Sensor Document

Sensor Findings:

Due to the limited amount of specific contaminant sensors that are largely accessible and economically feasible, we believe that it would be best to use more general monitoring sensors that we can use to make inferences about the quality of the water and the possible contaminants inside the water.

- pH Sensor: pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). {ex: in addition to affecting how much and what form of phosphorus is most abundant in the water, pH also determines whether aquatic life can use it. In the case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble. (Source: A Citizen's Guide to Understanding and Monitoring Lakes and Streams https://www.usgs.gov/special-topic/water-science-school/science/ph-and-water?qt-science_center_objects=0#qt-science_center_objects)**}**
- Turbidity Sensor: Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold**.** Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in developing watersheds.
- Dissolved Oxygen Sensor: Dissolved oxygen (DO) is the amount of oxygen that is present in water. Water bodies receive oxygen from the atmosphere and from aquatic plants. Running water, such as that of a swift moving stream, dissolves more oxygen than the still water of a pond or lake. DO is considered an important measure of water quality as it is a direct indicator of an aquatic resource's ability to support aquatic life. Bacteria take up oxygen as they decompose materials.

Dissolved oxygen levels drop in a water body that contains a lot of dead, decomposing material.

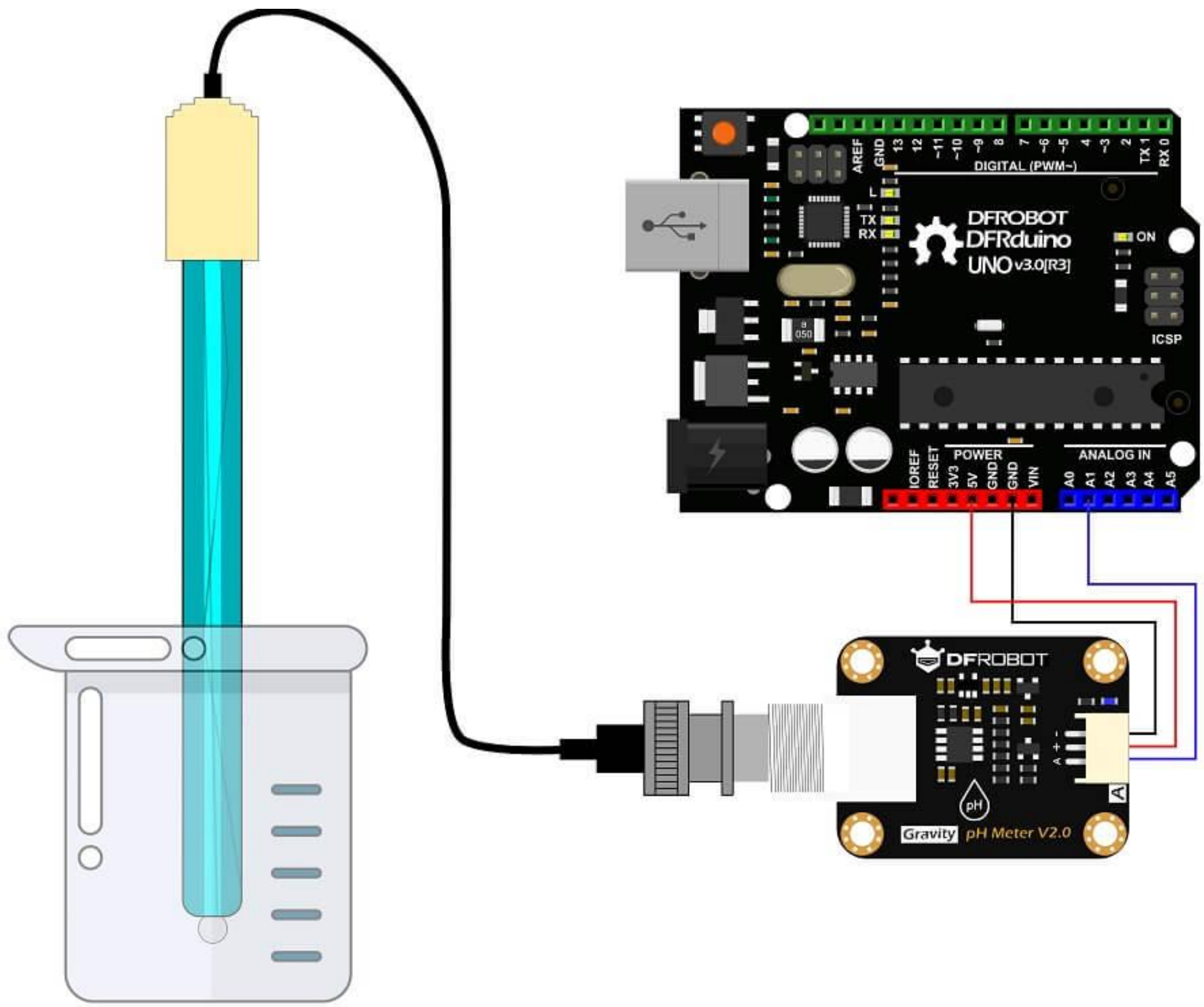
- Conductivity sensor: Measures ability to conduct an electrical current. Presence of ions in a solution that allows the solution to be conductivity. The greater the concentration of ions, the greater the conductivity. Significant changes (usually increases) in conductivity may indicate that a discharge or some other source of disturbance has decreased the relative condition or health of the water body and its associated biota.
- ORP Sensors: Reduction potential (also known as redox potential, oxidation / reduction potential or ORP) is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced. Examples of oxidation include conversion of elemental iron to rust, elemental sulfur to sulfate, and elemental hydrogen to water.
- Power Supply: The power supply that we decided on using for the first iteration is a 9V battery connected to the arduino with a 9V battery clip with 2.1mm X 5.5mm Male DC Plug: Purchase Link

