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LABORATORY INVESTIGATION ON WATER QUALITY OF SPRING WATER FOR SMALL COMMUNITY AND WATER SECURITY

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ABSTRACT: Water has become a necessity in our daily life. The impact of unsafe water on the consumer is critically alarmed and has contributed human health problem. An alternative clean water sources as a water supply should be sustainable solution to overcome this problem. Malaysia is located at the equator to have rain and hot weather along the year. Therefore, the possible use of spring water as an alternative clean water source will improve the quality of water consumption especially for small community in rural area. The aim of this study is to investigate the performance of spring water sources located in National Defence University of Malaysia (NDUM) campus to support the Green Campus champaign. The spring water analysis was performed for various physicochemical during February 2020. Temperature, pH, electrical conductivity, total dissolved solid, total suspended solid and dissolved oxygen were measured to generate water quality index. The results demonstrated the water samples were found to be suitable for use were within permissible limits except pH were close to or exceeded the permissible limit of standards, which indicates that requirement of treatment prior to use. The outcome of this study may contribute to propose the new way of monitoring water quality in campus by using real-time system. In addition, the outcome also to provides the baseline information about water quality for the welfare of society, support the green campus campaign and that may also help in future water security and sustainability planning for the NDUM campus area.

Keywords: Water Quality Monitoring, Spring Water, Sustainability, Water Security

1. INTRODUCTION

Water has become a necessity in our daily lives. Water is the most important natural element for human, health, ecological, biological and environmental. Other than be used as drinking, water also is an essential component for industry, and agriculture processes. In 2013, the average usage of water per day for Malaysians is 210 liters, while in 2014 the value increased by 2% which means 12 liters or about 141 bottle of 1.5 liters water bottle [1]. However, the amount of water usage in 2018 has increased to 300 liters per person. The value set by United Nations (UN) is 165 liters per person [2]. The amount is enough for a person's basic daily needs and yet Malaysians use almost double that value. The trend of excessive usage of water in Malaysia might raise water shortage problems. According to [36] and [37] water shortage occurs when freshwater supplies are insufficient to supply the standard water demand due to pollution, less of precipitation or droughts. The lack of clean water will be forced people to drink unsafe water, this will lead to more diarrhea cases which is the second leading cause of death in children [21]. More than 600 million people utilize unimproved drinking water sources worldwide including unprotected wells, springs and surface water [34].

World water day celebrates water and raises awareness of the 2 billion people living without access to safe water. It is about taking action to tackle the global water crisis. The focus is to support the achievement of Sustainable Development Goal (SDG) 6: Water and sanitation for all by 2030. This year, 2022 theme is “Groundwater is invisible, but its impact is visible everywhere”. This event is to support three themes which is to minimize the contaminant in groundwater, implement integrated water management at all planning levels and to maximize water efficiency and adapt withdrawals to water availability [3].

Besides natural water resources like streams, lakes, and river basins, alternative water sources are also started eagerly by humans to overcome the scarcity of water in the future. By exploring new water resources and inventing recent technologies [23,24, 25], the current agencies generate extra or replace the current water supply to reach the water demand for the current situation and future generations [4].

In Malaysia, surface water and groundwater are the main source of water supply for drinking [26], domestic, industrial, and agricultural purposes. Spring water is one of the most important for humans as a source of fresh water, especially in arid regions which have a lack of annual rainfall [27]. Spring is an opening at or near the surface of the Earth for the discharge of water from underground sources or directly into the lake, sea, or steam.

The quality of spring water sources varies widely, depending on the location and environmental factors [28]. The quality of water discharged by a spring depends on the type of aquifer and rock strata through which the water has passed, the temperature along the route and the volume of circulating water, past and present [5]. Water quality expresses the suitability of water for various applications including drinking, industrial water supply, irrigation, and generation of hydro power. Because it directly impacts people's live, water quality research is a top concern that demands increased commitment from policy makers.

Monitoring water quality offers the data required to help policymakers make important decisions regarding water quality management for today and in the future. In addition, it served as a tool to preserve other beneficial uses of water and to inform the public about current, ongoing and developing issues as well as to assess if drinking water requirements are being met.

Water quality is indicated by various physical parameters such as pH, total solids, total dissolved solids (TDS), total suspended solid (TSS), dissolved oxygen (DO), hardness, chlorine content and many other related parameters. Water quality index (WQI) is a measure of the physical, chemical and biological characteristics of water [29]. Recently, several studies have focused on monitoring spring water quality in international [33,35] and Malaysia [6, 7, 8, 9]. In Malaysia, spring water quality evaluation and monitoring have received little attention, therefore, these types of analyses are needed to understand the physiochemical and quality changes of spring water.

