river water pollutants as shown in the specifications in table 1 was fabricated to connect to the microcontroller. Figure 5 shows the fabricated system and tested on a mini scale. Results show that the system was able to read all the water parameters and are shown in the LCD display. Next step is to test the prototype after improving the casing to be taken to the riverside.

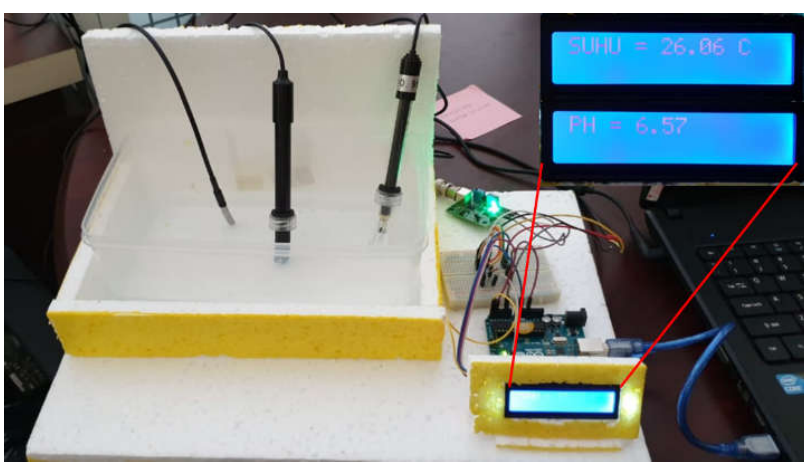

Fig. 5. Prototype of multiple sensors for detection water pollutant.

The testing was done in the laboratory for long period of time to check its long-term performance. Results show that the readings for the various parameters gives accurate results when compared to the manual calibration or conventional way. The use of multiple systems for detection is good because it provides various indicators of polluted water to be analyzed to ensure that the final result for determination of polluted water to be more accurate. Furthermore, introducing an intelligent system on microcontroller programming assist the accuracy of the decision on the results.

B. WSNs Sensing Communication

Communication to the backend system is one of the requirements to pull data to the server and monitoring system. In actual conditions, the sensor system was located on-site at the riverside. Several sensors were connected to each other for data sharing and a system was used as a gateway for communication to the backend system. Based on the survey, the distance of site location can be more than 30 km to the backend system. Figure 6 shows a design of data transfer to the remote monitoring, every sensors node represented water pollutant sensing system that has their individual sink for data collection and were keep on-site by local host before sending to the monitoring system. The proposed multiple sensing for water pollutant apply 4G as network for communicating from sink node to backend. The database or data center allows faster transfer of data as well as real-time monitoring, which in most of area are currently covered by network in latest technology such as 4G.