Version 1 Sensors:

pH Sensor: *"Gravity: Analog pH Sensor/Meter Kit V2"*

Description: DFRobot Gravity: Analog pH meter V2 is designed to measure the pH of a solution and reflect the acidity or alkalinity. pH is also known as the hydrogen ion concentration index, meaning pH is a scale of hydrogen ion activity in a solution. pH = 7 is considered neutral, pH < 7 is considered acidic, pH > 7 is considered alkaline(basic) The output signal is analog and comes with its own software library to interface with arduinos or any other control board that is programmable in c++. The library adopts the two-point calibration method, and can automatically identify the two standard buffer solutions it comes with(pH: 4.0 and 7.0). This sensor is IoT so no soldering is necessary.

Schematic:

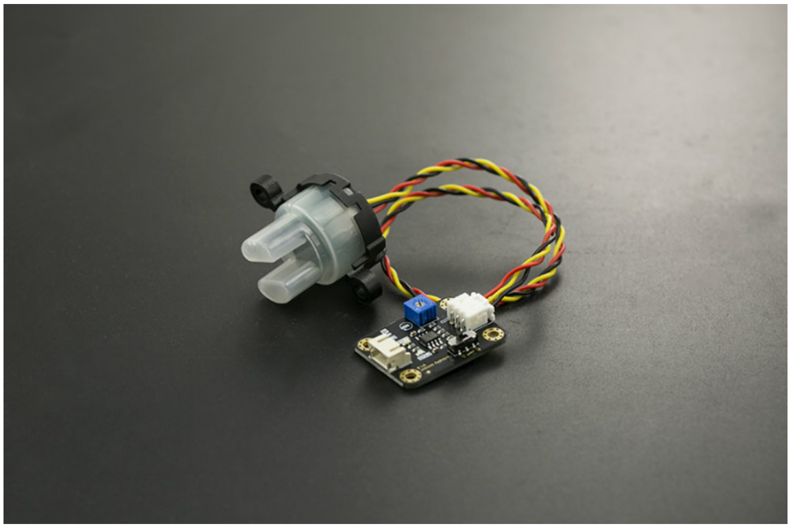


Additional Info:

- [Product Wiki]()

