

# Automatic Dehydration Level Detection Devices (Equipped With pH Measurements and Calculation Of Body Fluid Requirements)

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## Abstract

Dehydration is a condition that occurs when the loss of body fluids exceeds the amount entered in the body so that it can disrupt the balance of minerals in body fluids. Most people do not feel thirsty until finally, they experience a period of severe dehydration, which can cause physical, cognitive, fatigue; if not corrected immediately can cause death. The purpose of this study is to design a dehydration and urine pH detection devices automatically. The contribution of this study is that this device is equipped with urine pH measurement and automatic body fluid calculation. This device is able to detect urine color levels, read urine pH values, and provide information on body fluids needed to treat the patient's condition when detected. The sensors used in this device are color sensor TCS34725, pH meter sensor module SKU-016 and DS18B20 temperature sensor, the calculation of the amount of fluid that must be entered automatically from the patient's body weight input. The programming uses Arduino Nano as the main controller with a 128x64 graphic LCD. From the testing that has been done, it is known that the percentage error in the module is 3.5%, which means that it is still in the tolerance value because the tolerance limit is 5%, for the sensitivity test results get a value of 60% and specificity of 70%. Thus, it shows that the device is feasible and can be implemented as a dehydration detection device that is carried out independently at home.

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## I. INTRODUCTION

Health monitoring can be done independently, one of which is biochemical tests which are generally often carried out by many people. One of the biochemical tests is a urine examination, which is done independently at home. Urinalysis is recommended to be part of the initial examination of all patients because it is cheap, feasible, and provides productive results[1]. Urine examination in patients provides very extensive information based on existing parameters and can indicate problems in the body. Information that can be identified includes urine color, urine sediment, urine pH, protein, glucose, nitrite, red blood cells, and white blood cells, bilirubin [2]. In the urine color and pH check, the test is usually done manually using a color strip that uses strip paper as a comparison. The results are often obtained by semi-quantitative analysis, where only people with expertise can read the results of the manual test. In the context of health, home-monitoring is generally done by reading manually reading error-prone. Also, parents or people who are color blind are likely to face difficulties in conducting rapid visual analysis, which can lead

to incorrect results. Therefore biochemical tests are automatic and can provide easy information that is very much needed in such cases. Biochemical tests through urine can detect kidney damage, from the results of these tests immediately carried out further tests on the patient, to follow up on the treatment of kidney damage[3][4]. Dehydration or loss of body fluids is often experienced unconsciously. Most people do not feel thirsty until finally, they experience a period of severe dehydration[5][6][7]. Water is needed in the body for metabolic processes, body temperature regulation, joint lubrication, distribution of nutrients, and so on[8][9]. Acute dehydration can cause physical and cognitive disorders, heatstroke and fatigue, and if severe and uncorrected, even death[10][11]. Apart from infants and people with special medical conditions, athletes, military personnel, workers, and older adults are at particular risk of dehydration due to their physical activity, environmental exposure, and the challenges of maintaining fluid homeostasis[12][13]. The earliest detection of dehydration is the color of urine, which is often unknown is the calculation of fluids that must enter the body when dehydration is detected, therefore the need for an

automatic dehydration detector and is equipped with an automatic calculation of the amount of fluid entering the body. Also, the pH level (Power of Hydrogen) plays an important role in the maintenance of human metabolic activity. The kidneys have a role in regulating the concentration of hydrogen ions in body fluids to prevent acidosis or a way to excrete acid or alkaline urine[2]. In the body can describe accurately the concentration of hydrogen ions in it. Excessive acidity of urine may be a sign of diabetes, systemic acidosis, dehydration, etc. Urinary excessive alkalinity may be a sign of bacteriuria or kidney failure[14]. The reverse, the pH of the urine becomes alkaline can be due to urinary tract infections, pyloric, chronic kidney failure, certain drug therapies. Examination of urine color and urine pH does not have to wait to the clinical laboratory, and the examination can be done at home as an early detection if dehydration is detected so that it can be handled directly by entering fluids in the body as needed by the body and can be checked again until it is classified as normal urine. Likewise, with the pH value in the urine if the reading of the pH value is not normal then immediately carried out further examination and treatment, because it indicates a problem in the kidney[15][16].