This study supports the green campus campaign in NDUM by providing the initial data collection for water security and sustainability planning in future. Green campus campaign has been introduced in NDUM campus as one of efforts to support sustainable development goal set by United Nation. Several studies have been performed to identify the potential of natural and environment resources in NDUM campus for further action including wetland [10], recycle waste [11], solar energy [12] and other study related [13].

The primary objective of this study is to assess the quality of spring water by determining the parameter of water samples from NDUM campus locations. The selected physio-chemical parameters were analyzed (Dissolved Oxygen, Temperature, Total Suspended Solids, Total Dissolved Solids and pH) to decide if it safe for domestic uses.

2. RESEARCH SIGNIFICANCE

The study of water quality monitoring provides empirical evidence about the physical, chemical, and biological aspects of a body of water resources. An alternative water source has been found on NDUM campus. Spring water can be an alternative water source for a small community on NDUM campus.

In this study, the water quality of spring water located in NDUM campus was measured and monitored. The water quality results were classified based on National Water Quality Standard [14] and World Health Organization (WHO) parameters [15]. The data collection includes five (5) parameters (Dissolved Oxygen, Temperature, Total Suspended Solids, Total Dissolved Solids and pH) chosen as the initial factors in determining the spring water quality. The data is particularly important for water security and sustainability planning in future planning in NDUM campus. It is also important for decision-making about human and environmental science related. In addition, this study supports the green campus campaign at NDUM.

3. MATERIALS AND METHODS

3.1 Study Area and Sampling Sites

The study area is in the NDUM campus area, which is 10 kilometres from the city of Kuala Lumpur, Malaysia and close to Sg. Besi. There are roughly 3000 residents in the campus neighborhood including staff and students. The map of NDUM campus is shown in Fig. 1 and the location of the investigated springs in NDUM campus is presented in Fig. 2, Fig. 3 and Fig. 4. Sg. Besi is a town and suburb area, and the climate is considered humid throughout the year. The town is easily accessible from the main highway. The campus is situated in the Malaysia Army forces camp at Sg Besi Kuala Lumpur. The average daily temperature is between 21ºC and 32ºC. The area receives an annual rainfall of 750-900 mm. The major water sources are streams, lake, and groundwater. There is a lake and some of the small watershed under the hilly area in the campus. There are still many unexplored areas within the UPNM campus. Spring water sampling points were spotted on the NDUM campus near hilly area.

3.2 Data Collection and Analysis

Water samples were collected from the sources of spring water locations and some parameters have been tested on-site and other parameters was tested in the Civil Engineering Department NDUM environmental laboratory. Sampling was undertaken from February to April 2020 between wet (Northeast Monsoon from October to March) and dry (Southwest Monsoon from April to September). The water samples were placed in 500 ml polyethylene bottles that were rinsed with distilled and rinsed several times in spring water at site during sampling and then filled with water. A total of sixteen samples were collected. These bottles containing water samples were later transferred into a cooling box and stored in a refrigerator at 20ºC for water quality analysis.

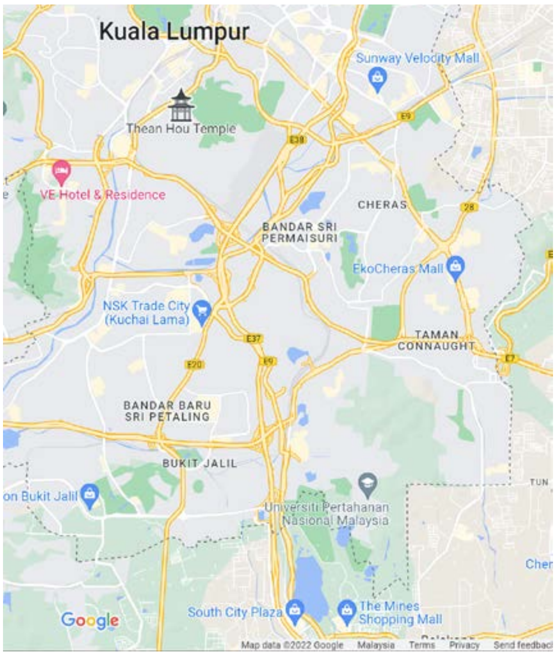

Fig. 1 The location of NDUM campus

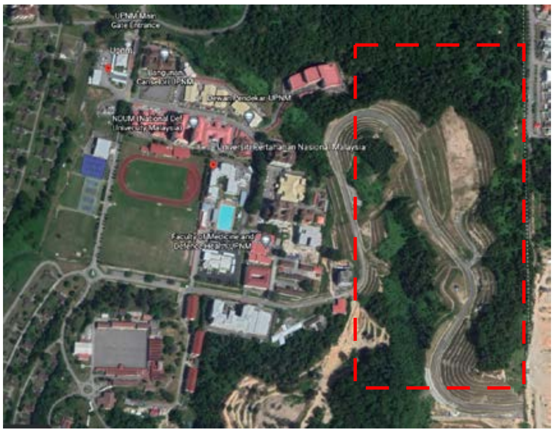
Fig. 2 The location of spring water in NDUM campus

