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Objective and Scope Overview

The objective of this project is to build the pH and temperature meter with the help of Arduino and pH and temperature sensor in order to create a tool for water quality assessment. The success criteria of this project is to be able to write a functioning code for pH and temperature sensor and able to represent the result by using Node-red and Grafana.

Introduction

WATER POLLUTION

In the past few centuries, humanity is facing with countless issues but one of the major ones are the problems relating to water quality and contamination. Water pollution problems have a very wide range of impacts; it does not only affect humans but also animals as water is the key of life. There are no borders for water like for countries. Water is also known as "Universal Solvent" as it can dissolve almost everything and because of this, water can be easily contaminated. Contaminations can be transported from one place to another in a short period of time. Even though, they are invisible to humans' eyes but it does not change the fact that many aquatic organisms are suffering by the pollutions human had caused.

There are four types of contaminants associated with water contamination: Organic, Inorganic, Biological and Radiological contaminants. Firstly, Organic contaminants create contamination through

organic materials such as pesticides, domestic and industrial wastes, etc. This type of contaminant can cause serious illness to living organisms such as hormonal disruption, nervous system disorder and cancers (Sharma and Bhattacharya, 2017). Most pesticides contain endocrine disrupting chemicals which can cause thyroid and reproductive system abnormality in humans (Lauretta et al., 2019) and can cause the changes in immunity and behavior, skeleton deformities and lower reproductive ability in aquatic animals such as sea turtles (Cocci et al., 2017). Secondly, inorganic contaminants are elements or compounds found in water supplies caused by mining, industry, agriculture or naturally occurrence. Examples of inorganic contaminants are mercury, fluoride-bearing minerals and arsenic. Short term exposure to these contaminants can cause kidney stone and dental and skeletal fluorosis, while, long term exposure can cause many types of cancer (Sharma and Bhattacharya, 2017). Thirdly, biological contaminants are living organisms such as pathogens, algae, bacteria or viruses (Sharma and Bhattacharya, 2017). Lastly, radiological contaminants are caused by radioactive elements and can cause serious deformation in bone structure and many types of cancers (Sharma and Bhattacharya, 2017).

CAUSES OF WATER POLLUTION

Water pollution can be caused by various reasons but most countries are suffered most from chemicals and waste discharge from industrial area, municipalities and agricultural land. As a result of a rapid growth of industries, it became one of the biggest sectors that contribute to the water contamination. Industrial discharges normally are dumped into the water bodies like river and ocean without a proper treatment and they contain heavy metals, organic sludge and inorganic waste. Moreover, toxic substances emitted through air also have indirect effect to the increase of pH value of nearby water source as they cause acid rain. Municipalities wastes contains many things ranging from cleaning agents to plastic materials and other chemical used in household including cosmetics. Micro-plastics contamination is becoming one of the leading issues. Seafood and other products made with water and salt could be the major routes of human exposure to micro-plastics as seawater contains high amount of micro-plastics (Smith et al., 2018). Lastly, agricultural land is accounted for 70 percent of water abstractions worldwide (Mateo-Sagasta et al., 2017). Chemicals discharge from farmlands contain high amount of agrochemicals, organic matter, drug residues and pesticides which can cause huge negative impact to human health. For example, high level of nitrates can trigger blue-baby syndrome which is a fatal illness that cause methaemoglobinemia (Mateo-Sagasta et al., 2017).

POTENTIAL RISKS OF WATER POLLUTION

In the aspect of the risks of water contamination to public health, the impact that is experienced by more than 35 percent of world population is the lack of access to clean water (Prüss-Üstün et al., 2008), while around 780 million people do not have the access to the improved water source (Centers for Disease Control and Prevention, 2016). Moreover, contaminated water can contain pathogens and toxic chemicals that can cause serious illnesses to the drinkers and even more severe in children as the immune system in children is weaker than in adults. The diseases and illnesses caused by unclean water are, for example, Soil-transmitted Helminths (STH), Guinea Worm Disease (GWD), diarrhea from bacterial diseases and acute poisoning from toxic chemicals intake. STH is a type of parasitic disease which occurs mostly in the area where water supplies are unsafe and inadequate sanitation. The parasites feed on the host tissues and blood which can lead to malnutrition, abdominal pain and impaired cognitive and physical development (Samuel, 2017). GWD is a disease caused by female nematode *Dracunculus medinensis* which emerges painfully and slowly from the hosts' skin (Cairncross et al., 2002). Aside from the mentioned health risks, water contamination also contributes to food shortage. Water is the main element in agriculture and livestock. Animals are the same as

human, they need clean water in order to grow and survive. When the water source contains toxic chemicals, it can cause short and long term effects to animals which can then be transferred to human if that animals were to be eaten. As a result from research done by Evers et al., 2011, among 15 fish species consumed by people and wildlife in the Great Lakes region around 6 species contain mercury concentrations above 0.3 ppm, while the threshold is at 0.27 ppm. Even though the potential risks of water contamination to animals are not as well-known as those in affecting human health, but the excessive amount of nutrients released from agriculture can cause algal blooms and cyanobacterial growth on the water surfaces which will reduce the amount of sunlight penetrating through the water and the amount of oxygen in water will be reduced to the uninhabitable level which can contribute to some aquatic species extinction in that area and, as mentioned above, endocrine disrupting chemicals are presence in most pesticides which can cause behavioral and immunity system change and lower toxicity and environment persistence (Burkholder et al., 2007). Moreover, it was reported that the high density of chemical such as ammonia released from the concentrated animal operation in North Carolina had caused major kills of freshwater fish of all species (Burkholder et al., 1997).

WATER QUALITY MONITORING

Water quality monitoring is important as water is the main component of living beings' bodies. By intaking contaminated water it can cause harms and serious illnesses as mentioned above. The parameters that are needed for water contamination assessment in this project are temperature and pH level. The most common physical assessment of water quality is temperature as it impacts both chemical and biological characteristics of aquatic organisms and the surface water. For aquatic organisms, the higher the water temperature the higher the rate of chemical and metabolic reactions including photosynthesis of aquatic plants. However, with the increase of temperature it can cause the reduce of dissolved oxygen in water surface as warm water is less capable of holding dissolved oxygen. And this is where the problem begins, when the rate of chemical reaction and metabolism in aquatic organisms increase, the oxygen demand will increase at the same time but with low ability to hold oxygen of warm water it can cause oxygen shortage for living aquatic beings. The second parameter that will be used to indicate the water quality is the pH level as it shows how acidic or basic the water is as well as the level of contamination of that water source. The pH level also determines the solubility and biological availability of chemicals such as nutrients and heavy metals (USGS, 2020). High pH level in water can reduce the effectiveness of the disinfection of chlorine for domestic use which can cause the bitter taste, the contamination of calcium, magnesium and pathogens, while, low pH water will corrode or dissolve pipeline material which can cause heavy metal contamination (USGS, 2020).

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