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Research Article

Water Security Issues in Inhabited Islands: A Survey on Domestic Water Resources Management in the Sebatik Island, Sabah (Malaysia)

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Abstract

Malaysia is a country rich in natural water resources. The average rainfall annually is high at 2940 mm. High rainfall is essential for surface water (rivers, lakes, ponds) and groundwater supply systems in enhancing the ecological system and natural resources. However, the abundant supply of natural water resources cannot guarantee the existence of water security issues, especially in inhabited island areas such as in the Sebatik island. The definition of water security itself is the ability for each individual to access an adequate supply of clean water at an affordable price to live a productive, clean and healthy life without neglecting the wellbeing of the inhabitants and safeguard the environment. Ironically, it is unachievable if the domestic water supply management in one area is in inadequate control systems and lacks its domestic supply system. In other words, it is still inefficient, unsystematic and not holistic. This will then disrupt the stability of water supply resources in terms of quantity, quality, and accessibility. Therefore, this study aims to examine the potential sources of water supply systems in Pulau Sebatik and discuss how they are managed and controlled for domestic use. Therefore, to answer the objectives outlined, observation, evaluation and interview methods were carried out accordingly. It is found that three main sources of domestic water supply can potentially be developed and should be improved in terms of quality, quantity, and accessibility, namely groundwater, rainwater and surface water. In essence, the water

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security issue that exists in Pulau Sebatik is not entirely due to the lack of natural water supply resources but instead, due to unsystematic, inefficient, and incomprehensive management systems, methods, and structures.

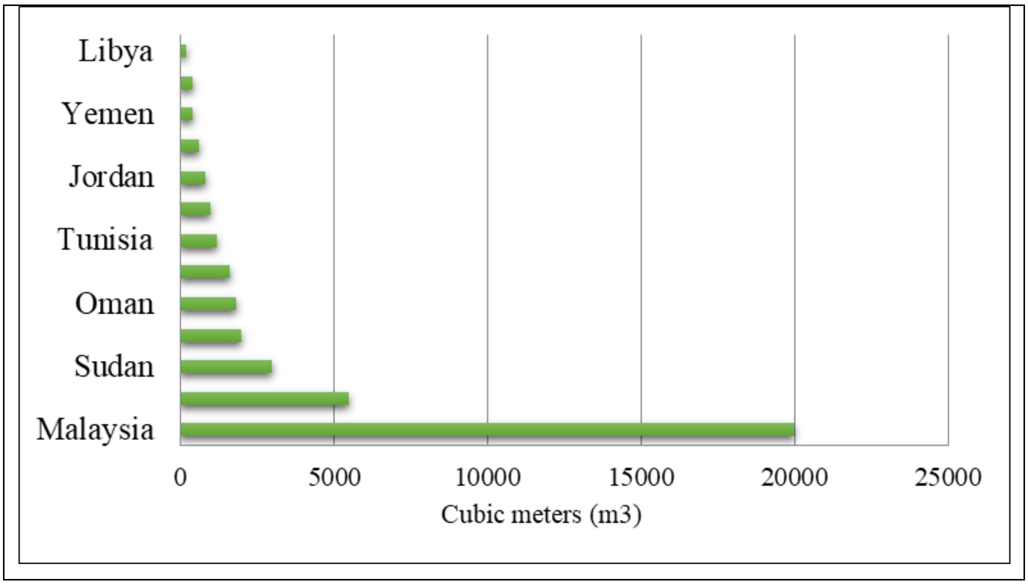
Keywords: Water security, Pulau Sebatik, water supply management, quantity, quality, achievable

Introduction

Malaysia is one of the countries that are rich in water resources. The range of annual rainfall reaches one thousand five hundred millimetres (1,500 mm) to three thousand millimetres (3,000 mm) per year, while the average annual rainfall reaches as much as two thousand four hundred millimetres (2,400 mm) per tear (Sani & Rindam, 2017). The amount of rain with a high average rate in Malaysia is influenced by its position factor, which is located in the Equatorial Zone. This zone experiences heavy rainfall due to the influence of the Northeast Monsoon season, which brings wet wind (Hung, 2008). On a regional scale, the climate on local scale is also similar to Pulau Sebatik, which is located on the East Coast of Sabah and is greatly influenced by large-scale climate phenomena such as monsoon winds. Therefore, Pulau Sebatik records a high annual rainfall with an annual range of one thousand nine hundred and fifty-four millimetres (1,954 mm) to two thousand one hundred and eight millimetres (2,108 mm) per year. The average range of annual rainfall is about one thousand nine hundred and twenty-five millimetres (1,925 mm) per year. It is six hundred and thirty-five millimetres (635 mm) lower than the average annual rainfall received in Sabah (JPS, 2011).

In line with the high average rainfall, Malaysia has a per capita water resource of five thousand four hundred cubic metres ($5,400m^3$) per year. The number is very high because it is more than five times the international level of one thousand cubic metres per person, per annum. According to Chan (2002), if Malaysia can trap the entire surface runoff, then the amount of water per capita is more than twenty thousand cubic metres ($20,000m^3$) per year. It is one hundred (100) times higher than the amount of water per capita per person in Libya as shown in Figure 1. The figure also shows that among the 13 countries in Asia, Malaysia records the highest value of water resources per capita compared to other countries. In other words, the value indicates that Malaysia has a high-water supply. Therefore, it seems impossible for Malaysia to experience a water supply crisis or water deficits, including Pulau Sebatik, as the meteorological and hydrological characteristics of the island are more or less similar to Malaysia in general.