A similar study was conducted by Rint Zata in 2017 with the title Dehydration Detection System Based on color and ammonia levels in the urine based on TCS3200 and MQ135 sensors with the Naïve Bayes method[17]. From this device, the level of dehydration and the level of ammonia in the urine were detected. However, the device has not been equipped with body fluid needs. Subsequent research was carried out by Ika Shofiyah Naharin in 2018, and she developed an automatic detection of dehydration levels based on the color of urine supplemented with the number of fluid needs. The device uses the TCS3200 color sensor to detect the color of urine and the amount of fluid needed for the body. However, there has been no development of measurements for other urine components, the TCS3200 sensor reading error value is still relatively high, and the device is not yet portable, so there are limitations in placement when making measurements. Further research was carried out by Alexander et al. in 2018, and they propose a urine dehydration system based on urine color [18]. The device uses the same sensor as what the author will develop, namely the TCS34725 color sensor. In his research, he gave conclusions and hopes for future research to establish the system to modify other parameters such as pH, specific gravity, glucose, etc. This system can be implemented in a home system[19].

Based on the weaknesses and limitations that have been mentioned in previous researchers, among others: 1) There is no other parameter to detect dehydration other than the color of urine 2) not portable; 3) the type of sensor used is less than the maximum in detection. Against this background, the authors intend to research the title Detection of Dehydration and Urine pH Automatically. It was using a sensor that is different from before using the TCS34725 sensor and adding another parameter in the examination of the urine component, namely the measurement of the pH value. It is hoped that this device can help to monitor health at home through early detection of

dehydration as well as knowing the needs of fluids in the body and knowing the pH of urine to determine whether there are metabolic problems, especially in the kidneys and the devices are made using different sensors from previous studies, and the device is made automatically and portable to make it easier to use.

This Article is composed of: Chapter 1 Introduction, Chapter 2 Material and Methods, Chapter 3 Result, Chapter 4 Discussion, Chapter 5 Conclusion, and Chapter 6 Reference.

## II. MATERIALS AND METHODS

### A. Experimental Setup

This study conducted using eight samples to detect and measure. Samples were obtained from liquids whose color approached the color scale urine hydration chart.

### B. Materials and Device

In this study, we used a TCS34725 color sensor (TCS34725FN, TCS34725, Headquarter sams AG Tobelbader Strasse 308141 Premstaetten Austria, Europe) (**Fig. 1**), pH meter module sensor SKU-016 (PH-4502C, DIY MORE & BNC Electrode pH probe, China) (**Fig. 2**), temperature sensor DS17B20 (waterproof, Maxim Integrated Products, China), buffer pH 4.01 and aqua dest for calibration of the pH meter electrode, and some solutions according to the urine hydration color scale. Components used in this study is a microcontroller Arduino Nano (programming by software Arduino 1.8.2) and 128x64 LCD graphic as the display.

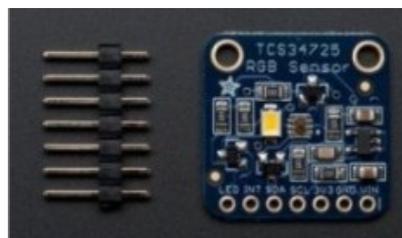


Fig. 1. TCS34725 Color Sensor[20]



Fig. 2. pH Meter Module Sensor SKU-016

### C. Experiment Protocol

In order to experiment, provide a liquid to be detected in accordance with the color scale urine hydration chart (**Fig. 3**).