The water quality analysis involved several parameters including temperature (°C), pH, electrical conductivity (EC), total dissolved solid (TDS), total suspended solid (TSS) and dissolved oxygen (DO) in accordance with the procedures delineated in the standard guideline described by [14] and [15]. Electrical conductivity (EC) and pH of each water sample were measured in-situ. The water quality assessment from other water resources around UPNM (i.e. groundwater [16], tap water [17] and rainfall [18] was used as a control.


Fig. 3 The location of spring water in NDUM campus


Fig. 4 The location of spring water in NDUM campus

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3.1.1 Temperature

Temperature is one of the factors that affect water density and dissolved oxygen levels in the water. Moreover, temperature control rate reactions and growth of living organisms in water. The variation in temperatures may be influenced by various conditions along its path to the surface. WHO (2011) stated that there is no requirement for temperature as it changes depending on the location of the water source.

3.1.2 pH

pH refers to a quantitative degree of acidity or alkalinity of a water or other liquid solutions. The terms is widely used in chemistry and biology that translate the values of the concentration of the hydrogen ion which ordinarily ranges in between number of 0 and 14 where 7 is being neutral, less than 7 indicate acidity and greater than 7 indicates a base.

3.1.3 Electrical Conductivity

Pure water in general is not a good conductor of electricity. The conductivity in water increase as the concentrations of ions increases due to the facts that electrical current is transported by the ions in solutions. The conductivity in water is the measure of the capability of water to pass electrical flow. This ability directly depends on the concentration of conductive ions in the water. This is proportional to the ion concentration in the water.

3.1.4 Total Dissolved Solids

Water is considered as a universal solvent due to its ability to dissolve and absorb molecules from various substances. TDS is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form. It is including anything present in water except H2O. It also known as any mineral salts, metals, cations or anions that dissolved in water. TDS come from many sources, both natural and man-made. Human and agricultural activity can produce total dissolve solids in water. TDS also used as a parameter to evaluate the quality of drinking water.

The TDS of a water sample based on the measured EC value can be calculated using the equation below:

TDS (mg/l) = 0.5 x EC (dS/m or mmho/cm) or = 0.5 * 1000 x EC (mS/cm)

The above relationship however does not apply to wastewater. [20]

3.1.5 Dissolved Oxygen

The amount of oxygen dissolved in water is referred to as dissolved oxygen (DO). The atmosphere and aquatic vegetation both provide oxygen to water bodies. Running water, such as a fast-moving stream, dissolves more oxygen than stagnant water, such as that found in a pond or lake. Water at lower temperature tends to have higher concentration of DO on the other hand warmer, polluted water have lower concentration of DO. Healty water generally have DO concentrations above 6.5-8 mg/L and between 80%-120%. Levels that are too high or too low can harm aquatic life and affect water quality.

Descriptive statistics, such as mean and standard deviation (SD), were calculated to describe the variation of each parameter.

4. RESULTS AND DISCUSSIONS

The water quality analysis of spring water was determined. The summary of parameters (TDS, pH, Temperature, Conductivity and DO) measured including unit, range, mean, standard deviation and standard references for spring water in NDUM are presented in Table 1.

TDS is frequently used as useful parameter for evaluating the quality of water and for classifying drinking and irrigation water. TDS main purpose is to analyze the amount of inorganic and organic substance contain in liquids. The TDS in natural waters consists of carbonates, bicarbonates, chloride, sulphate, calcium, magnesium, sodium and potassium while dissolved metals and dissolved organic matter represent a small percentage [30]. The results of TDS for the spring water samples shows in Fig. 5. The results reflected that the TDS for spring water and groundwater was around 30 to 300 mg/L and the same reading. The mean TDS was 206 mg/L with standard deviation of 10.8. these variations in TDS values mainly depends on the solubility of minerals in different geological areas [30]. These values are acceptable based on recommended values by WHO [15] which is within 1000 mg/L and 500 mg/L for NDWQS [14].

Table 1 Summary of parameters measured for spring water in NDUM.