Figure 1
Comparison of Malaysia's Per Capita Water Resources with other countries



Source: Adapted from Chan (2002)

Water security in a country may be classified into five dimensions, namely, household water security, economic water security, urban water security, environmental water security, and resilience to a water security disaster. However, the main thrust system among the five dimensions of water security in a country is household water security (Siwar & Ahmed, 2014). Water consumption by households is also termed as domestic water consumption. Hence, the primary purpose is to ensure that water consumption for households such as drinking supplies, flushing toilets, washing dishes, cooking, washing clothes, bathing, watering crops, and other household activities are adequate. It is estimated that water consumption for domestic purposes represents 40 percent to 60 percent of the total water supply (Phang Wai Leng et al., 2013).

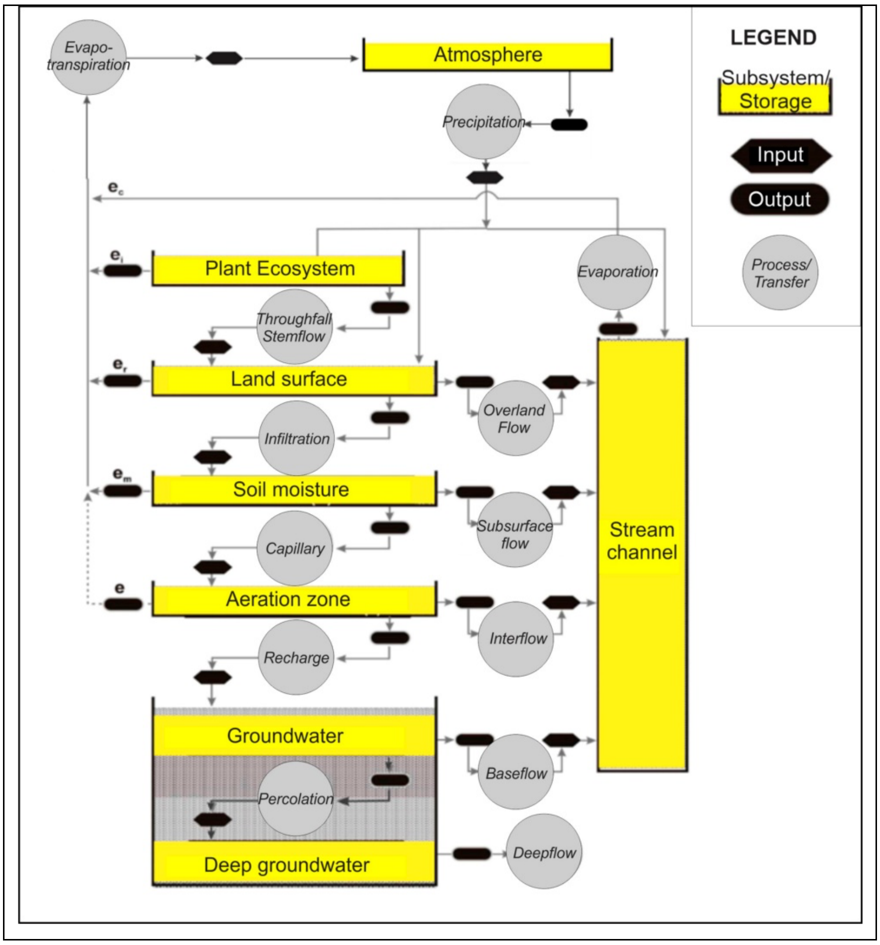
However, not all domestic water needs in every household can be achievable, especially in the context of small island areas, albeit the area receives a high average amount of rainfall. Owing to the fact that small, inhabited island areas are generally more neglected and underdeveloped in terms of the availability of basic facilities or public amenities compared to mainland areas close to the city centre. This takes into account the terms of provision of domestic water supply sources. According to Agarwal et al., (2002) every human should have access to adequate clean water supply at affordable prices to live a productive, clean and healthy life without neglecting the well-being of individuals and preserving the natural environment. If the issue is ignored, then it culminates to a water security issue in the area. Based on that specific problem, this study aims to examine the potential of water supply sources in Pulau Sebatik, Malaysia, and discuss how the potential of water supply sources are managed and controlled for domestic use purpose. The problem of lack of efficiency and quality control in the management system of domestic water supply resources at the study site is also discussed.

Literature Reviews

Water Storage Components in the Context of Drainage Basins

Based on the hydrological process, the mainstay of the supply of raw (fresh) water resources in a drainage basin is greatly influenced by the rainfall rate in the area. It does not matter whether it is in the context of the island area or the mainland. This is because, rain is the main input to the water supply in a subsystem in a drainage basin. Considering the rain input, other water storage such as surface water subsystem, groundwater subsystem and river channel subsystem are filled through the process of infiltration, surface water runoff, and so on (Nordin, 2018). Thus, in general, the higher the rainfall, the higher the water supply input received by a subsystem.