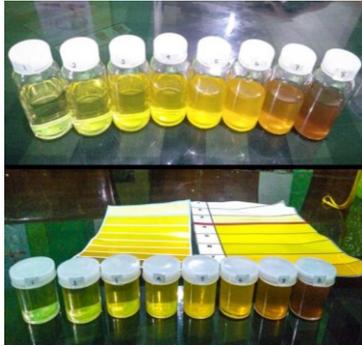


Fig. 3. Liquid Accordance With The Color Scale Urine Hydration Chart

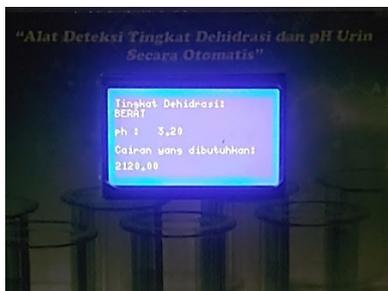


Fig. 4. Final Information

Color detection using the TCS34725 color sensor, the board is blue as in (Fig. 1), after which the liquid is measured pH using the pH meter module sensor SKU-016 as in (Fig. 2) with calibration step using buffer 4.01. then the electrodes are cleaned utilizing a tissue carefully until completely clean and dry after that dipped in aqua liquid and did the same thing. Then dip pH meter electrode in the liquid to be measured after the value appears on display. Select the weight input menu, enter digits of the when conditions are taken for sampling. Final information will come out on the screen from the detected results as in (Fig. 4) shows the level of dehydration, pH, and fluids that the body needs to overcome this.

*D. Diagram Block*

The input was obtained from the sample. First, the sample color check is performed, the color of the sample is detected by the TCS34725 color sensor, and the ADC (R, G, B) data is generated and processed by Arduino program. Second, it takes the pH of the sample. Before it carries the pH check out, the sample is dipped by a pH meter electrode and then processed by the pH meter sensor module to produce a voltage output, which is then treated with a buffer amplifier circuit. In the examination of pH temperature also affects the reading results; therefore, the sample is also measured by using a DS17B20 waterproof sensor. After that, the measurement results of the pH, temperature, and color of the sample are displayed on the graphic LCD.

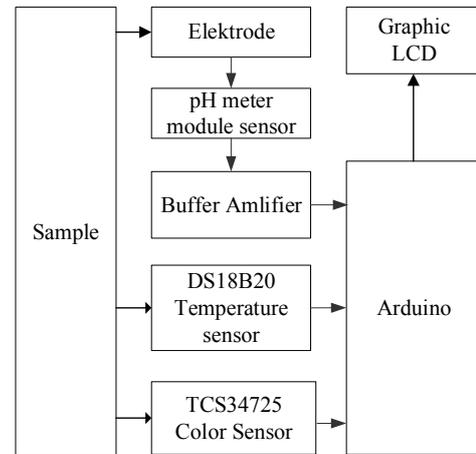


Fig. 5. A Block Diagram System

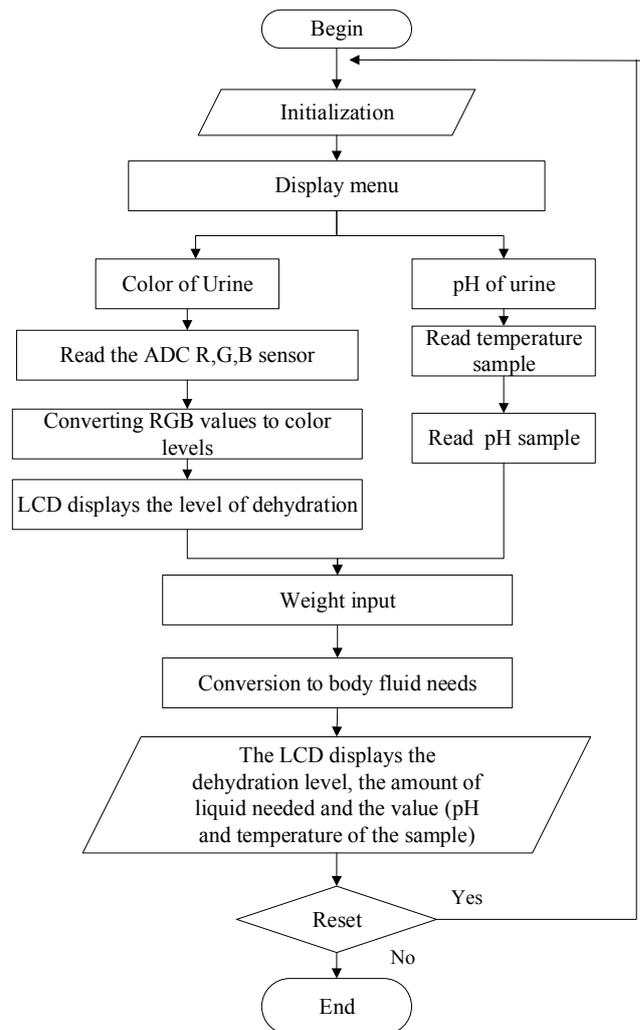


Fig. 6. The Flowchart Program Arduino

E. The Flowchart

The flowchart of the proposed method is shown in (Fig. 6). The program starts from the LCD initialization with three menu displays, namely color detection, pH and temperature measurement, the weight input. After measuring in the first and second menus and then selecting the 3rd menu for weight input, then press enter, then the general information will appear on the LCD screen. There is also a reset button to return to the initial LCD initialization program.

