## Water Quality Analysis

Abstract

* Water pollution always occurs in Malaysia due to industrial, construction, agriculture, and household activities. River pollution can disturb water supply that eventually affects business and household activities. Thus, water quality monitoring system is needed to detect contaminated water.
* We developed a water quality monitoring and filtration system controlled by Arduino. The proposed system was designed in Proteus software and ThingSpeak platform was used for real-time monitoring. The main objective of the study was to compare water quality of river, lake and tap water in terms of pH, temperature, turbidity, electrical conductivity and oxidation–reduction potential. If the water quality was not satisfied, the water sample would be filtered through filtration system. Water turbidity level, pH, temperature, electrical conductivity, and oxidation–reduction potential for filtered and nonfiltered water were compared and analyzed according to international and national water quality standard.
* Besides that, statistical analysis such as box plot and one-way analysis of variance test was applied to validate data from the system. The real-time water quality monitoring system was implemented through data storage, data transfer, and data processing. The system was connected to wireless fidelity whereas the output data was sent to the user and monitored by ThingSpeak. The system can be further upgraded and scaled up to be applied in the main tank at our home or factory. The outcome of this research can be used as a reference for further study on lake and river pollution monitoring system.\

Introduction

* Surface water and groundwater are the main water supplies for Malaysia. Although Malaysia has abundant water resources, the accelerating pace of industrial development and population growth in recent decades has affected the quality of water (Bao [2010](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR7)). Pandemic issue, Covid-19 also affects water quality when the non-essential services such as work for development project are ceased (Najah [2021](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR25)). Domestic sewage, waste, and discharge from agriculture and manufacturing industries are the main sources of river pollution. Groundwater sources near agricultural areas, radioactive waste landfills, municipal water supply sources, and waste dumps are mostly polluted with arsenic, iron, lead and others (Khalit [2008](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR21); Bilal et al. [2016](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR8)). Water pollution increases in parallel with the country development that shows the requirement to detect water pollutants. Detection system was built to recognize metal ions in water using colorimetric sensors (Alberti et al. [2020](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR2)). Raril and Manjunatha ([2020](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR29)) developed a system that traced mercury and lead ions in water through the usage of polyglycine-modified graphene paste electrode. Each pollutant has distinct characteristics that can be traced. Thus, the detection system needs to be fast, accurate, and continuously up to date.
* Monitoring water quality was previously done based on temporal and spatial scales which used multi-metric indices and operational indicators (Sany [2018](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR32)). The quality of water in canals, drains and irrigation wells were analyzed and compared using MODFLOW software which could forecast the effects of surface water on groundwater in long-term period (Galal et al. [2020](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR16)). It is essential to measure and monitor physical, chemical, and biological parameters of water in order to identify its quality. Then, types of water treatment can be identified before it can be supplied to consumers as tap water and drinking water (Huang et al. [2015](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR17); Alsulaili et al. [2015](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR5)). Elsheikh et al. ([2018](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR12)) compared three different types of water filtration systems and allowed assessment and evaluation to be made towards the execution and fulfillment of each water filtration systems. Delgado et al. ([2020](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR9)) determined the effect of illegal mining on the water quality by applying grey system. By applying grey clustering method, water quality was grouped into three categories: good, moderate, and low water quality. Supriyono et al. ([2020](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR31)) developed a telemonitoring system that automatically measured and collected variables of water and air quality in coastal fishponds and continuously displayed the data to the user.
* Water quality management and monitoring networks are also crucial. The allowed wastewater discharge rates for contaminant resources depend on two factors: treatment costs and water quality standard (Aghasian et al. [2017](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR1)). Aghasian et al. integrated water quality simulation model with particle swarm optimization model and developed various pollution loadings discharge policies using bankruptcy method. Results showed that the proposed model reduced the salinity of the allocated water demands leading to a decrease in salinity discharged into the river. Genetic algorithm was developed to minimize wastewater treatment costs and dissolved oxygen violation from the standard level. This method was estimated to reduce waste load from 145.5 to 79 and treatment cost from the range of ($160,000–180,000) to ($100,000–130,000). Thus, the proposed models can satisfy water quality with low treatment cost (Farjoudi et. al. [2020](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR38)). Meanwhile, monitoring network of groundwater was designed using DRASTIC method and capture zone analysis where the design was developed according to monitoring wells priority. Differential Evolution (DE) algorithm was used to optimize the DRASTIC model in order to find the highest correlation between high and vulnerable areas of electrical conductivity. The authors claimed that by proper estimating vulnerability of existing wells and the capture zones, the monitoring wells could be prioritized (Yousefi et. al. [2021](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR37)). Thus, proper water quality monitoring, filtering, and treatment methods are needed.

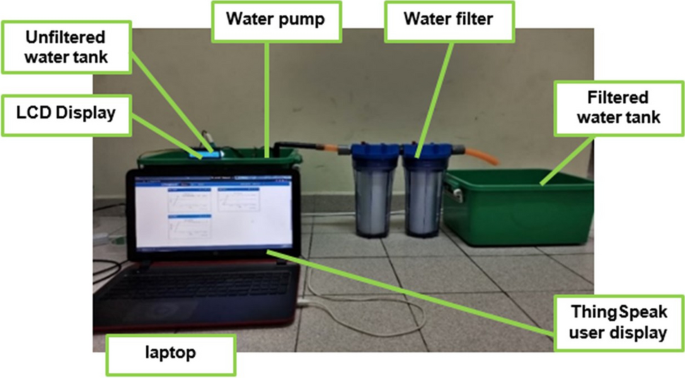
Existing

* a)
* *Water sampling method*
* Water samples were collected from Mahang River, a lake in Universiti Sains Islam Malaysia, and tap water. We monitored pH, turbidity, temperature, electrical conductivity (EC), and oxidation–reduction potential (ORP) of the samples from 9:00 a.m. until 6:00 p.m. for 10 h. Water samples were also transferred into a tank to undergo filtration process. Readings from the sensors were collected, translated and processed by the microcontroller before being displayed using LCD and uploaded into cloud storage for monitoring.
* b)
* *System design*
* We designed a water monitoring and filtration system using sensors to detect temperature, pH value, oxidation–reduction potential (ORP), electrical conductivity (EC), and turbidity. A microcontroller unit consisted of Arduino Uno and Mega, was used as the main controller. We also used a data transmission block, ESP8266 Wi-Fi module and a water filtration unit which consisted of a water pump and a water filter.

