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Assessing Groundwater Quality for Agricultural Applications in Bemban, Melaka: Implications for Sustainable Farming Practices

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ABSTRACT – Groundwater's significance in safeguarding food security becomes even more critical, particularly amidst the unpredictability of climate change. The utilization of groundwater in Bemban remains significantly underutilized, even though the local villagers engage in small-scale agricultural practices with a focus on sustainable productivity. Several agriculture practitioners rely on river water for irrigation purposes; however, the combination of a hot climate and limited water availability adversely affects crop growth, leading to stunted plants and diminished agricultural yields. This research aims to evaluate the groundwater and river water quality in comparison to guidelines from the National Water Quality Index Classification and Water Quality Interpretation Guidelines for Irrigation in Bemban, Melaka. Two groundwater sampling wells along with a nearby river were utilized to collect representative samples, which were subsequently analyzed for various key characteristics including pH, ammoniacal nitrogen (AN), total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), biochemical oxygen demand (BOD), electrical conductivity (EC), total dissolved solids (TDS), and turbidity. The test results were compared with the guidelines provided by the National Water Quality Index Classification (NWQS) and Water Quality Interpretation Guidelines for Irrigation. The results show the parameter pH and COD are within the acceptable tolerance range, indicating that The water can be used for irrigation. The research findings will encourage agriculture practices to utilize their well water for irrigation purposes. This will contribute to enhancing the overall efficiency and sustainability of agricultural practices in the region. Further investigations should focus on finding the parameters for the Groundwater Quality Index (GWQI) for Bemban's agriculture landscape.

KEYWORDS : Agriculture; groundwater; water quality; water test; well

1.0 INTRODUCTION

Water is very important for life in the world. Water sufficiency is a major problem in Malaysia considering that water resources are a critical challenge in sustaining resources in Malaysia. The country is facing several water-related problems such as water scarcity, poor water quality, and insufficient access to clean drinking water. Issues concerning water quality and degradation have garnered attention due to their implication on water resources, the environment, human health, and well-being [1-4]. Although Malaysia has sufficient resources to ensure the availability of safe treated water, it confronts issues and challenges in water management to maintain, govern, and manage water resources comprehensively. The authorities have taken several initiatives to address these issues including increasing public awareness about the importance of conserving water and implementing policies that promote efficient use of water resources [5]. Therefore, as stated by the Malaysia Department of Environment (DOE) in 2021 [6], produces Environment Quality Reports encompassing air, river, groundwater, and marine assessment, aiming to address the impact of human activities in the country. These issues are becoming increasingly severe due to climate change and rapid urbanization [7-10].

The escalating demand for water supply in Malaysia is driven by population growth, industrialization, and water pollution, which necessitates exploring alternative sources of water. Consequently, groundwater emerges as a significant alternative source for the country. In the Malaysian states of Kelantan, Terengganu, Pahang, Sabah, and Sarawak, groundwater is used as a main alternative source of drinking water, while in Melaka, Sarawak, and Selangor, it is a reliable source, especially during the dry season [11]. Groundwater sources are generally clean and simple water sources obtained through the construction of wells, and intake utilizing pipes and channeled into the reservoir [12]. There are various problem statements discovered that the utilization of groundwater water resources supply becomes critical during the dry season [13-15]. The negative impacts of pollution in groundwater stem from human activities such as urbanization, crop agriculture, and natural sources [16]. There are heavy metals in the groundwater samples that result in health problems for drinking water [7,13,17]. Syafiuddin et al. [17] highlighted the importance of groundwater pollution control for future sustainability, while Asadi et al. [19] proposed limiting natural, farming run-off, and urban land utilization as groundwater contamination control. The previous study also found there is a lack of national groundwater policy as a guide and uniform groundwater regulation in Malaysia [20].