F. Circuit

1) pH Meter Module Sensor

The pH meter input module SKU-016 is derived from the electrode dipped in the sample and the sensor output pin is connected to the buffer amplifier circuit.

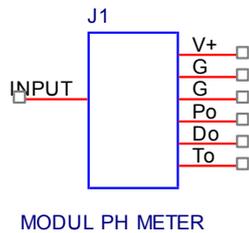


Fig. 7. pH Meter Module Sensor

2) Buffer Amplifier

The input circuit is derived from the pH meter output of the sensor module, this circuit comprises 2 circuits namely a buffer circuit that functions so that the input voltage and output voltage are the same and the amplifier circuit to amplify the voltage which then outputs the incoming circuit at the Arduino A0 pin.

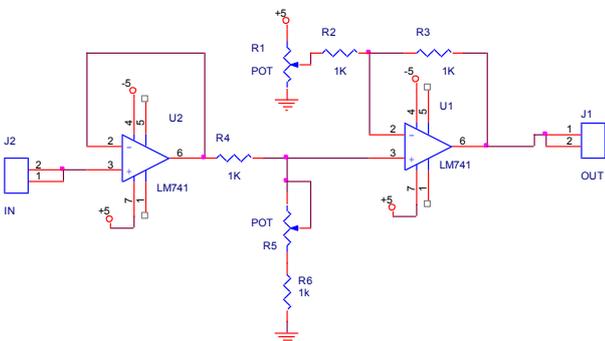


Fig. 8. Instrumentation Amplifier

3) TCS34725 Color Sensor

It connects the tcs34725 sensor to the VCC, GND, SDA and SCL pins on the Arduino pin.

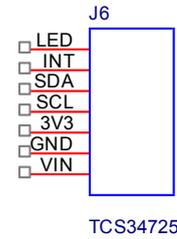


Fig. 9. TCS34725 Color Sensor

4) DS18B20 Temperature Sensor Connection

It connects the DS18B20 sensor to the pull-up circuit and then connected to the Arduino D12 pin.

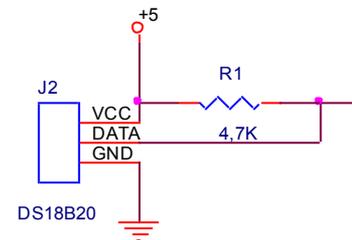


Fig. 10. DS18B20 Temperature Sensor

III. RESULT

In the research carried out, it carried tests out using 8 sample colors that resembled eight levels of color scale urine hydration chart. (Fig. 11).



Fig. 11. Fluid Samples Used For Measurement

A. Device Design

We can see the design of the instrument (Fig. 12). There is an exact sample that has the surface of the box in which there is a tube to insert the sample at the time of color detection. There are push buttons for setting and selecting menus. There are two connectors on the right side in the picture, which are connected to the pH meter electrode and temperature sensor.



Fig. 12. Automatic Dehydration and pH Urine Level Detection Device

### B. The Results of Program Arduino

In the Arduino program is divided into 6, namely the color level reading program, the pH reading program, the temperature reading program, the weight input program, and the liquid calculation program.

#### Pseudocode 1. The Program is to Read Color By Sensor TCS34725

```
void LOOP(void)
uint16_t r, g, b, c;
tcs.getRawData(&r, &g, &b, &c);
Serial.print(" Color sensor ");
Serial.print("R: "); Serial.print(r, DEC); Serial.print(" ");
Serial.print("G: "); Serial.print(g, DEC); Serial.print(" ");
Serial.print("B: "); Serial.print(b, DEC); Serial.print(" ");
Serial.print("C: "); Serial.print(c, DEC); Serial.print(" ");
Serial.print(" ");
```

This program is used for the color reading of the sample, which will later be read the ADC value of its R, G, B.