Figure 2
Subsystems Involved in the Process of Water Storage in a Drainage Basin



Source: Modifed from More (1979).

In the water resources management system, one of the main principles that should be emphasised is to reduce the exchange of rainwater (input) into the form of surface runoff that could potentially be disposed or flow into the sea (output). Excess water that is disposed into the sea is called wasted water. Preferably, rain inputs are collected and filled the natural and man-made resources in reservoir centres such as groundwater, rivers, lakes, dams, and reservoir ponds. This principle is vital to prevent a water shortage crisis. Indirectly, this will stabilise the rate of water supply in the affected area.

Research Method

This study uses triangulation techniques to obtain data. Othman Lebar (2006) defines triangulation as a technique that uses various sources and data collection methods. This technique is believed to increase the validity and reliability of research findings, especially for qualitative research (Ikhsan et. al., 2016). The triangulation process in this study is done through a combination of observation techniques, interviews, and fieldwork (measurement of the well). In this process, informants comprising residents in several villages were interviewed. The purpose is to identify water sources that are commonly used, apart from understanding the often-experienced problems. Data from interviews with the villagers were cross check through observation. This is important to ensure that the data obtained has high reliability. The data obtained were then analysed descriptively and mixed with secondary data as supporting information.

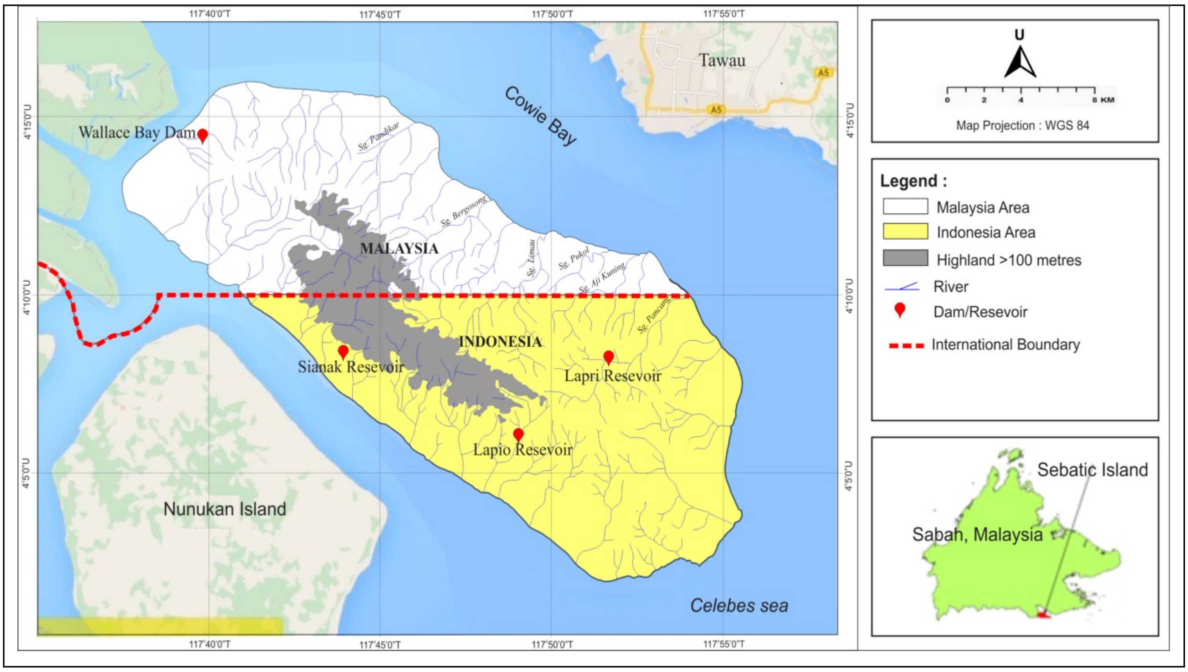
Findings and Discussion

Main Domestic Water Sources for Pulau Sebatik, Malaysia

Generally, there are three primary water sources used by the community of Pulau Sebatik, Malaysia for domestic use, namely rainwater sources, groundwater sources and treated tap water sources (Walace Bay Dam). The total capacity of the three water supply sources is estimated to be adequate for the use of the Pulau Sebatik community. According to Nordin et al., (2016), it is estimated that 110.8 million cubic metres per year (CMP) of rainwater can be stored in riverbeds, surface water reservoirs, and groundwater which is the main source of water supply for the Pulau Sebatik community. This value does not include the total evaporation of 226.6 JMP, about 69 percent of the total rainfall in a year. The amount also does not consider the value of water storage obtained through rain harvesting activities. The potential supply of rainwater harvesting is huge as the annual rainfall of Pulau Sebatik is high with a range of 1,954 mm to 2,108 mm per year. The value is slightly lower than the average amount of rainfall received by the state of Sabah which is 2,560 mm per year (Nordin et al., 2020). Furthermore, the capacity of a large amount of rainwater can be collected and stored with the basin catchment area with a size of 452.2 km². As shown in Figure 3, half of the island belongs to Malaysia, accounting for 204.7 km², while the rest belongs to the Republic of Indonesia.

