MAPPING OF SIDOARJO WATER QUALITY USING A MICROCONTROLLER BASED WATER QUALITY MEASUREMENT

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ABSTRACT
The purpose of this study was to determine the quality of drinking water that is suitable for drinking based on the pH value and TDS content and to provide information on the water level map in Siduarjo Regency. This research is descriptive quantitative research of experimental analysis. The stages of the research included making instrument calibration instruments as well as collecting and analyzing field data which included 14 water sampling points. Based on the reference value for drinking water quality (<500ppm) and tolerance for appropriate use (<1000ppm) 1 sample point of water is classified as suitable for drinking with a TDS value of <500ppm which is in the calm zone. Whereas TDS 13 points above >500ppm but still <1000ppm so it can still be used in household activities but if eaten it needs to go through a cooking process to remove heavy metals or substances in the water. The pH of the water from 14 points is not extreme outside the normal pH range of 6 – 9,5. The lowest water pH is 6,97 in the Siduarjo city area and the highest is 7,79 in the Tariq area. The main thing is that the TDS and pH in the Situarjo area are evenly distributed because of the flow of the river so that if one area is polluted it will affect the water quality in other areas either TDS or TDS and pH.

Keywords:
TDS, pH, PPM, Sensor, Contaminated

INTRODUCTION

Water is one of the most essential elements for life on earth. Living things cannot survive without water (Sumarjo, Arbi, & Dirja, 2017). Water's role in life cannot be replaced by other compounds. The primary and most important use of water for human life is drinking water but it is also used in other ways including industrial agriculture. However, if water is not available in the right conditions it can become dangerous. Because of the importance of water to life there must be a source of water that can provide good water both in quality and quantity (Purwonugroho, 2013). 2017 Drinking Water Quality Requirements No. 32 Drinking water is distinct from sanitation and drinking water. Drinking water is called treated or treated water that meets the hygiene requirements and can be drunk directly. For water to be safe for human health it must meet physical and biological requirements (Ministry of Health 2014).

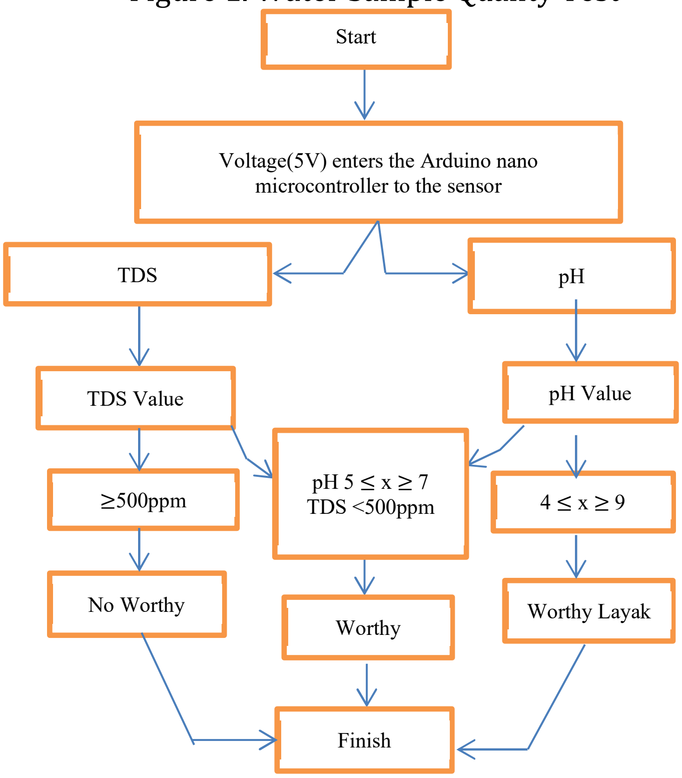
Siduarjo region is an area of rapid industrial development in East Java. Based on a paper by Ronald Ridhoi. (2017) industrial Sidorjo began in the third decade of the 19th century which is characterized by the development of the sugar industry. The manufacturing industry began to flourish after industrialization under the central government in the 1950s and grew rapidly under the New Order. Large-scale production in Ciduarjo has changed the environmental conditions of social and economic life and the environment. The environmental impact that society is experiencing is the change in water quality in the environment.

Acidity or pH is a factor of good water quality and is listed as a chemical parameter. The pH value ranges from 0-14. A pH of less than 7 indicates that the water is acidic. If the pH is 7 then the water is neutral and if the pH is greater than 7 then the water is alkaline (Astari, and Iqbal, 2020). Another parameter is TDS (Total Dissolved Solids) where TDS is a physical parameter. High concentrations of dissolved solids can affect the taste of water. High pH and dissolved solids are poorly associated with several aquatic environmental factors that have had significant negative impacts on marine life (Rinawati et al, 2016). Water health is evaluated based on a TDS factor of less than 300 ppm and a pH between 6-9,5 (Siswantoro et all, 2018).