#### Pseudocode 2. The Program is to Convert RGB Digital Data to Color Levels

Make 8 program for 8 color scale of urin hydration, for example as follows :

```
IF ((reda >= 1.12 & reda <= 1.13) && (greena >= 1.07 & greena <= 1.08) && (bluea >= 0.79 & bluea <= 0.81)) THEN
    u8g.drawStr(37, 40, "Normal");
    condition=1;
ENDIF
ELSE IF ((reda >= 1.15 & reda <= 1.19) && (greena >= 1.04 & greena <= 1.05) && (bluea >= 0.75 & bluea <= 0.80)) THEN
    u8g.drawStr(20, 40, "Dehydrated ");
    condition=4;
ENDIF
```

```
ELSE IF ((reda >= 1.14 & reda <= 1.19) && (greena >= 0.98 & greena <= 0.99) && (bluea >= 0.82 & bluea <= 0.88)) THEN
    u8g.drawStr(20, 40, "Severe Dehydration");
    condition=8;
ENDIF
ELSE
    u8g.drawStr(20, 40, ".....");
ENDELSE
```

This program is used to convert the reading data in the form of R, G, B values to a color level. This program is used for setting tools to achieve correct and accurate readings.

#### Pseudocode 3. The program is to Read pH Value

```
DEFINE
int pHvalue = analogRead(phSensorPin);
VoltagePh = 5 / 1024.0 * pHvalue;
phadc= pHvalue;
phteg=(VoltagePh);
```

#### Pseudocode 4. The Program is to Calibration 1 Point

```
DEFINE
pH=(-0.0184* pHvalue)+18.481;
```

When the sensor was performing calibration, the media was set using a pH powder of 4.01. The formula added to the program is made using Excel to adjust the value when the setting is done.

#### Pseudocode 5. The Program is to Readings From The Temperature Sensor

```
LOOP (void)
sensors.requestTemperatures();
Serial.print("====Temperature: ");
Serial.println(sensors.getTempCByIndex(0));
delay(1000);
ENDLOOP
```

This program is used for reading the temperature value at the time of pH measurement because the temperature value affects the pH value, therefore, a temperature sensor must be added when measuring the pH of the sample.

**Pseudocode 6. The Program is to Calculation of Fluid Requirements**

```

IF (condition==3)
    BN=BB;
ENDIF
IF (condition==4)
    BN=BB*100/96;
ENDIF
IF (condition==1)
    u8g.drawStr( 0, 15, "NORMAL");
ENDIF
ELSE IF (condition==1)
    u8g.drawStr( 0, 15, "DEHYDRATED");
ENDIF
ELSE IF (condition==1)
    u8g.drawStr( 0, 15, "SEVERE DEHYDRATION");
ENDIF
ELSE
    u8g.drawStr(0, 15, ".....");
ENDELSE
    
```

This program is used to automatically calculate the body's fluid requirements using a formula and input derived from the patient's body weight

*C. The Results of The Output TCS34725*

The output of the sensor detection is displayed on the graph (Fig. 13) for easy reading.