Figure 3

Catchment area of Sebatik Island, Malaysia and Indonesia



Source: Nordin, 2018

In the Malaysia's territory alone, the total volume of freshwater storage facilities affected by the dimension of the water catchment area and the amount of rainfall is estimated to be adequate for the use of the Malaysian Sebatik Community if exploited and appropriately managed. This is because, the total population and population density of the Sebatik territory of Malaysia is much smaller than Sebatik territory of Indonesia as shown in Table 1. Based on the table illustration, the total population of Sebatik Indonesia residents is more than six times larger than Sebatik Malaysia, although the size of the territory is almost the same. This accounts for the population density size of the Sebatik territory of Malaysia almost six times smaller than the population density of the Sebatik territory of Indonesia. This specific case indicates that the population of Sebatik Territory of Malaysia should have a higher opportunity or potential to obtain natural raw water resources as opposed to the population of Sebatik Territory of Indonesia due to its much lower population density factor.

Table 1

Total and population density of the Sebatik island of Malaysia and Indonesia, 2014

Malaysia		**Indonesia**	
Population	5,600 persons	Population	36,876 persons
Area	204.7 km²	Area	247.7 km²
Population density	27 person/km²	Population density	149 person/km²

Source: Modified from DUN Sebatik, 2016 & Nunukan Regency Central Statistics Body, 2015

The Natural Potential of Surface Water

As elucidated at the beginning of this article, one of the main sources of fresh water utilised by the Pulau Sebatik community in the Malaysian border is the treated water distribution pipes managed at the Sebatik Water Treatment Plant (WTP). The Sebatik WTP, built in 2006, has the capacity to treat around 2.5 million litres of water per day (MLD). However, currently Sebatik WTP only produces treated water amounting to 700 m3 per day (Department of Pulau Sebatik Water Supply, 2017) to be supplied to 810 houses in nine villages, namely Kg. Mentadak Baru, Kg. Tamang, Kg. Wallace Bay, Kg. Tamang Baru, Kg. Sungai Pandikar, Kg. Sungai Lahi, Kg. Sungai Limau, Kg. Sungai Tongkang and Kg. Bergosong (Nordin et al., 2016).

The watered stock obtained by the Sebatik WTP is derived from the Wallace Bay small dam source. Thus, the availability of adequate raw water supply for the water treatment process at the Sebatik WTP is highly dependent on the total volume of water at the Wallace Bay Small Dam. The weir built in 2002 has a storage capacity of 91,100 m3 (Nordin et al., 2016). The surface area of the dam is estimated at around five hectares while the catchment area is around 203.4 hectares. The main inputs of the dam source are from river discharge, surface runoff, and direct fallout process in the gazetted water catchment area with an area of around 400 acres (JBANS, 2017).

