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Water Quality Measurement System for Water Reuse using a PH Sensor

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Abstract: In comparison to the average precipitation per capita in the world, the precipitation per capita in Korea is low, so, it is difficult to secure available water resources in Korea. To solve this issue, the method of reusing the water was used. In this study, the virtual environment is created on the undercurrent facility and the storage period of water inflow andthe changes in the hydrogen ion concentration are measured. The tool used in the measurement was the Arduino-based Sensor (SEN-0161) andthis test results were used to inspect the stability on the method of reusing the water.

Key words: Water reusing method, undercurrent time, hydrogen ion concentration, pH, facility, method

INTRODUCTION

When we look at the recent 10 years of precipitation in Korea (2007-2016), the annual average precipitation is approximately 1.274 mm to be 1.6 times of the global average but due to the high population density, the total precipitation per capita is 2546 m^3 annually to be only 1/6 of the global average (Anonymous, 1996, 2011). On the precipitation for each season, spring is approximately 252.44 and 653.4 mm in summer, 275.84 mm in autumn andabout 92.34 mm in winter to be concentrated in the summer season, so it is difficult to secure available water resources. OECD (Organization for Economic Cooperation and Development) also classified Korea as the nation with the serious level of water stress and WRI (World Resources Institute) also reported that Korea is the second highest nation in a serious shortage of water.

To secure the insufficient water resources, the Ministry of Environment established the 'Act on the Promotion and Support of Water Reuse' to promote the reuse of water, enable efficient utilization of water resources andto reduce the harmful influences on the water quality, thereby to enable a sustainable use of water resources andto enhance the quality of life of people (Suh *et al*., 2008; Anonymous, 2010). The reuse of rainwater, heavy water andtreated waste water are enabled to take efforts in expanding and promoting the reuse of water. The water reuse enables a sustainable development that protects the environment andcan overcome the drought and also restore the aquatic water and improving the river water quality.

In this study, a virtual environment was created to measure the changes in the hydrogen ion concentration (pH) of water in the reuse of rainwater, heavy water andtreated waste water. The hydrogen ion concentration of water is changed according to the time of stay due to automatic ionization of the water andfrom the water inflow. In this test, the virtual environment was created to measure the hydrogen ion concentration. The water used for measurement I the virtual environment is domestic sewage: vinegar, detergent and waste cooking oil were mixed for use. The measurement was enabled in one hour interval to measure according to the residence time. 50mL of water inflow was enabled for each hour.

For the tools used in measurement, the Arduino-based sensor hardware program of Arduino Uno and pH Sensor (SEN-0161) were used. This test results were used to verify the possibility for stable use of the water reuse method.

Literature review

Acid rain: Acid rain refers to the rain where the oxygen pollutants in the atmosphere such as sulfurous acid gas and nitrogen oxide are flown into the clouds or into the rainfall to reduce the rainwater acidity (log value of the hydrogen ion concentration within the rainfall) <5.6 (Anonymous, 2016; Gao *et al*., 2015).

For the standard of the acid rain when the Carbon dioxide (CO_2) causing acidity within the normal air condition is about 350 ppm in concentration anddissolved in moisture in the atmosphere, the subacidity of carbon is formed andthe pH when completely saturated to maintain

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the equilibrium state is approximately 5.6. The acid rain acidifies the water quality to cause direct damage to the crops or to the forest andcan have harmful effects to the human eyes or skin, etc. Also, it can cause property damage by causing corrosion on the metal or on the building, etc. (Anonymous, 2016).

MATERIALS AND METHODS

Water reuse method: First, the method used in this study of water reuse method is to be described. The water reuse method refers to the following: the Ministry of Environment and the Korea Environment Corporation perform water treatment on the rainwater, wastewater, treated waste wasted and hot wastewater of hydraulic power andthe treated water is used for the purpose of living, industrial and agricultural use, landscaping and for maintain the river. Rain water, heavy water and treated wastewater are circulating resources that can be used consistently andefficient utilization of water resources through the water reuse is mandatory to improve the capabilities to respond to the drought andto preserver the water quality of the rivers in Korea, one of water-stressed countries (Gao *et al*., 2015; Anonymous, 2018).

The rainwater use method is collecting the rainwater in advance to be used later to overcome drought and to prevent flood. In the heavy water reuse method, the water used once can be reused individually or regionally through the wastewater reclamation and reusing system before sending to the public sewage the water used and disposed into the public sewage treatment plant is treated according to the purpose of use and managed of water quality for reuse (Dan-Qun *et al*., 2010).

pH Sensor (SEN-0161): pH (Power of Hydrogen ions) shows the value of 0~14 in numeric value and pH 7 is neutral value (H+ = OH-) in which the relevant solution is clear water. In this standard, the value lower than pH 7 (H+>OH-) is a solution showing acidity and the value higher than pH 7 (H+<OH-) is a solution having alkalinity. In this study the Arduino pH Sensor is used to measure the pH of the solution. Figure 1 and 2 show the structure of the pH meter and the pH sensor is operated as shown in the structure of the pH meter.

In Fig. 2, saturated KCI refers to the electrode storage solution which is the reference electrode and HCI solution becomes the glass electrode. In this state when the + pole in the HCI solution is authorized and pole is authorized into the electrode with the KCI solution, the hydrogen ion concentration is found by using the potential difference between the two AgCl on Ag electrodes in the center according to the hydrogen ion concentration of the surrounding solution (Anonymous, 2018).