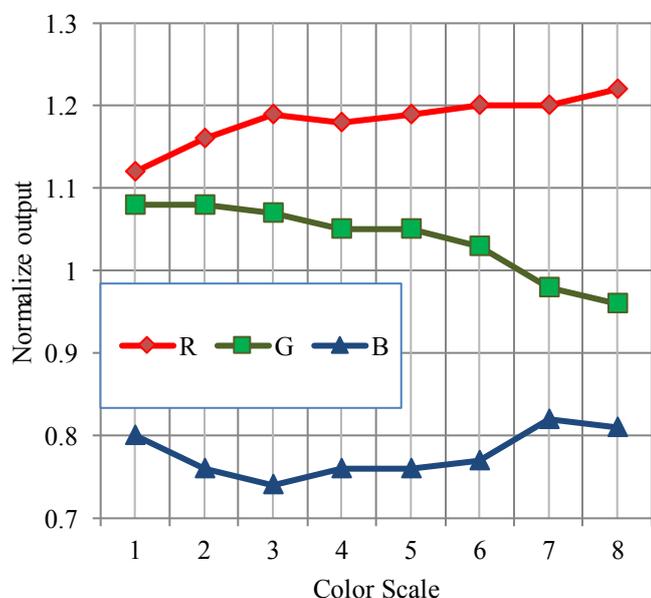


Fig. 13. Graphic RGB Value of Output TCS34725

TABLE I. MEASUREMENT RESULTS

Sam ple	Module TCS3472 5	pH meter	Weight gain when dehydr ated	Weight gain when normal conditio n	Status	Fluid need (mL/ days)
1	R=1.12 G=1.08 B=0.81	2.80	60	62.5	Normal	2300 ml
2	R=1.16 G=1.07 B=0.77	2.69	54	54	Normal	2180
3	R=1.18 G=1.06 B=0.76	2.97	46	46	Normal	2020
4	R=1.18 G=1.05 B=0.76	2.73	47	50	Fair	2060
5	R=1.13 G=1.04 B=0.83	2.65	48	50	Dehydr ated	2100
6	R=1.16 G=0.99 B=0.85	2.67	56	56	Dehydr ated	2264
7	R=1.15 G=0.99 B=0.87	2.65	45	45	Very dehydr ated	2054
8	R=1.15 G=0.99 B=0.87	3.20	48	50	Severe dehydr ated	2120

Table I. explains about overall measurements when the device works in sequence according to the system made.

*D. Measurement Error*

TABLE II. CALCULATION OF pH SENSOR ERROR VALUES

Sample	pH (Module)	pH (comparison device)	Deviation (comparison device-Module/ comparison device)	% error
1	2.8	2.46	0.13821	13.8211
2	2.69	2.16	0.24537	24.537
3	2.97	3.26	0.088957	8.895706
4	2.73	2.86	0.045455	4.545455
5	2.65	2.46	0.07724	7.72358
6	2.67	2,87	0.069686	6.968641
7	2.69	2.52	0.06746	6.74603
8	3.2	3.01	0.06312	6.31229
Average 1 :				4.84128

**Table II.** explains the calculation of the error pH value in the module compared to the comparison device.

TABLE III. CALCULATION OF TEMPERATURE SENSOR ERROR VALUES

Sample	Temperature of the sample (module)	Temperature of the sample (comparison device)	Deviation  (comparison device-Module/ comparison device)	% error
1	29	28.6	0.01399	1.3986
2	29.38	28.5	0.03088	3.08772
3	29	28.7	0.01045	1.0453
4	29.5	28.6	0.03147	3.14685
5	29.63	28.7	0.0324	3.24042
6	29.75	28.8	0.03299	3.29861
7	29.31	29.3	0.00034	0.03413
8	29.94	28.9	0.03599	3.59862
Average 2 :				2.35628

**Table III.** explains the calculation of the temperature value in the module compared to the comparison device.

Overall error value

$$\begin{aligned} \text{Error} &= \frac{A1+A2}{16} \\ &= \frac{4.84128+2.35628}{2} = 3.59878\% \end{aligned}$$

#### IV. DISCUSSION

Previous research in 2017 which is conducted by Rint Zata [17], there was a development of parameters that detect through the color of urine gas and ammonia gas, and other studies mostly using TCS3200 color type sensors, for the current development using TCS34725 color sensors whose quality is better because there are IR block filters. Further research was carried out by Alexander et al. in 2018 [18]. The device uses the same sensor, namely the TCS34725 color sensor. Still, the dehydration detection parameter is only through the color of urine and suggests that there be additional development of other parameters. Now, this study is done by adding a different parameter, namely urine pH, because pH affects the dehydration condition, and I also add that the calculation of body fluids is needed automatically. In **Table II.** and **Table III.** that this device is suitable for use as detection of dehydration at home as early detection of dehydration status in the body.

#### V. CONCLUSION

This study shows the development of a community movement to check urine itself by making a dehydration level detection device that is equipped with urine pH measurement and automatic body fluid calculation. This study uses Arduino

programming to create the desired system. Program processing uses Arduino Uno and is displayed on a 128x64 graphic LCD. This study has an error value of 3.5%%, which means that it is still in the tolerance value because the tolerance limit is 5%, a sensitivity of 60% and a specificity of 70%. That it shows that the device to be feasible and can be implemented as a dehydration detection device that is carried out independently at home. In the future, I expect it, that development can be carried out for the addition of other urine component detection parameters.

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