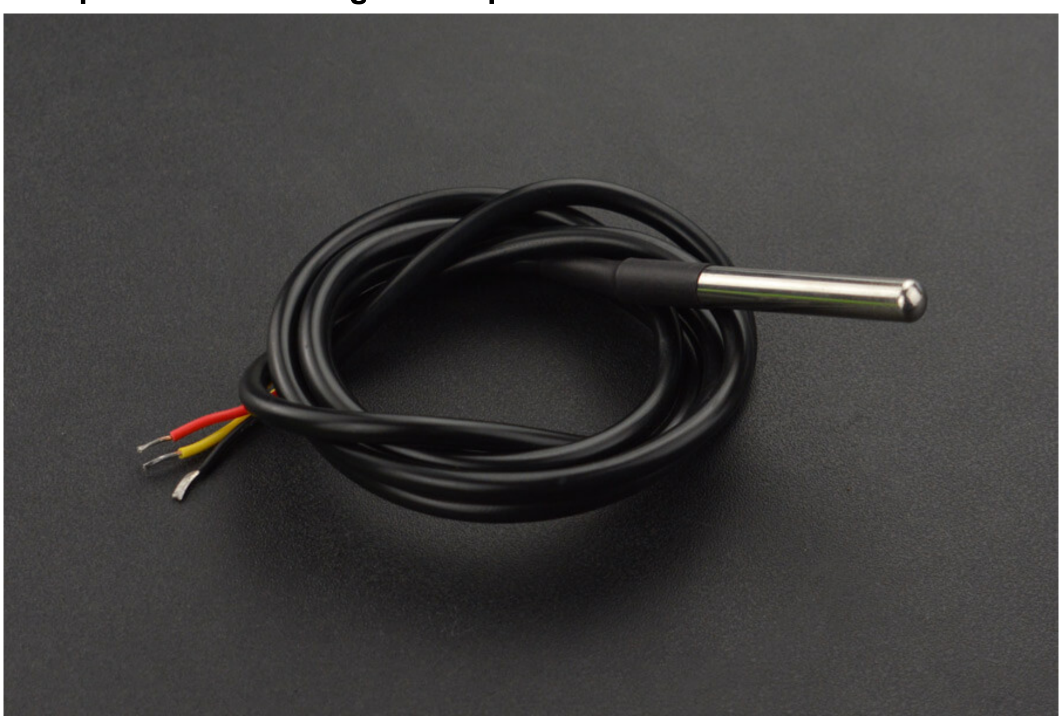
Electrical Conductivity Sensor

Gravity: Analog Turbidity Sensor For Arduino



- Cost: $9.90
- It is able to detect suspended particles in water by measuring the light transmittance and scattering rate which changes with the amount of total suspended solids (TSS) in water.
- https://www.dfrobot.com/product-1394.html

Waterproof DS18B20 Digital Temperature Sensor for Arduino



- Cost: $7.50

- https://www.dfrobot.com/product-689.html

Gravity: KnowFlow Basic Kit - A DIY Water Monitoring Basic Kit

- Cost: $199.00
- Monitor 2 parameters of water: **pH, Electronic Conductivity**
- https://www.dfrobot.com/product-1649.html

Version 2 Sensors:

Gravity: Analog Dissolved Oxygen Sensor / Meter Kit For Arduino

- Cost: $169.00
- https://www.dfrobot.com/product-1628.html

Gravity: Analog ORP Sensor Meter For Arduino

- Cost: $89.00 Only 1 Left
- https://www.dfrobot.com/product-1071.html

pH and ORP inline sensors(American/German)

Chlorine Sensor(American/German)

Chlorine, ORP, Dissolved Oxygen Sensors(Chinese)

Table I. Water Quality Parameters and the WHO Values for Safe Drinking Water

Measurement Parameter	Definition	WHO Standard (Drinking Water)	References
pH	Effective hydrogen-ion concentration (i.e., $pH = -\log[H+]$)	7–8.5 (preferably ≤ 8)	WHO [2011], Yue and Ying [2011], and Wagner et al. [2006]
Turbidity	Amount of solid matter (particles or colloids) suspended in water that obstruct light transmission	1–5 NTU	WHO [2011], Yue and Ying [2011], and Wagner et al. [2006]
Dissolved oxygen (DO)	Amount of DO	5–6mg/l	Yue and Ying [2011] and Wagner et al. [2006]
Residual chlorine detection (RCD)	Amount of chlorine (residual after chlorine-based water disinfection)	2–3mg/l	WHO [2011]
Conductivity (also Salinity)	Ability of an aqueous solution to transfer an electrical current (measure for salinity)	25°C	Wagner et al. [2006]
Temperature	Temperature impacts DO content	Drinking water supply (15°C)	Eckenfelder [2001], Wagner et al. [2006], and WHO [2011]
Fluoride	Salts that form when fluorine combines with minerals in soil or rocks	4mg/l (or 2mg/l, secondary standard)	WHO [2011] and Analytical Technology, Inc. [2015]
Calcium hardness	Amount of calcium salts (reacts with most detergents and can reduce the effectiveness of the cleaning process)	75–100mg/l	WHO [2011] and Cotruvo [2011]
Total dissolved solids (TDS)	Amount of inorganic salts and small organic matter	600–1,000mg/l	WHO [2003, 2011]
Magnesium hardness	Amount of magnesium salts (causes an undesirable taste and stains laundry)	50–100mg/l	WHO [2011] and Cotruvo [2011]
Manganese	Mineral that naturally occurs in rocks and soil and is a normal constituent of the human diet	<0.1mg/l	WHO [2011] and Connecticut Department of Public Health [2015]
Sodium	Essential mineral that is commonly found in the form of sodium chloride (salt)	~200mg/l	WHO [2011] and WA Health [2012]
Hydrogen sulfide	Formed by sulfur and sulfate-reducing bacteria that can occur naturally in water	0.05–0.1mg/l	McFarland and Provin [1999] and WHO [2011]
Oxidation reduction potential (ORP)	Capacity to either release or accept electrons from chemical reactions; influences the life span of bacteria in water	650–700mV	Suslow [2004]

Kofi Sarpong Adu-Manu, Cristiano Tapparello, Wendi Heinzelman, Ferdinand Apietu Katsriku, and Jamal-Deen Abdulai. 2017. Water Quality Monitoring Using Wireless Sensor Networks: Current Trends and Future Research Directions. ACM Trans. Sen. Netw. 13, 1, Article 4 (February 2017), 41 pages. DOI:https://doi-org.csulb.idm.oclc.org/10.1145/3005719