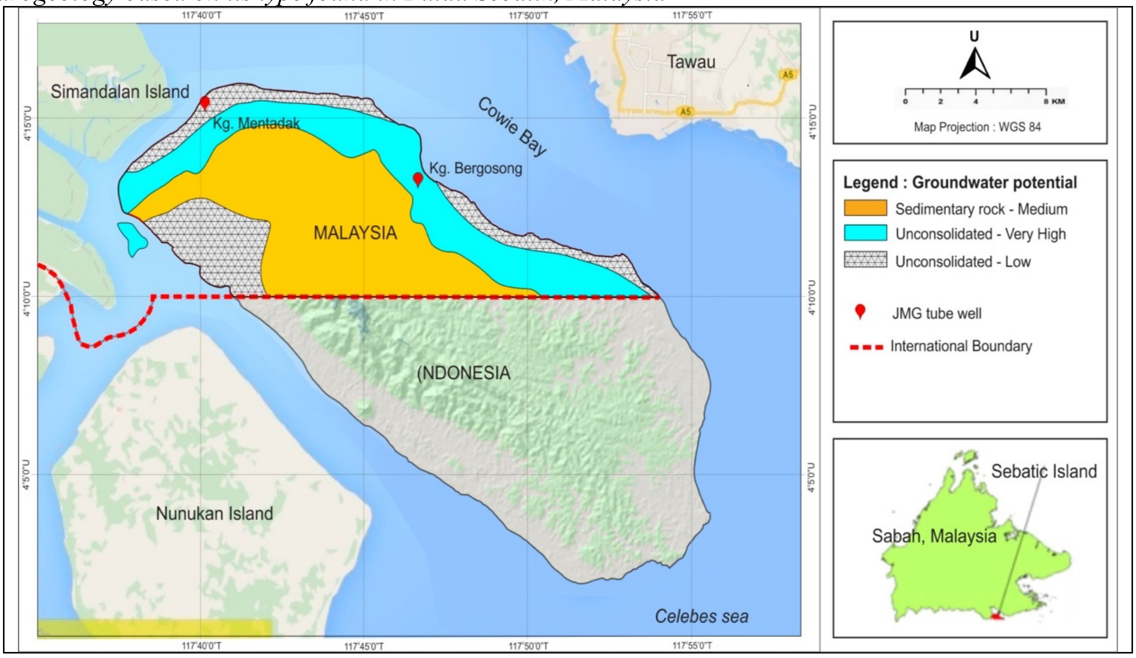
The Natural Potential of Groundwater

According to China Geological Survey (2012), Pulau Sebatik is an area with groundwater resources with a moderate level of productivity. The level of productivity or capacity of groundwater supply is generally influenced by the type of hydrorock found in the locality. In Malaysia side, two types of hydrorock can be found in this area, namely unconsolidated deposits and sedimentary rocks. Sedimentary rocks are more dominant in the area with approximately 1,500 to 3,000 metres from the shoreline. Meanwhile, unconsolidated rocks are more predominant in the coastal zone. Sedimentary rocks consist of Melange and sequences of interbedded mudstone, tuff, tuffaceous sandstone, shale, conglomerate with minor chert and limestone (JMG, 2015). Within this type of rock, JMG classified as a low potential of groundwater (JMG, 2007).

For unconsolidated rocks, it consists of coastal and riverine alluvium - coastal, silt and coral sediments (JMG, 2015). A large amount of groundwater in this rock area (JMG, 2007) allows two tube wells for domestic purposes to be built by the Department of Mineral and Geosciences Malaysia, each located in Kg. Mentadak and Kg. Empty. These wells can produce more than ten cubic metres of water for one hour (JMG, 2007). There are also geographic areas with insignificant amounts of groundwater to be exploited such as in the catchment area of Sungai Simpang Dua and Sungai Simpang Tiga. However, the two water catchment areas located in the Southwestern Part of Pulau Sebatik, Malaysia in terms of percentage of area size, are much smaller than areas or regions with significant groundwater potential.

It is undeniable that developing groundwater exploitation facility infrastructure requires relatively high costs, especially when it involves large-scale projects. Nevertheless, the long-term effects obtained through groundwater exploitation, whether for domestic use, industry and so on, have many benefits. Apart from being able to improve the quality of the availability of domestic water supply, which is important to improve the local community's wellbeing, it is also indirectly a catalyst to increase the growth of development in an area. This is because the supply of groundwater resources is stored or trapped for hundreds or thousands of years in the closed aquifer, and in addition to having a very high level of water quality, it also has a large volume. It is estimated that groundwater quantity in closed aquifers is much more than that of petroleum resources. Therefore, even during the long draught season, the groundwater supply is still well stored and can continue to be used (Ibrahim, 2015).

Figure 4
Hydrogeology based on its type found in Pulau Sebatik, Malaysia



Source: Modified from JMG, 2007, 2015

The Inefficiency of Water Resources Management in Pulau Sebatik, Malaysia

There are several weaknesses in the management of water resources in Pulau Sebatik, Malaysia. In general, it can be broken down into three segments, namely incomplete reception of water supply to consumers, low water quality problems for consumer use, and sustainable water access. These three problems are indicative of the emergence of water security issues in Pulau Sebatik, Malaysia. The water supply system and network in the Sebatik Territory of Malaysia can be broken down into three types of water systems], namely rainwater catchment systems treated water piping systems, and groundwater supply system. These three water distribution systems are the main source of domestic water supply to the Sebatik Community, Malaysia. However, all three water distribution systems have some weaknesses that need to be improved to ensure adequate access to clean treated water. Table 2 shows the problems faced by consumers in obtaining domestic water supply using the method.

Table 2

Weaknesses in the management of Water Supply Resources for Domestic purposes in Sebatik Territory, Malaysia

Type of problem / Type of water supply	Incomplete reception of water supply	Low water quality	Remote water access
Treated tap water	X	-	-
Rainwater	-	X	-
Groundwater (wells)	-	X	X

Indicator: X= Having problems, - = not having problems

Management of Treated Pipe Water Supply System

Figure 5 shows that the treated pipe water supply system is experiencing incomplete water supply reception problems. Not all villages in the Sebatik Territory of Malaysia receive treated pipe water supply. Out of fifteen villages, only nine villages, namely Kg. Mentadak Baru, Kg. Tamang, Kg. Wallace Bay, Kg. Tamang Baru, Kg. Sungai Pandikar, Kg. Sungai Lahi, Kg. Sungai Limau, Kg. Sungai Tongkang, and Kg. Bergosong receive treated pipe water supply (Nordin, et al., 2016). Six more villages, namely Kg. Sebatik, Kg. Lahat-Lahat, Kg. Sg. Melayu, Kg. Sg Pukol, Kg. Pisak-Pisak, and Kg. Haji Kuning do not have any treated water supply piping systems. Even so, there are villages that already have treated water piping systems but still experience some cases of water supply scarcity and disruption. Such forms of water disruption are due to water supply outages lasting up to several days and unsatisfactory levels of treated water accessibility due to low tap water pressure (Nordin et al., 2016; Amirah et al., 2021).