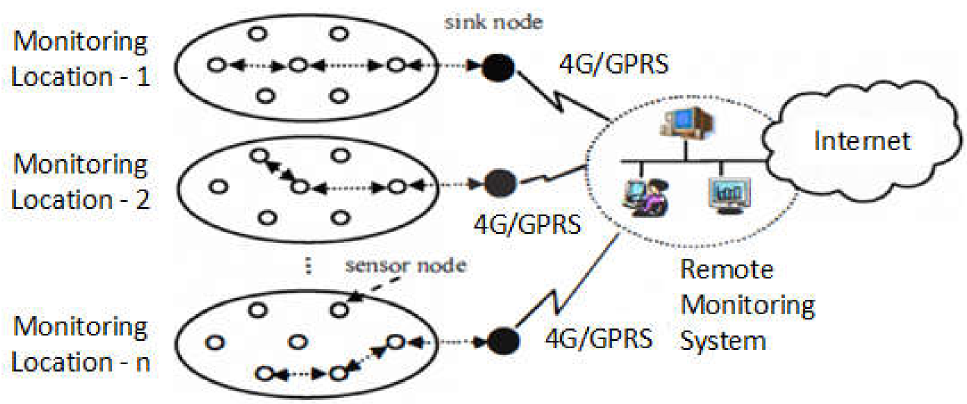

Fig. 6. WSNs nodes communication to sink node and monitoring system

The system design with real-time monitoring system thus was able to detect data from the sensors which must be transferred immediately with short delay. A block diagram for communication to the backend is shown in figure 7. Fourth Generation (4G) technology or General Package Radio Services (GPRS) was used then river water pollution data collected in an interval of time to minimize dumb and useless data that can be waste in local memory. Universal Asynchronous Receiver/Transmitter (UART) unit was used as interface between MCU to the 4G communicaiton unit.

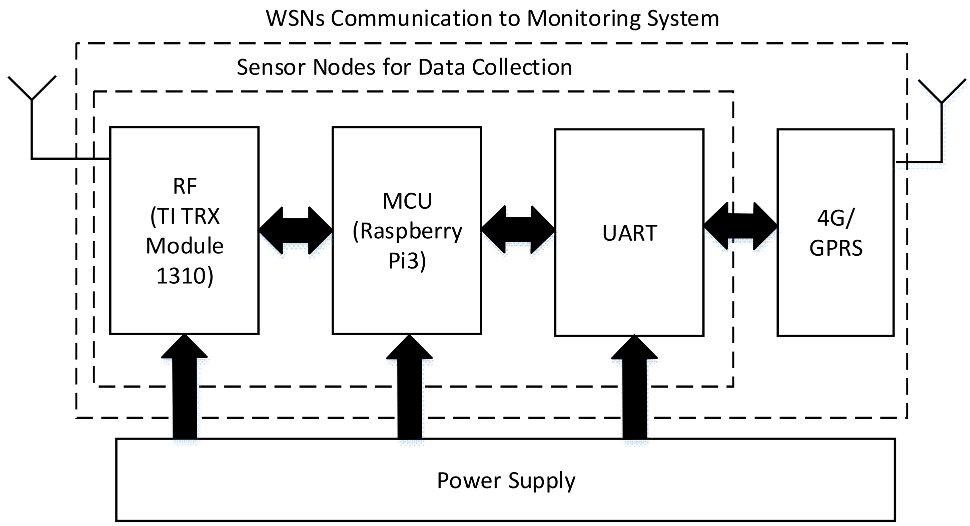

Fig. 7. Proposed diagram WSNs sink node communication to sensors

The design of multiple sensors system consists of four parameters which are common indicator in polluted water but the sensor node for WSNs was able to serve up to fifty nodes or location in 10 of a sink node. The distance of sensing system node from a location to others according to site survey must not be more than 500 meters because longer distance results in low accuracy because of the fast river water flow especially during rainy season. The system was supplied with independence power system from the solar panel because of some locations are very far away from the electrical utility. Figure 8 shows an actual scan of Siak River located in the capital of Riau Province. A set of sensor under testing on-site was used to get the readings for analysis and calibration to be compared to the actual value. Many activities on the river create the pollution to the river and effected the sensor reading. Needless to say, the polluted river water can be very hazardous to the community when consume or use for daily activities.

Fig. 8. A set of sensor under testing on-site

C. IoT System and Communication

Internet of Things (IoT) is a technology that was used as support in this case with integration to WSNs system, the design scenario of sensing system for effective communication and data transfer in order to achieve good response of sensors in the location. Combination between WSNs system and IoT as proposed in this design enables optimum data collection from every sensor to be kept in buffer memory in sink node of WSNs. Figure 9 shows a network architecture of IoT and WSNs integration.