Proposed

* Analysis of variance (ANOVA) is a statistical method that is useful to give important information like interpreting outcomes of an experiment and identifying the influence of a factor on the processing parameters by comparing the mean values of some samples (Ostertagova [2013](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR26)). One-way ANOVA is used for data that are divided into several groups associated with only one factor. The mean values are compared to determine the significant level of differences in the associated population of samples. One-way ANOVA test produces *F* value (Eq. [1](https://link.springer.com/article/10.1007/s13762-022-04192-x#Equ1)) (Sullivan [2021](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR30)) and *p-value*.
* is the size of *j*th group,  is the sample mean in *j*th group, is the overall mean, is the number of independent groups and  is the total number of observations in the analysis (Sullivan [2021](https://link.springer.com/article/10.1007/s13762-022-04192-x#ref-CR30)).  represents mean squares, thus  is the mean sum of squares between sample groups and  is the mean sum of squares within the sample groups. *F* value is used to determine *p-value* where the *p-value* is the probability of *F* statistical values that measures the evidence to accept or reject hypothesis. To evaluate the null hypothesis, the differences between means are identified by comparing the *p-value* with the standard significance level, 0.05 (Ostertagova 2013)

System Requirement

* Water quality analyzers are used for monitoring process chemistry including water quality, providing process optimization and control. Water quality parameters are of three types – physical, chemical and biological – and are tested or monitored according to the desired water parameters. Water quality parameters often sampled or monitored include pH, ORP, conductivity, dissolved oxygen, chlorine, salinity, ozone, and corrosion rate. However water monitoring may also include measurement of chlorophyll, blue-green algae, ammonia nitrogen, nitrate, fluoride ions, or laboratory parameters such as BOD, COD and TOC.
* Water quality analysis is essential for protecting capital assets including boilers and cooling towers, by preventing corrosion, minimizing maintenance, and maximizing uptime.
* Apure is a recognized world leader for reliable liquid analytical equipment, providing accurate and repeatable solutions for maintaining and controlling even the most demanding process applications with unparalleled ease of operation.
* [](https://link.springer.com/article/10.1007/s13762-022-04192-x/figures/4)
* The proposed technique of monitoring water with water filtration system

| **SELECTION OF PARAMETERS**  **SELECTION OF PARAMETERS**  **SELECTION OF METHODS**  **PRECISION AND ACCURACY OF METHOD SELECTED AS PER REQUIREMENT**  **PROPER SAMPLING**  **PROPER LABELING**   | CHAIN-OF-CUSTODY PROCEDURES | | --- |   **PRESERVATION**    **ANALYSIS**  **REPORTING** Figure -1: Steps for Water Quality Analysis |
| --- | --- |

System design

* # Proportion of missing values by column  
  def isnull\_prop(df):  
   total\_rows = df.shape[0]  
   missing\_val\_dict = {}  
   for col in df.columns:  
   missing\_val\_dict[col] = [df[col].isnull().sum(), (df[col].isnull().sum() / total\_rows)]  
   return missing\_val\_dict  
    
  # Apply the missing value method  
  null\_dict = isnull\_prop(df)  
  print(null\_dict.items())
* # Create a dataframe of the missing value information  
  df\_missing = pd.DataFrame.from\_dict(null\_dict,   
   orient="index",   
   columns=['missing', 'miss\_percent'])  
  df\_missing

**Conclusion**

* In conclusion, water pollution is a detrimental issue that leads
* to water cut, health problem and a threat to aquatic life. Monitoring water quality is important to control water pollution. Here, water quality monitoring and filtration system was designed using Proteus software.
* Arduino was used as the main controller and five sensors were applied to detect physical parameters of water to monitor water quality. The data is analyzed based on three types of water samples, tap water, lake and river in Nilai, Negeri Sembilan, Malaysia.
* The purpose of this research is to investigate and monitor the turbidity level, pH value, temperature, electrical conductivity and oxidation–reduction potential of three different types of water resources in Malaysia. The study shows that tap water that is supplied to the household, has the safe range of turbidity and pH. The filtered lake and river water which give lower turbidity and neutral pH values than the unfiltered samples prove that the filtration system is crucially needed for the household use.
* Tap water shows the highest electrical conductivity and oxidation–reduction potential due to chlorine that is used for treating the water. The data analysis is done using box plot and one-way ANOVA test. The ANOVA test shows that the sensing parameters can be used to monitor water quality.
* The ThingSpeak application gives real-time and continuous water quality monitoring system. The research outcome is important to analyze water quality in Malaysia before it can be safely used by consumers. The system can be upgraded using high endurance and capacity of microcontroller and sensors. Then, it can be applied in the groundwater source or tank at home. We believe the proposed system can assist Malaysia government in closely monitor physical parameters of water quality and indirectly mitigate water pollution issues.