Parameters	Unit	Range	Mean	Std Dev	Recommended WHO (2017)	Recommended NDWQS (2000)
Total Dissolved Solids (TDS)	mg/L	30-300	206	10.8	1000	500
pH		6-6.4	6.3	0.6	6.5-8.5	6.5-9.0
Temperature	°C	22-27	25	1.5	-	-
Conductivity	µS/cm	10-100	52	5.8	400	1000
Dissolved Oxygen (DO)	mg/L	5-8.5	6.5	0.8	7	-

Similar trends of result were obtained by [19] but [7] recorded lower concentration of TDS in ground water samples in Selangor, Malaysia. Usually, EC and TDS are related to each other. The more the number of ions, the more will be the value of TDS and furthermore will be the EC [20].

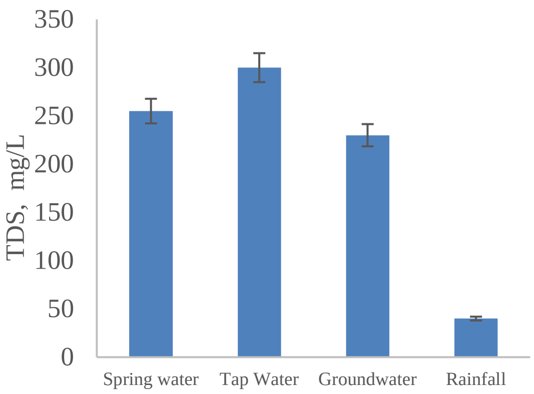

Fig. 5 NDUM campus spring water TDS

pH is another indicator of water quality. The results of pH values for spring water sampling were in range of 6 to 6.4 as shown in Fig. 6. The recommendation of drinking water pH range stated by [15] is in between 6.5 and 8.5. on this basis, all the water samples were almost neutral to slightly acidic. The mean pH was 6.3 with standard deviation of 0.6. Most of the data are around the mean value. The slightly acidic pH value might due to the presence of carbon dioxide gas that dissolved into the water during hydrologic cycle. The carbon dioxide gas existing in water formed weak carbonic acid and thus contributing the acidity properties in water. Overall, the samples sites and controls were found to be acceptable. These values aligned with the finding by [6] and [7] for spring water flow from fractures in granite rocks in Semenyih, Malaysia with pH range of 6.7. [6, 19] reported that the pH of water sources in hot spring around Selangor, Malaysia is characterized as alkaline, and this might be due to geological composition of the region [8] tested a spring water from the hill of Ulu Yam also shows the pH value for hill water is 6.8 and almost neutral. The pH of water and the amount of TDS are related. As the spring water quality in NDUM's potential therefore can be thought. The correlation between pH value and TDS count can explain the water quality is good or not. Furthermore, pH is affected and higher TDS levels leads to higher conductivity where lower pH towards acidic [38].

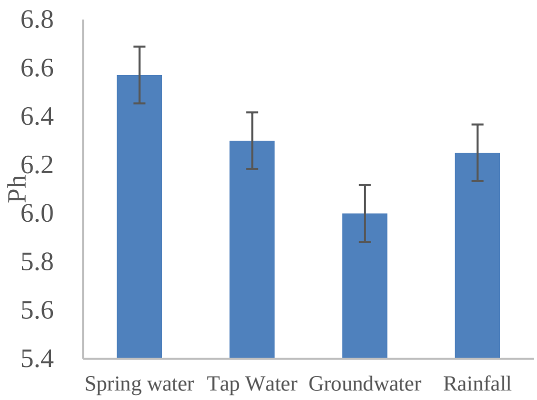

Fig. 6 NDUM campus spring water pH.

The temperature of spring water as shown in Fig. 7 were consistent with other types of water resources in NDUM campus at 25° with a standard deviation of 1.5. The error bar also shows the result is significant. Overall, the samples sites and controls were found to be acceptable. The present study shows related results on range of temperature of spring water flow from fractures in granite rocks near SILK Highway in Malaysia reported in [7]. [19] and [6] reported the high temperature in hot spring water with temperature range between 36°C to 68°C. The difference in temperature may be due to geothermal heating. The temperature values in this study is within the normal temperature.