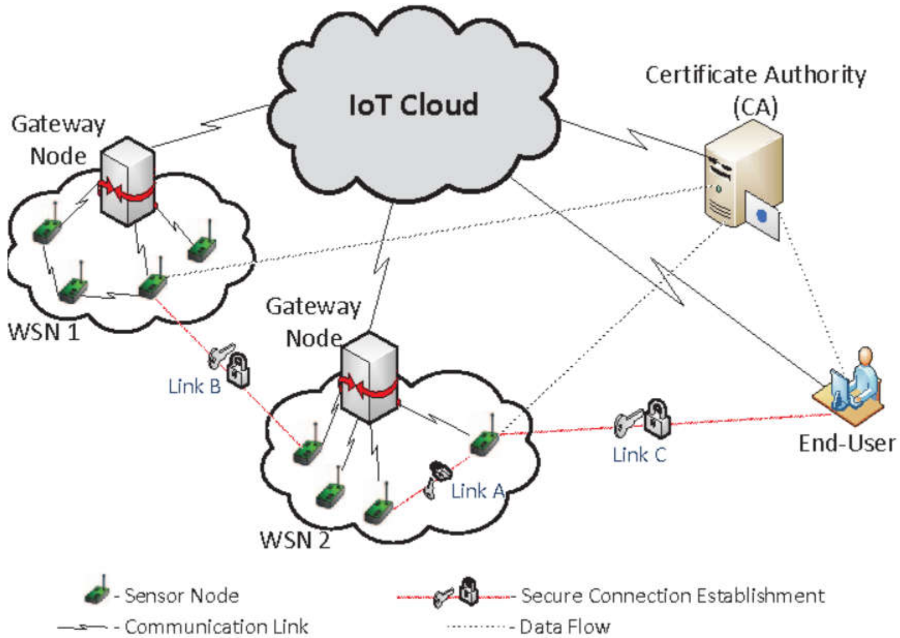

Fig. 9. An architecture of WSNs and IoT system integration.

After the sensors collect and store signals in memory in sink node, the next process is to provide useful data information for IoT application. In addition, integration of WSNs and IoT can be as such properties.

- The placement of the sensor nodes of IoT and sink nodes WSNs is in static locations.
- Because of the sensor nodes location is fixed then the distance of each sensor nodes and sink nodes can be determine by calculated using equation (5).

$$dist = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \tag{5}$$

where $(x_1; y_1)$ is the location of the first node, and $(x_2; y_2)$ is the location of the second node. The distance calculated based on effective communication of WSNs node to transfer the data.

- The power of transmission for each sensor nodes set as required, although the distance is the same but every sink nodes has different path loss and environmental effect.

IV. Simulation Results and Discussion

The results from the in-house testing system that measures temperature, water pH, and electrical conductivity and DO are compared to the conventional system which manually measures the quality of the tested water. Preliminary testing is very important to make sure that the readings of the sensing system is accurate compared to the actual conditions. Some of the results from the sensors were compared to other datasheet and literature in reference [2]. Good agreement of results from the two methods was found (Figure 10). The deviation between the sensing system to the readings of manual thermometer is very minimum (0.071°C to 1°C).