Water quality measurement system

Test description: In this study, in the use of the water reuse method, the solution was measured by creating a virtual environment to measure the water quality according to the undercurrent time within the under current facility storing the water (Fig. 3). Originally, there is a water quality standard that must be considered to reuse the water but items possible to be measured by the sensor are very limited andamong them, this test measures only the hydrogen ion concentration of the solution with the pH sensor possible for easy measurement.

For the purpose of measuring the hydrogen ion concentration of the solution according to the time flow, the hydrogen ion concentration measurement was tested according to the Framework Act on Environmental Policy. The solution is put into the beaker as if the undercurrent facility is storing water andthe hydrogen ion concentration of the solution is measured in certain time interval.

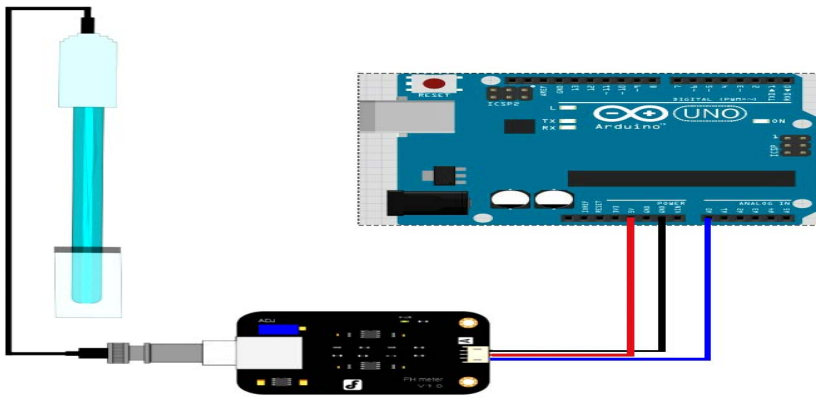

Fig. 1: pH sensor

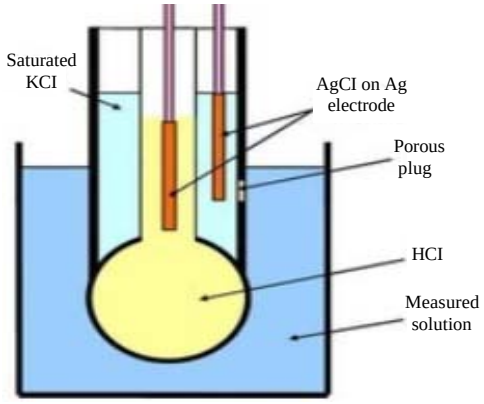

Fig. 2: Structure of pH meter

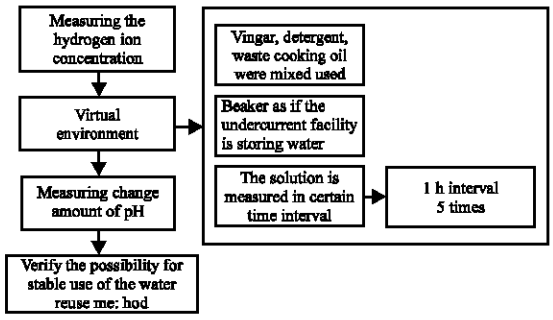

Fig. 3: Measurement process

After the initial hydrogen ion concentration measurement, the measurement is performed again after 1 h anda fixed amount of water is added for each fixed period as if raining to increase the volume of the solution. The change in pH concentration according to the time flow is measured to verify the possibility of stable water reuse.

The solution used in the test is domestic sewage that can be easily seen in our surroundings; vinegar, detergent and waste cooking oil were mixed for use. For the test method, 50 mL of the solution is measured for 5 min and 50 mL of water is added in 1 h interval to repeat the measurement for 5 min.

The hydrogen ion concentration is measured continuously for total of 5 times andthe change amount of hydrogen ion concentration according to the time flow and solution volume is measured.

RESULTS AND DISCUSSION

There were changes in the hydrogen ion concentration of water as the time and water cooking oil was measured initially of the hydrogen ion concentration, there were changes in the pH of water as the time and water inflow increased (Table 1).

Table 1: Test result

Order/Conditions	pH
First	
Vinegar:10 mL	3.22
Detergent: 20 mL	
Waste cooking oil: 20 mL	
Total: 50 mL mixture	
Second	
Vinegar:10 mL	3.25
Detergent: 20 mL	
Waste cooking oil: 20 mL	
Water: 50 mL	
Total: 100 mL mixture	
Third	
Vinegar:10 mL	3.30
Detergent: 20 mL	
Waste cooking oil: 20 mL	
Water: 100 mL	
Total: 150 mL mixture	
Fourth	
Vinegar:10 mL	3.38
Detergent: 20 mL	
Waste cooking oil: 20 mL	
Water: 150 mL	
Total: 200 mL mixture	
Fifth	
Vinegar:10 mL	3.40
Detergent: 20 mL	
Waste cooking oil: 20 mL	
Water: 200 mL	
Total: 250 mL mixture	

First, pH 3.22 was measured andwhen 50 mL of water was added after 1 h, pH 3.25 was measured, followed by pH 3.30, 3.38 andincreased up to pH 3.40 in the final measurement. So, it can be measured sensitively in real time.

CONCLUSION

The test results showed that the hydrogen ion concentration of water increased according to the increase in the undercurrent time and water inflow. In this study, the change amount of hydrogen ion concentration was insignificant due to the testing in a virtual environment and short measurement time. The result of the test confirmed the possibility of stable reuse of water. In this study, the testing in a virtual environment and short measurement time but when the measurement is performed for longer period in an actual environment, the change amount will be significant. Also, this test measured only the hydrogen ion concentration for the water quality but when turbidity, temperature and other organic matters are measured it could obtain more accurate results to enable safer water reuse.

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