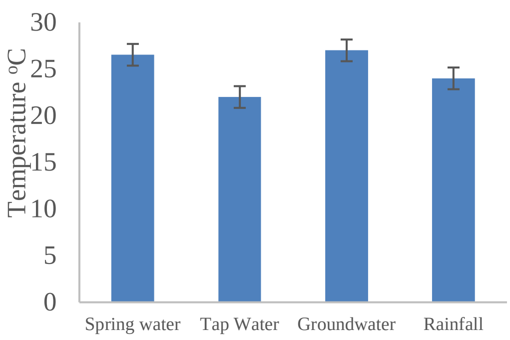

Fig. 7 NDUM campus spring water temperature

Although electrical conductivity measures the ions in water, it does not identify the specific ions that are present in water. The quantity of treatment chemicals that could added to a water sample can be calculated using this parameter [30]. Fig. 8 show the results of conductivity for the spring water in NDUM campus. The graph shows the value for the location fluctuated slightly throughout the testing period. The conductivity values in all sampling were in the range of 10 µS/m to 100 µS/m. The highest conductivity recorded is 100 µS/m. On the other hand, the lowest data recorded is 10 µS/m. The low value of conductivity indicates a smaller number of ions present in the water sample, making it suitable to consume. A similar trend was found in the work conducted by [7]. The research conducted by [19] shows an average result of 505.9 µS/m. According to [6] the spring water has an average conductivity value of 443 µS/m. The average value for the conductivity for this spring water is within the limit of [14] and [15]. Therefore, the water is safe to use for human consumption and for daily activities use including cleaning.

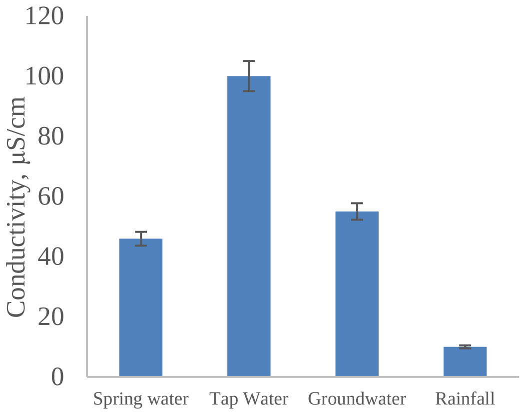

Fig. 8 NDUM campus spring water Electrical conductivity (EC)

Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in the water. The amount of dissolved oxygen in water can helps to determine the water quality as microbiological organism in water utilise the dissolved oxygen in water [17]. The graph (Fig. 9) shows the value for the spring water locations fluctuate slightly throughout the testing period. The DO values in all sampling were in the range of 5.00 mg/L to 8.50 mg/L. The highest turbidity recorded is 8.50 mg/L. On the other hand, the lowest data recorded is 5 mg/L. Therefore, the spring water for this source is safe for consumption as the results the within limit set by WHO and NDWQS. The DO value in the present study shows that it is higher compared to values reported in [6]. The turbidity of spring water flow from the spring water in Jordan by [22] shows that the DO value of 4.63 mg/L. A study on hot spring in Selangor by [19] shows a lower DO value with an average of 3.38 mg/L.

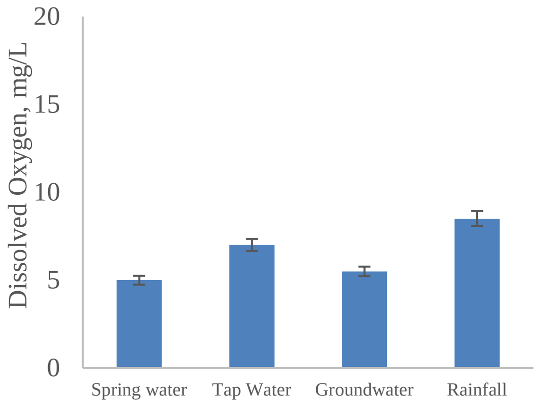

Fig. 9 NDUM campus spring water DO

5. CONCLUSION

A healthy and safety of human and communities' life depends on access to clean water. To prevent numerous diseases, risk assessment and monitoring are crucial since natural water sources, especially groundwater are contaminated. The present study has been conducted to evaluate the quality of spring water in NDUM campus based on several parameters. The physical quality of NDUM spring water had a pH of 6.3. The spring water samples had a mean of 25ºC of temperature. The NDUM spring water shows a TDS of 206 mg/L. The mean electrical conductivity of the samples is 40 µS/cm and the mean of DO values show 5mg/L.

The NDUM spring water samples were found to be suitable for use were within permissible limits or Malaysia and WHO standards. As discussed earlier, the water sample is slightly acidic due to the presence of carbon dioxide gas which contributes to the formation of weak carbonic acids. In general, is not recommended for consumers to drink directly without analyzing the water in the laboratory. The outcome of this study may contribute to propose the new way of monitoring water quality in campus by using real-time system.

In the future, biological and chemical testing should be conducted to fully assess the quality of the spring water to be used for drinking. However, it is also important to investigate other potential water contamination such as microbial and radiological for longer periods to assess the overall water quality of NDUM.

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