Most of the villages that still do not have treated water piping systems are located in the Eastern Part of Sebatik Territory of Malaysia. This is because, Sebatik WTP is located in Kg. Wallace Bay which is situated in the West Side of Sebatik Territory of Malaysia. Therefore, due to the long distance between the Sebatik WTP and the villages located in the Eastern Part of the Sebatik Territory of Malaysia, there are constraints in the area's water piping system installation process. Priority for the installation of treated water piping systems is given to villages close to the location of the Sebatik WTP, namely villages located in the West and Central Sebatik Territory of Malaysia. Based on the premise, more than 677 residents living in the Eastern Part of Sebatik Territory of Malaysia do not have the opportunity of access to treated tap water supply (DUN Sebatik, 2016). However, based on the interview process from some villagers who have access to treated tap water supply, it was found that the source of treated tap water supply in terms of quality is believed to be cleaner than the other two sources of water supply. Therefore, the people of Pulau Sebatik Malaysia are more confident in using treated tap water for cooking purposes and as a drinking water supply compared to other water sources. This situation shows the importance of access to treated tap water supply to all the villages that still do not have access to the treated water supply.

Management of Rainwater Harvesting System (RHS)

The Rainwater Harvesting System (RHS) is also one of the main water supplies for the community of Pulau Sebatik Malaysia (Nordin & Adi, 2018). This is because, almost all houses in the villages of Pulau Sebatik Malaysia apply this method. This situation shows that the dependence of the community of Pulau Sebatik

Malaysia on RHS is immeasurable. However, in the context of Pulau Sebatik, the system applied has some disadvantages, either in terms of the quality of water that is collected and stored, or in terms of the quantity that can be stored. Based on the observation process and interview sessions with the residents of Pulau Sebatik who applied this method, it was found that the RHS in the area is implemented traditionally. Traditional RHS pays less attention to the hygiene of the quality of the water harvested compared to modern RHS. For example, the traditional RHS applied in Pulau Sebatik does not use the application of foreign matter filter and first flush as is the case with modern RHS, while foreign matter filter and first flush is a method used to improve the quality of rainwater harvested. The function of foreign matter filter (leaf retainer) aims to prevent the presence of foreign matter and deleterious substances on the roof surface to enter the storage tank, while first flush application aims to remove the first flush water so as to not enter the tank system (Shamsuddin & Noorazuan, 2015). By applying both methods in RHS, it can improve the quality of harvested rainwater.

Apart from that, most of the villages that exist in the Sebatik Territory of Malaysia are composed of old settlement areas that are more than thirty years old, such as Kg. Wallace Bay, Sg Pukol, Sg Tongkang, and so on. The houses built in the villages are also mostly over twenty years old. Due to this condition, the dilapidated house components have become obsolete, such as corrosive roof structures. The roof structures of the houses in the villages of Sebatik Territory of Malaysia mostly use zinc roofs. There are disadvantages to using zinc roofing systems as a house roof as it is easily rusted or oxidised compared to some other types of roofing structures such as bitumen, ceramic, and clay. The lifespan of a galvanised zinc house roof can last for around fifteen to thirty years, depending on the slope rate of the house roof (Nur Shahira, 2018), while the lifespan of a typical zinc roof is only two to three years. Due to the age of the house, most of the roofs of the residents of Sebatik Territory of Malaysia are worn and rusty (oxidised) as shown in Figure 6.

Generally, rainwater is safe for domestic use if it is harvested carefully. However, the quality of harvested rainwater can be influenced by roof characteristics (Asman et al, 2017). Contaminants from rain-harvested sources can result from the age of old zinc roofs (Chang et al, 2004). In RHS, traditionally, the roof surface of the house plays an important role as a catchment area for harvested rainwater. Therefore, the probability of rainwater being polluted is high when the roof surface of the house has been oxidised. This is because, the roof surface of a dilapidated and oxidised house contains high levels of lead (pb) where it is categorised as a heavy metal contaminant (De Kwaadsteniet et al., 2013). When raindrops touch the surface of oxidised zinc, lead (pb), which stabilizes the zinc layer bond, can dissolve with rainwater (Agung, 2017). Rainwater contaminated with lead (pb) content and toxic substances is very harmful and risky for drinking water and food supply purposes. Turning polluted rainwater into drinking water and food can have serious health effects on the community. Among the possible consequences are neurological developmental disorders especially for children (Goyer, 1993), enzyme disorders in the body, gastrointestinal problems, diarrhoea, anaemia, mental disorders, decreased intelligence (IQ), hyperactivity in children, reduced weight of new-borns, and increase high blood pressure for adults (Agung, 2017). Whereas the residents of several villages in the Sebatik Territory of Malaysia who still do not have a treated pipe water supply system still use rainwater harvest system as a source of supply of drinking water and food production. Among the villages that are adapting this method are Kg. Sungai Melayu and Kg. Sungai Pukol.

Figure 6
House roof that has been oxidised used as a storage device for the use of RHS in Kg. Wallace Bay

Source: Fieldwork, 2018

Exploitation and Groundwater Supply Management System

Apart from the treated tap water system and RHS, groundwater supply is also an alternative source for domestic use which is no less critical to the residents of Pulau Sebatik Malaysia. Generally, three main mediums are used to obtain groundwater supply, namely shallow well supply, spring water, and bur water supply (Volentino, 2013). In the context of the Sebatik Territory of Malaysia, the method of using shallow wells is the most widely used to harness groundwater supply. Among the villages that use shallow wells as a medium to obtain groundwater supply are Kg. Sg. Pukol, Kg. Sg. Melayu, and Kg. Wallace Bay. Unfortunately, there are some disadvantages to the method of using shallow wells as opposed to the bur water method. Two main factors influence the difference in water quality from the two methods, namely depth and exposure of water supply with external pollutants.