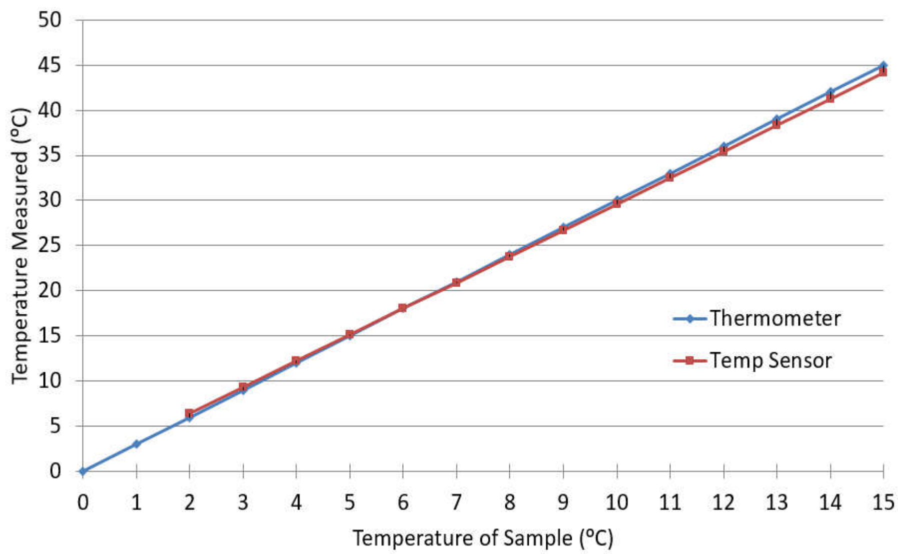

Fig. 10. Comparison of temperature obtained from the proposed system to that obtained using conventional method using thermometer.

Electrical conductivity is one of the indicators used to obtain information on a polluted water. Small error on results based on testing for the electrical conductivity is expected to get high accuracy for the determination of polluted water. Normally error for this measurement is not more than 15%, similar to other indicators of polluted water. Good agreement of results in the comparison between readings of simulated electrical conductivity to the actual signal conditioning was found (Figure 11).

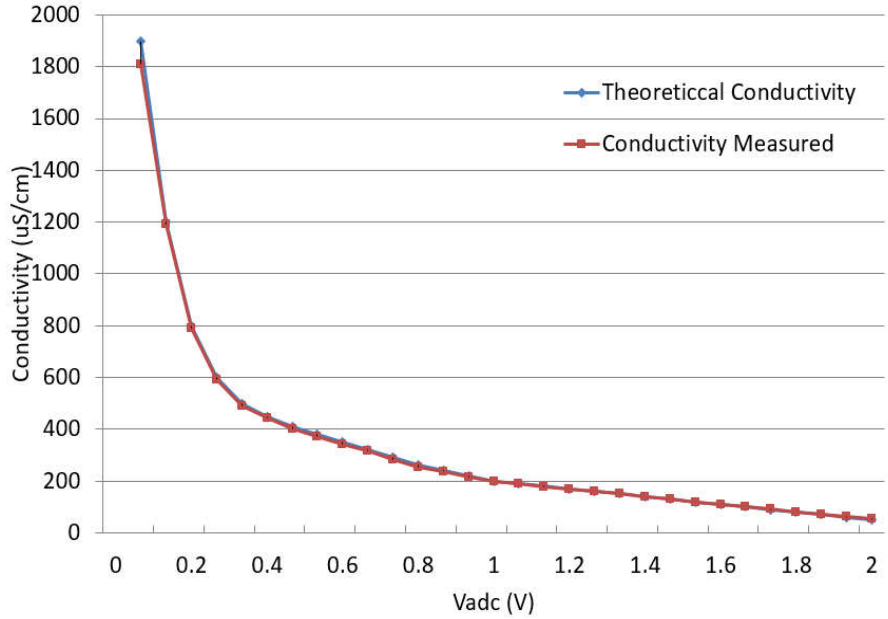

Fig. 11. Test results of the electrical conductivity of the sensor node

Another common indicator to measure water quality is water pH, sensing system for detection of water pH was designed to integrate other sensors and results were analyzed using the same microcontroller. Referring to the table, the specification of pH within the range from 0 to 14 is within 0.1 accuracyy. Figure 12 shows the results of measurement water pH compared to the theoretical.