Desmiras, Ariwibowo, and Pratama (2018) research determines the quality of drinking water using a pH sensor but with a limited range of measurement results e.g., 1-10. While the reference pH range is 1-14 (Sitorus, 2014). The accuracy of the sensors is very good with temperature sensor accuracy of 99,39% and pH sensor accuracy of 99,76% but the instrument error value of 5,23% is very high. This research will develop a portable TDS and pH instrument to overcome the high error value of 5.23%. On the other hand, the water statistics around Sidorjo cover a wide area and have 3 sources of well water and storage water. This research can help the community to know the quality status of the water used every day and map the water quality in the Sidorjo region.

METHOD

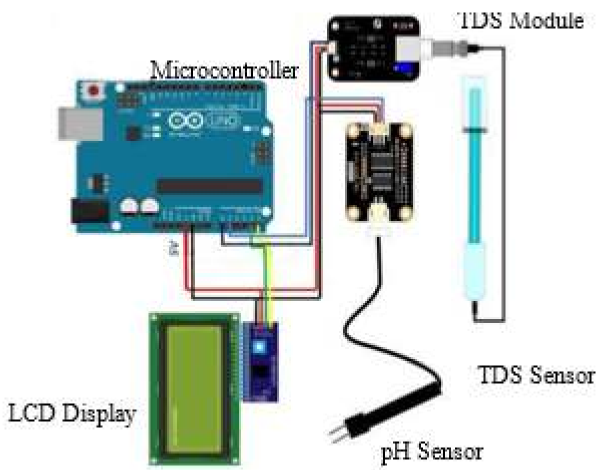
Figure 1. Water Sample Quality Test



An experimental method was used in the research where data collected directly from the field were quantitatively measured and analyzed descriptively. The steps are as follows: Tool making Tool fitting Prototyping and testing. Further analysis is conducted based on quantitative data obtained from test results and analysis results are interpreted in terms of water reference standards. The flow of experimental pH and TDS in the research sample is shown in Figure 1.

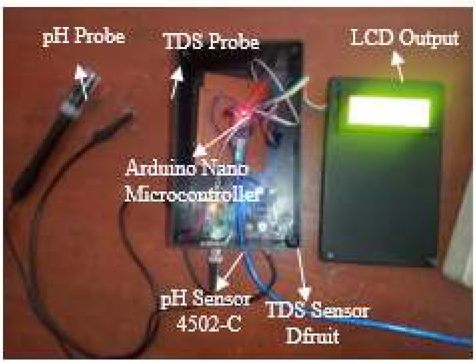
Samples were collected from 14 sites in Regency City Sidoarjo. Typical research sites include Prambon Krembung Porong Jabon Tangulangin Wonoayu Sukodono Sidoarjo Buduran Sedati Waru Gedangan Taman Krion and Balongbendos Tenth. The whole country is an industrial area. The researchers took 600 ml of water from each random site around the settlement. The water quality test uses two sensors with a design as shown in Figure 2. The pH sensor is used to measure the pH value of the water. The normal pH value of water ranges from 6-9,5. The working principle of the pH sensor changes the value of a chemical reaction that is taking place or is being detected and converts it into an electrical potential. This makes pH sensors fall into the category of chemical sensors as well. The different pH range is 0-14 (Sapitra 2020). A dissolved solids sensor is used to measure the ppm value of water. Plain water has a TDS value of less than 300 ppm. If the ppm value is above 300 it is classified as unfit for consumption but may be processed to make it workable. While more than 1000 ppm is considered dangerous. The TDS sensor has a working principle that depends on the nature of the electrical conductivity. 2 electrodes can measure the conductivity of liquids. The content of ionic particles and the properties of the electrolyte in the liquid affect the measurement results with a TDS sensor (Wirman, I. Wardhana, and Isnaini, 2019).

Figure 2. Water Quality Test Design



The microcontroller works to receive data from each sensor to automatically process and display the data on the screen on the sensor monitor which works to store the data. The complete equipment for testing the research sample is shown in Figure 3.

Figure 3. Water Quality Test Equipment



TDS and pH sensors are calibrated before use for measurement and use pH powder and raw water with the specified value. The measurement read by the sensor is in the form of an ADC (analog to digital converter) value and is compared with the change in microcontroller voltage.

RESULT AND DISCUSSION

Figures 4 5 6 and 7 show the results of calibration of sensor readings against changes in measured quantities. According to Figure 4 the linearity of voltage change of TDS sensor in ADC is 98.69. Meanwhile according to Figure 5 the linearity of voltage change of pH sensor in ADC is 98.59. It shows good response from TDS and pH sensors. Then after knowing the ADC value of both the sensors. Compare the ADC value with the quantity to be measured eg. ppm and pH of water. ADC sensors were obtained from calibration powder as shown in Figure 6 and Figure 7.