Groundwater is recommended for agricultural and domestic purposes, especially in rural and isolated areas. A research study conducted by Harun et al. [21] indicates that using fertilizer and pesticides in Kuala Langat does not significantly degrade groundwater quality. However, in contrast, Saimi et al. [20] found that several parameters in the Langat Basin due to urbanization and industrial development exceed allowable limits, classifying the water as polluted. However, Zainol et al. [22] showed that the Lower Muda River Basin's surface and groundwater water quality is acceptable for drinking and agriculture. A previous study by another researcher also found that the well water quality in Pasir Puteh, Kelantan can be categorized as Class III, indicating the water is suitable for drinking water after the appropriate treatment process [23]. Hashim et al. [24] also emphasized Melaka River has been classified as Class III. The guideline for water quality standards for conventional raw water treatment should be within permissible ranges and groundwater quality can also be assessed using the Groundwater Quality Index (GWQI). Research and innovation are crucial to further enhance groundwater usage. For example, based on data output, Zainurin et al. [25] have created a water quality monitoring system to help farmers use safe irrigation water. Numerous studies have investigated the quality of river and groundwater resources in Malaysia. Despite the abundance of research in the country, there are no recent studies on the use of groundwater for agriculture in Melaka. The absence of research papers examining groundwater and river water quality in the local area creates a significant knowledge gap, hindering the ability to determine the suitability of water for agricultural purposes.

This study was conducted for small-scale agricultural practices in Bemban Melaka, particularly in Kg Tehel Hulu. The dependency on the Melaka River to plant crops causes a problem during the dry season. The challenge of finding access to treated water sources to irrigate their crops is due to the distance of the properties. Furthermore, the treated water is the source that could increase the cost of small-scale agricultural practices. Underground water is one of the alternatives to overcome the issue. However, the usage of murky and moss-infested well water caused several of the planted plants to become stunted, less promising, and less fertile. Therefore, the study intends to compare the river and groundwater quality in comparison to guidelines from the National Water Quality Index Classification and Interpretation of Water Quality Guidelines for Irrigation in Bemban.

2.0 METHODOLOGY

2.1 Study Area

The study site is located in Kg Tehel Hulu, Bemban, Melaka, situated in the southern region of Peninsular Malaysia. It is located between latitudes 2.257688 and longitudes 102.354136. Kg Tehel Hulu is a small village in Bemban in the Jasin District of Melaka, Malaysia. The area is surrounded by farming areas such as fruits and vegetables.

2.2 Water sampling and testing

The location of water sampling stations in Kg Tehel Hulu is shown in Figure 1. Water samples are collected from Melaka River and 2 wells and analyzed according to the desired parameters. Figure 2 shows the well and river utilized by agricultural practices in Kg Tehel Hulu to cultivate crops.

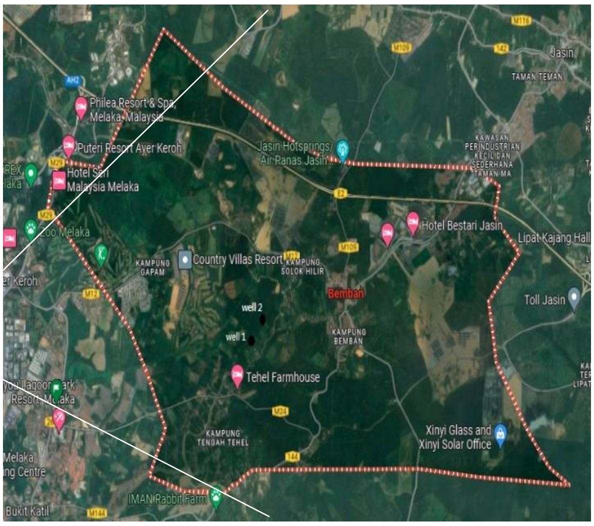

Figure 1. Location of water sampling station in Kg Tehel Hulu, Bemban

(a) (b)

Figure 2: Sources of water used by agriculture practice in the Tehel Hulu (a) well, and (b) river

The parameters testing for samples are turbidity, ammoniacal nitrogen (AN), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total suspended solids (TSS), pH, and electrical conductivity (EC). A portable pump was used to collect underground water samples. According to Feitz et al. [26], the portable pump was utilized to pump the principal groundwater for 15–20 minutes, or at least three times the volume of the well. Water and groundwater samples are obtained from different locations and tested in the laboratory according to the American Public Health Association (APHA) procedure [28].