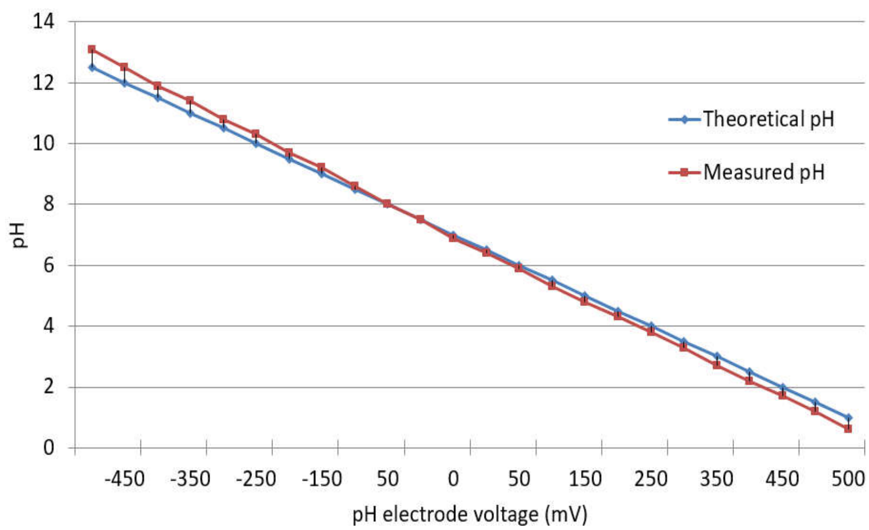

Fig. 12. Water pH test results versus theoritical values

According to the initial testing in the laboratory, all the sensors were able to function well and were be able to detect water parameters as displayed on the LCD. Further action is required to install and to do testing at the actual site as the proposed system. The results expected to achieve high accuracy based on actual contain polluted water. Figure 13 shows the results of water flow meter between manual and sensing system.

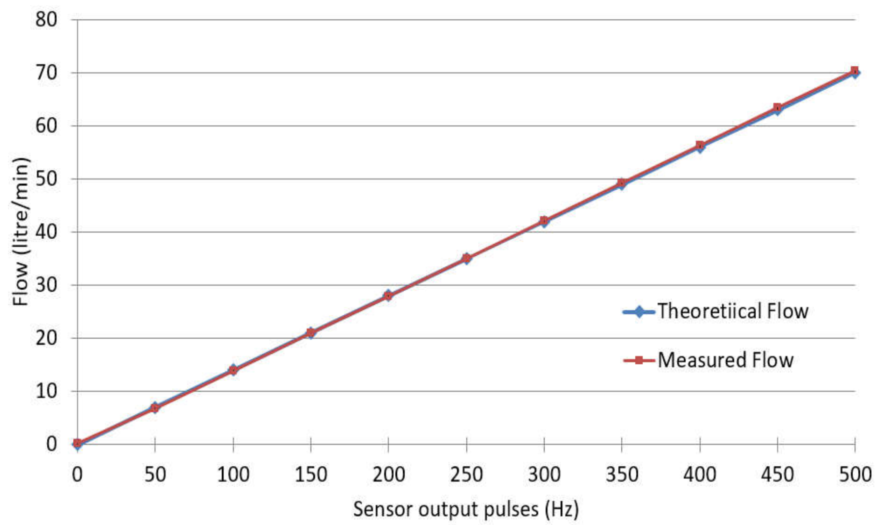

Fig. 13. Water flow meter test versus theoretical analysis

According to the initial testing in the laboratory for all the parameters of the water, good agreement of results between the conventional measurement unit to the sensing systems was found. Thus the proposed system has a significant impact on the community and further step was continued to test on-site for real environmental conditions. The proposed system applied both WSNs and IoT technology for monitoring, Distance between sensing node and the sampling site is one of the considerations to achieve good and representative readings of the sensing system.

V. Conclusion

A system was proposed for the assessment of polluted water using multiple sensors, the fabricated unit was tested in the laboratory as well as initial testing on-site. Results show good agreement between the proposed system and that of conventional measurement. Four main indicators in sensing system such as water pH, temperature, DO and electrical conductivity were measured to assess the quality of river water. The proposed system applied intelligent system as well in programming the microcontroller to achieve high accuracy in the final decision based on the detected values. Further action to get a sensing system that is beneficial to the community, to include water level and flow are required to include into the integrated sensing system for flood warning. In final, to make sensing system smart, intelligent algorithm should be applied into microcontroller programming because of the various types of material and chemicals in the water.

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