Changes in the TDS and pH sensors to the calibration powder readings obtained the following 2 linear equations:

$$y = 0{,}002x + 0{,}0522 \quad \text{.........................} \quad (1)$$

$$y = 0{,}1379x + 1{,}7341 \quad \text{.........................} \quad (2)$$

By entering the value of x = 1 into each linear equation, the y value is obtained as the sensitivity of the TDS sensor of 0.0542 V/ppm and the pH sensor of 1.872 V/pH. With the linearity value of the TDS sensor to changes in the water ppm value of 98.7% with an error of 1.3%. For the pH sensor, the sensor linearity is 99.37% with an error of 0.63%.

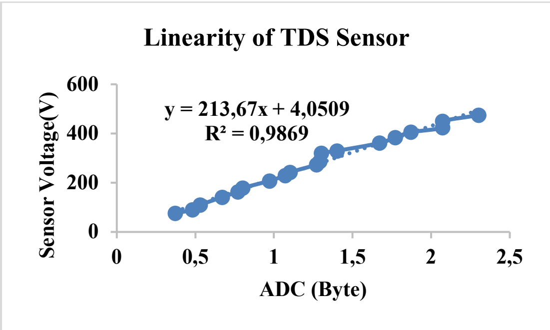


Figure 4. TDS Sensor Calibration to determine the linearity of sensor voltage changes to changes in ADC

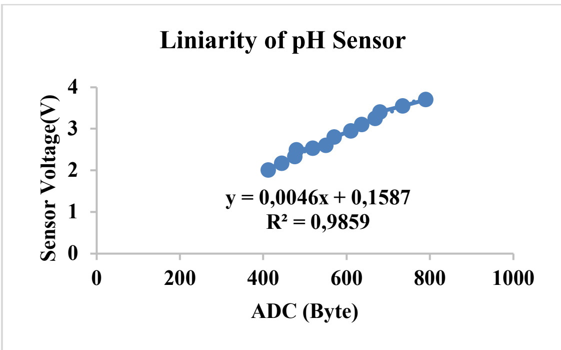


Figure 5. pH Sensor Calibration to determine the linearity of sensor voltage changes to changes in ADC

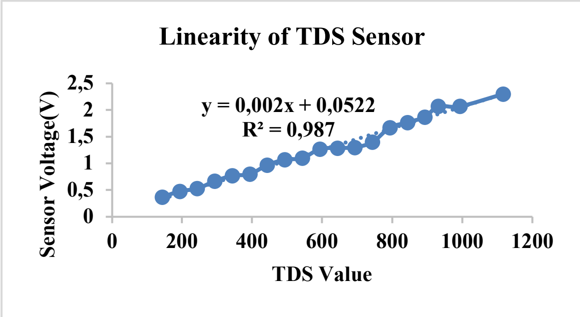


Figure 6. TDS Sensor Calibration to determine the linearity of sensor voltage changes to changes in water ppm

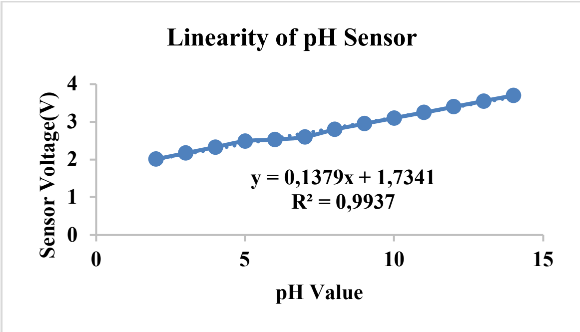


Figure 7. Calibration of the pH sensor to determine the linearity of changes in sensor voltage to changes in the amount of water pH

After sensor linearity was achieved, the instrument was calibrated using commercially available bottled water and calibration powder as shown in Table 1. It appears that two bottled water drinks were measured using a microcontroller-based TDS and pH meter. The instrument calibration shows the same readings as 68 for alkaline conditions calibration and 42 for acidic conditions calibration. So, the accuracy of the tool is 98%. Table 1 compares common metrics. Common limits for safe drinking water are TDS values (<500 ppm) and pH values around 6-95. If the water has a TDS value of (> 500) then the water contains heavy metals but is still considered to be consumed. On the other hand (> 1000) water is polluted and unsafe for humans (Noreen Iqbal and Subhan 2015). On the other hand, if the pH value is too basic and too acidic it is not suitable for use because plain water has a pH indicator in the range of 6-95. Indonesian Ministry of Health Decision No. 907/Menkes/SK/2002 Drinking water quality Dissolved solids or TDS up to 1000 ppm. Based on calibration data using raw drinking water the maximum limits for water suitable for consumption are (<300 ppm):

Table 1. Calibration data of raw water samples measuring TDS and pH of the sample.