Generally, the quality of water supply from shallow wells is lower than the quality from bur water. This is because the depth of the water source obtained from the bur water method is relatively deeper than the depth of the shallow well. Groundwater resources with a water source depth that is between fifty metres and one hundred metres underground are safe to use because it is believed that it is not exposed to pollution factors (Lylia Hariz & Bernama, 2014). Nevertheless, the depth of wells built in Pulau Sebatik Malaysia mostly only has a depth of about two to three meters as found in Kg. Wallace Bay, Kg. Sg Pukol and Kg. Sungai Melayu. According to Sri Irianti et. al. (2002), the depth of water sources less than seven metres into the soil is still at risk of exposure to bacterial contamination (E. coli) through the process of entry of contaminated water that moves horizontally. Figure 7 shows one of the shallow wells found in Kg. Wallace Bay. Based on the findings from the interview process with the villagers, it is stated that the shallow wells are still used today for external purposes such as washing feet and houses, watering crops, and so on.

Figure 7

Among the shallow wells found in Kg. Wallace Bay with a depth of 2.8 metres

Source: Fieldwork, 2018

Water supply from shallow wells is more exposed to external pollutant elements than from bur water in terms of water supply exposure. External pollutant elements referred to in this article are pollutants that are transported or flowed through the surface runoff process. Two elements influence the entry of pollutants into shallow well water sources through runoff process, namely well infrastructure condition and seasonal influence (Sri Irianti et al., 2002). A good well infrastructure has concrete walls on the bank. The function of the concrete wall in shallow wells is to prevent the entry of contaminants or foreign objects into the well through the process of surface runoff during the rainy season. For example, preventing the entry of bacteria from sewage (E. coli) of animal feces, human feces, garbage, and so on. According to Sri Irianti et al., (2002), building a three-metre-deep concrete wall on shallow wells can prevent horizontal contamination through the surface area and sub-surface of the soil, apart from preventing the entry of soil particles through washing, sliding and erosion of well banks. Relatively, the higher the height of the concrete wall, the less polluted the well water source will be. The strength of the concrete wall in preventing the occurrence of cracks should also be emphasised. This is because contaminants into the well can also occur if the well has cracks on the concrete wall (Sri Irianti et al, 2002). In the context of the Sebatik Territory of Malaysia, almost all wells constructed do not have concrete walls. This condition allows the entry of pollutants or foreign objects into the well through surface runoff during rain. Domestic wastewater can also contaminate shallow well water sources by moving horizontally through sub-surface zones when not obstructed by concrete walls.

Seasonal or weather elements also greatly affect the entry of pollutants, especially E. coli bacteria, into shallow wells. The content or concentration of E. coli bacteria is higher in shallow wells during the rainy season than in the draught season or days without rain (Wright, 1986). During the draught season no surface water runoff enters the soil or wells compared to the rainy season. However, the process of surface and subsurface water runoffs that actively occurs during the rainy season is the main medium of entry of pollutants or E. coli bacteria into shallow well water sources. When contaminated water has entered shallow wells or low-depth soils, it cannot re-filter the incoming pollutants because the purification process itself will not take place (Geldreich, 1990). Water sources that have been contaminated with contaminants, especially E. coli bacteria, if used as a beverage or food supply may be detrimental to human health (Nusa & Heru Dwi, 1999). Compared to shallow well and bur water supply sources, sources from spring water are not explicitly discussed in this paper because they are natural in nature and only exist in certain areas.