The Water Quality Index was determined by evaluating six parameters, namely pH, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), ammoniacal nitrogen (AN), and electrical conductivity (EC). The water quality status was then assessed according to the National Water Quality Standards For Malaysia (NWQS). The results were also compared with Panduan Pengurusan Kualiti Air Pertanian [27] for pH, turbidity, total dissolved solids (TDS), and electrical conductivity (EC). The formula to obtain WQI is shown in equation (1) :

$$WQI = (0.22 \times SIDO) + (0.19 \times SIBOD) + (0.16 \times SICOD) + (0.15 \times SIAN) + (0.16 \times SISS) + (0.12 \times SIpH) \quad (1)$$

SIDO : Sub Index Dissolved Oxygen

SIBOD : Sub Index Biochemical Oxygen Demand

SICOD : Sub Index Chemical Oxygen Demand

SIAN : Sub Index Ammoniacal Nitrogen

SISS : Sub Index Suspended Solids

SIpH : Sub Index for pH

Table 1. Illustrates the water classification based on the National Water Quality Standards For Malaysia (NWQS).

Table 1. Water Quality Index Standard

Parameter	Unit	Class				
		I	II	III	IV	V
Total Suspended Solid	mg/l	<25	25-50	50-150	150-300	>300
Chemical Oxygen Demand	mg/l	<10	10-25	25-50	50-100	>100
Biochemical Oxygen Demand	mg/l	<1	1-3	3-6	6-12	>12
pH		>7.0	6.0-7.0	5.0-6.0	<5.0	>5.0
Dissolved Oxygen	mg/l	>7	5-7	3-5	1-3	<1
Ammoniacal Nitrogen	mg/l	< 0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
Water Quality Index		>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

Source: Malaysian Department of Environment (2021) [6]

3.0 RESULTS

3.1 Analysis of water quality using the National Water Quality Standards For Malaysia (NWQS)

Water samples were collected from rivers and wells in Tehel Hulu for analysis. Table 2 shows the test results.

Table 2. Water testing for the Water Quality Index (WQI)

TEST PARAMETER	UNIT	TEST METHOD	RESULTS		
			WELL 1	WELL 2	RIVER
pH	-	In-house Method MBC-TM-212 (MettlerToledo)	6.9 @ 25.4 ºC	6.1 @ 24.4 ºC	6.1 @ 24.3 ºC

Chemical Oxygen Demand (COD)	mg/l	APHA 5220 D (2005)	54.0	51.0	52.0
Biochemical Oxygen Demand (BOD_5)	mg/l	APHA 5210 B & 4500 – O G (2005)	16.0	14.0	8.0
Total Suspended Solid (TSS)	mg/l	APHA 2540 D (2005)	41.0	49.0	32.0
Ammoniacal Nitrogen (AN)	mg/l	APHA 4500 - AN B&C (2005)	8.25	7.8	8.00
Dissolved Oxygen (DO)	mg/l	APHA 4500-OG	10.6	9.2	9.6
Water Quality Index (WQI)			60.34	60.98	62.52
Class			III		
Index Range			Slightly polluted		

The water quality index (WQI) is used to assess the water quality status by calculating the six parameters specified in the National Water Quality Index (pH, DO, BOD, COD, AN, and TSS). Table 2 displays the water test results for well 1, well 2, and river water samples. The pH value for the water samples varies from 6 to 7, with the highest pH value being 6.9 in well 1. This value can be concluded as neutral. In the pH value indicator, pH 1 to 6 indicates acidity, 7 is neutral while pH 8 to 14 is alkalinity. The definition of COD is to measure the amount of oxygen predicted to oxidize natural compounds in water. If the pollution is high, it will give a larger COD value indicator. The COD test results showed that, on average, the results for the three locations were between 51 and 54, which indicates that the water was contaminated. According to the results of the BOD_5 test, the river's BOD_5 value is lower than the well's, indicating that it is less contaminated. Certain microorganisms, inorganic or organic substances, or perhaps both, in well water, can be the cause of this effect as previous studies have stated various inorganic pollutants, such as heavy metals and micro-plastics, and organic pollutants, such as pesticides, synthetic dyes, and persistent organics pollutants, have been produced in large quantities as a result of rapid development of industry and agricultural activities [13]. As for the TSS test, when compared to the TSS value of the well (41 mg/l and 49 mg/l), the TSS value of the river of 32 mg/l is lower. TSS values are considered to be slightly polluted in terms of river and well water quality. As for the analysis of AN parameters, it shows almost the same values for well and river water samples. The DO parameter values for wells and rivers are also not much different which are 10.6, 9.2, and 9.6. Although the DO level is relatively low, it is still within the permissible limits to maintain acceptable water quality. However, the concentration of AN is significantly high for water pollution.