Calibrator	**ppm**	**ph**
Acid Calibrator (pH 4,2)	1050	4,18
Base Calibrator (pH 6,8)	600	6,78
Reference Water 1	16	7,91
Reference Water 2	247	7,41
Normal	500	7

From the 14 sampling points, the results of the TDS and pH measurements are shown in Table 2. It appears that there are no samples that are classified as dangerous for consumption, because the TDS level is <1000 ppm. Overall, the water in the 14 water sample points was classified as normal pH.

Table 2. Water sampling data and measurement results of TDS and pH of the sample.

Address	**Ppm**	**pH**
Sidoarjo City	900	6,97
Waru Mosque	950	7,17
Gedangan Well	734	7,29
Candi Well	980	7,23
Prambon Well	595	7,2
Sedati Well	437	7,17
Tanggulangin Well	990	7,23
Tarik Well	572	7,79
Buduran Well	809	7,41
Wonoayu Well	788	7,35
Balongbendo Well	693	7,32
Taman Well	702	7,09
Krian Well	684	7,17
Sukodono Well	535	7,44
Normal	500	7

Sample 1 is in the urban area of Sidoarjo where the urban river is less polluted. Sample 2 from a sampling site in the Waru area near Dirty River. Sample 3 in the Gedangan area the pick-up point for the mosque is still a village near the Royal Mile. Sample 4 from the Candi area. Sample 5 from the Prambon area. Water sample 6 in Sedati district was collected from rice fields and mosques near residential houses. Sample from the Tangulangin area 7. The water intake is close to the Royal Mile surrounded by mills. Test 8 in the resistance zone. I collect water around the paddy fields. Sample 9. Water is collected from the main road near the factory. Sample 10 water intake facilities in Wonoayu area are located around main roads but there are few factories. Sample 11 was from the Balongbendo area. Water was drawn from the river surrounding the road, but factory waste was not exposed. Sample 12 of the park area. The Krian area was sampled by collecting water from residential wells away from the factory13. Sample 14 in the Sukodono area Water was brought from a mosque near a rice field far from the factory.

Potable water quality is subject to a reference value (<500 ppm) and a potable tolerance (<1000 ppm). In Table 2 one point in the water samples was indicated as suitable for drinking because its values were in the dilution region (<500 ppm). The remaining 13 points are higher (>500 ppm) but still less than (1000 ppm). It is still used for domestic use but if it is used for consumption, it must undergo the boiling process to remove heavy metals and other substances from the water. From point 14 onwards the pH of the water is not outside the normal pH range of 6-9.5. The pH of water in Sidorgio was the lowest in the urban area at 6.97 and the highest in Tarik district at 7.79.

From Table 2 the water quality based on the TDS values of the Seduarjo Regency water samples can be mapped onto an information map to facilitate the dissemination of information obtained from water quality studies. It is mapped with two colors according to the color value of the water indicator as shown in Figure 8.

Figure 8. Information on the Feasibility of Water from the Results of TDS and pH Meters in Sidoarjo Regency

Figure 8 shows the water quality map of the instrument test results for the Seduarjo area. Blue indicates the water quality in the area is fair (<500ppm) yellow indicates the water quality in the area is fair (<1000ppm) and red (>1000ppm) indicates the water quality in the area is insufficient. The TDS and pH measurements in the Payne Sidoarjo area are classified as normal but the TDS values in the water range between 400 and 990ppm. This indicates that the water in the Siduarjo area has started to be contaminated with metal objects. According to the number of plants in different locations in Sidoarjo (Ridhoi R. and Wahid A 2017). The main factor in drinking water pollution for residents in built-up areas is the presence of factories that generate production waste. This can be seen in the pH of the water in the Sadwarjo region which tends to reach acidity and alkalinity outside the pH range of 6 to 95. The river flow is also a factor in the equalization of water in the Siddharjo region if one area becomes polluted it will spread to other areas through the river or ground water. Then other areas will also be polluted.

CONCLUSION

The designed microcontroller-based TDS and pH meters have a very low error rate with error values of 1,3% and 0,63% respectively. Water potential analysis results tested with this equipment are more accurate. An analysis of water feasibility in Sidoarjo Regency after testing with a microcontroller-based TDS and pH instrument shows that only one point in the region has water quality that is suitable for consumption ie. Sedati area. The second test is the pH value of the water. The pH value of water in 14 tested samples is close to normal pH level and is not classified as acidic or basic hence it is suitable for consumption. At many places there was a change in pH as it reached the acid level ie. The pH value is 697 in Ceudergo urban area and 779 in Tariq area.

ACKNOWLEDGEMENT

Thanks to the Surabaya State University institution, the research that has been provided for this internal financing.

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