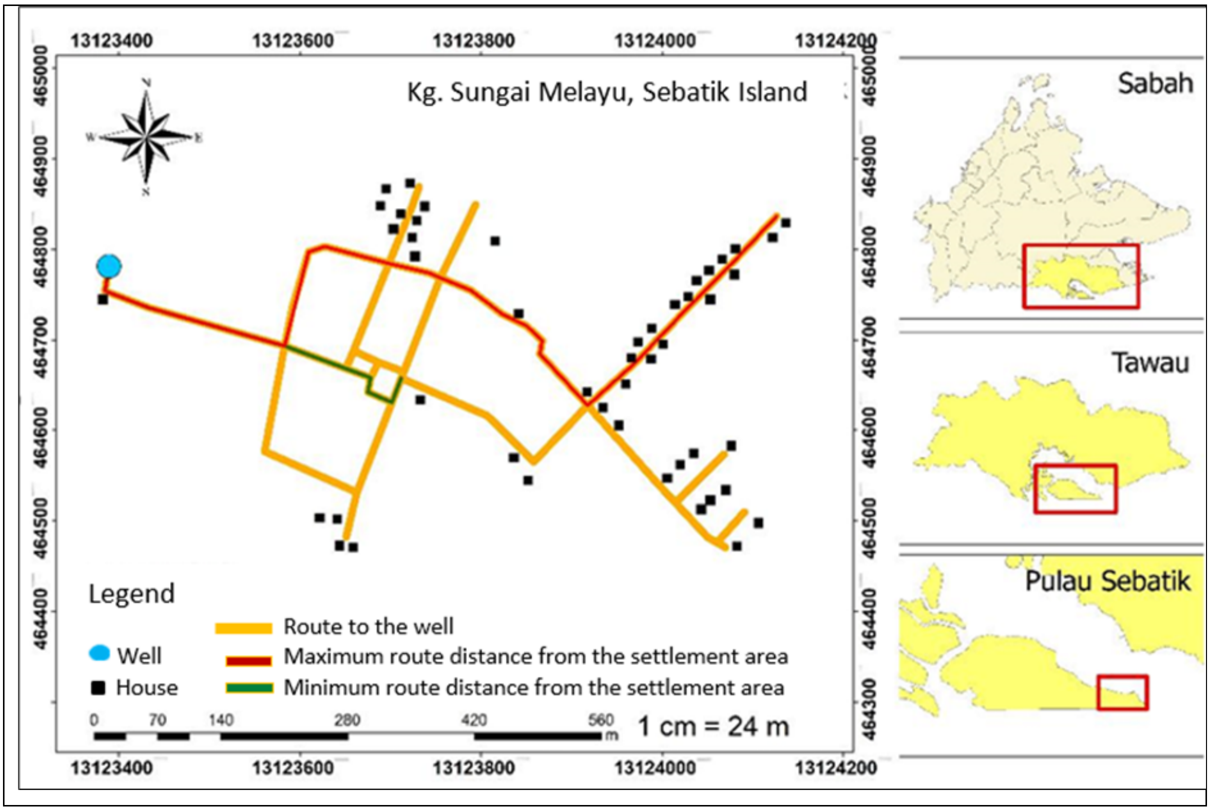
Aside from the low water quality, remote access to water resources for domestic use is also one of the challenges the community of Pulau Sebatik Malaysia faces, especially the residents in Kg. Sg. Melayu. The main water source in Kg. Sg. Melayu is only from RHS and shallow well water. Residents of Kg. Sg. Melayu uses RHS for drinking water supply, food processing, bathing, washing clothes, etc. For well water supply, it is only used for the purpose of outdoor activities such as bathing, washing clothes, washing dishes, and so on. However, if the rainwater supply has run out, the residents of Kg Sg. Melayu will manually get water from the well (using a bucket) to drink-water supply and food processing. Some villagers also buy gallons of water from the mainland of Sabah or neighbouring countries, which is explicitly used as a drinking water consumption.

According to the Village Committee of Kg. Sg. Melayu, it is estimated that about forty houses were built in the village. Apart from rainwater sources, to obtain water sources for domestic purposes, almost all residents of Kg. Sg. Melayu depends on the only well found in the village. This shows how crucial the wells to the villagers to strive for living, especially during the draught season. This is because, during the thirty-five years that the well was built, it has never dried up even during the draught season. According to the villagers, it is believed that the source of water that channels or generates water from the well is from a spring source or pockets of water source. Therefore, even on months or days without rain, the Sustainable water supply in the well will still be available.

The main challenge for villagers who use well water sources for domestic purposes is related to accessing these sustainable water sources. The difficulty of accessing water in particular in the context of this study means that the well water cannot be channeled directly into the house tank (the last stage of storage) through the piping system. However, the systematic management of sustainable water resources and good accessibility is by channeling water directly into the house through the piping system. This situation makes it difficult for the villagers to use the well water directly at the desired times. If the villagers need water from the well, they have to walk at least 410 metres (minimum route distance) to 1,015 meters (maximum route distance) to the water source area as shown in Figure 8. This is because, most of the settlement areas are located near to the water source of the well of about 410 meters away. While the farthest settlement area is about 1,015 meters from the well. The walking distance is a burden to the villagers who use the water source, especially for children and the elderly. Although washing clothes and bathing are done around the well, they also get the well water using gallons, buckets, and so on, to be taken home to wash dishes, and some also use the water to process food and beverage supplies. The supply of well water which is brought home makes it more difficult for the villagers to reach home on foot due to the weight and the inconveniences in transporting buckets or water containers on foot or on a motorcycle.

Figure 8

Location of Well Water Sources and settlement areas in Kg. Sg. Melayu



Sources: Modified from Google Earth (2019)

Conclusion

It is undeniable that weather factors also affect the availability of fresh water supply sources in Pulau Sebatik. However, it is not a major or chronic factor that leads to the problem of access to clean water among the Malaysian community. Instead, the sustainable water management system itself should be improved innovated and given more emphasis. This is because, if fresh water sources from direct fall, surface water and groundwater sources are managed accurately and systematically, then the problem of water for domestic use with the existing population rate is sufficient. At the same time, issues on water problems, including those related to the level of quality and accessibility, can be reduced. More systematic and efficient water resource management is necessary to prevent the occurrence of water security issues. This is in line with the definition of water security itself, which allows every individual to have access to adequate clean water at affordable prices, live a productive, clean, and healthy life without neglecting the health and well-being of the individuals and preserving the natural environment.

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