The water quality index for the sample is between 60 and 63. The classification of the sample water according to the National Water Quality Classification Index (NWQS) states that the sample water is classified as class III, which indicates slightly polluted water. Class III can be used to drink water supply according to the water class and other uses such as fisheries and livestock. But for drinking water supply it needs intensive treatment. Nevertheless, for agriculture purposes, water classified as Class III also can be utilized for fishing and livestock drinking purposes. Therefore, there are no concerns regarding the use of water for agricultural practices in terms of crop cultivation. This result was supported by DOE [6], Hashim et al. [24], and Che Osmi [28], the quality of underground and river water in the Melaka Tengah district is categorized as Class III. It should be noted that there is no difference in water quality categorization between the river and wells in terms of water quality in Kg Tehel Hulu, Bemban.

3.2 Analysis of water quality using Guidelines for Interpretation of Water Quality for Irrigation

The related parameters are total dissolved solids pH, (TDS), electrical conductivity (EC) dan turbidity. Table 3 presents the sample parameters alongside their corresponding tolerance limits, as outlined by the guidelines.

Table 3: Water testing using Interpretation of Water Quality for Irrigation Guidelines

TEST PARAMETER	UNIT	RESULT			TOLERANCE LIMIT
		WELL 1	WELL 2	RIVER	
pH		6.9	6.1	6.1	5.0-9.0
Total Dissolved Solid (TDS)	mg/l	117	110	116	≤ 2000 mg/l
Electric Conductivity (EC)	µS/cm	238	302	490	≤ 700 µS/cm (suitable for agriculture)
Turbidity	NTU	5.07	6.1	8.2	≤10

The samples are taken from well 1, well 2, and a river. All three samples have a pH of about 6 to 7, within the pH 5.0 to 9.0 tolerance unit. The EC values for each sample are below 700µS/cm, which is suitable for agriculture. While the TDS about 100 mg/l value is also below the tolerance limit of ≤2000 mg/l. The presence of particles in the water leads to an increase in turbidity. A turbidity test is done to measure how transparent the water is caused by particles. The water sample had a turbidity of less than 10 NTU, making it suitable for use in agriculture. All parameter values tested in this study were within agricultural tolerance limits, according to the Guidelines for the Interpretation of Water Quality for Irrigation. Therefore, the water used in this study is suitable and not contaminated, notwithstanding its turbid appearance.

4.0 CONCLUSION

Water samples from three stations in Kg Tehel Hulu were evaluated for six parameters (DO, pH, COD, BOD, AN, and TSS) using the National Water Quality Index Classification (NWQS). In comparison, four parameters (pH, EC, TDS, dan turbidity) were evaluated using Interpretation of Water Quality for Irrigation Guidelines. According to the NWQS, the samples are in class III, indicating that considerable treatment is necessary for drinking water supply. Water may be utilized for fishing and animal drinking in agriculture. The parameters analyzed using FAO Water Quality for Irrigation indicate within the tolerance limit. The finding of water samples shows the water is suitable for the crops. It is essential in convincing agricultural practitioners to use the well water for irrigation. For further research, the quality of groundwater can be determined using the Malaysia Groundwater Quality Index (GWQI) using several parameters such as Ferum, E. coli, iron, nitrate, sulfate, and phenol. Future studies on the suitability of the soil are also required to determine the characteristics and composition of the soil. The quality and fertility of plants are also affected by soil content [29]. The contribution of the study is consistent with the aims of the Ministry of Agriculture and Food Industry (MAFI) to develop Melaka as an Integrated Agricultural Development Project (IADA) in the southern region. The plan intends to lessen Melaka’s reliance on imports of fruit, vegetables, and seafood [30].

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