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Alternative Water Resources Quality Assessment during Flood Disaster in Kuala Krai, Kelantan, Malaysia

(Penilaian Kualiti Sumber Air Alternatif semasa Bencana Banjir di Kuala Krai, Kelantan, Malaysia)

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ABSTRACT

Quality assessment of water resources is important to ensure the well-being of residents, especially the victims who are affected by floods and having difficulties in obtaining clean water supply when the floods hit. This paper seeks to discuss the quality assessment of water resources in the district of Kuala Krai, Kelantan. Field methods were used to collect water samples during the northeast monsoon season in the month of December 2016/January 2017 involving six well stations, four flood water stations and four rainfall stations. The quality assessment of water resources involved six key parameters, namely DO, pH, BOD, COD, NH_3N and SS using the Water Quality Index (WQI) analysis. The results of the analysis showed that the WQI percentage of well and flood water stations accounted for 61.31 to 75.95% which is Class III of moderately contaminated status, except the T6 station that recorded 80.99% of WQI value which is Class II of good status. The findings also showed that all WQI values from the rainwater stations were at 87.85 to 89.10%, which is Class II of good status. This condition explains that the rainwater resources have better quality than the well and flood water resources. With the help of this research, the flood manager's party can take systematic management measures in ensuring that flood victims receive water supplies during flood events. In this regard, infectious diseases resulted from the consumption of contaminated water among flood victims can be reduced.

Keywords: Flood water; rainwater; Water Quality Index; well water

ABSTRAK

Penilaian kualiti sumber air penting bagi memastikan kesejahteraan penduduk terpelihara terutama mangsa yang terkesan akibat banjir dan sukar memperoleh bekalan air bersih semasa bencana banjir melanda. Kertas ini bertujuan untuk membincangkan penilaian kualiti sumber air di Jajahan Kuala Krai, Kelantan. Kaedah lapangan digunakan untuk mengumpul sampel air semasa musim monsun timur laut pada bulan Disember 2016/Januari 2017 yang meliputi enam stesen air telaga, empat stesen air banjir dan empat stesen air hujan. Penilaian kualiti sumber air melibatkan enam parameter utama iaitu DO, pH, BOD, COD, NH_3N dan SS dengan menggunakan analisis Indeks Kualiti Air (IKA). Hasil analisis mendapati peratus IKA stesen air telaga dan air banjir berada pada nilai 61.31 hingga 75.95% iaitu pada Kelas III yang berstatus sederhana tercemar kecuali stesen T6 didapati mencatat nilai IKA 80.99% iaitu pada Kelas II yang berstatus baik. Keputusan juga menunjukkan kesemua nilai IKA stesen air hujan berada pada nilai 87.85 hingga 89.10% iaitu pada kelas II yang berstatus bersih. Keadaan ini menjelaskan bahawa sumber air hujan mempunyai kualiti yang lebih baik berbanding sumber air telaga dan sumber air banjir. Dengan adanya penyelidikan ini, pihak pengurus bencana banjir dapat mengambil langkah pengurusan yang sistematik dalam memastikan mangsa banjir memperoleh bekalan air semasa bencana banjir melanda. Sehubungan itu, penyakit berjangkit akibat penggunaan air tercemar dalam kalangan mangsa banjir dapat dikurangkan.

Kata kunci: Air banjir; air hujan; air telaga; Indeks Kualiti Air

INTRODUCTION

Water resource is a renewable resource and very important in human daily activities, especially for domestic use. About 3% of the total freshwater is used for human domestic activities such as cooking, drinking, and washing (Agarwala 2006). However, water quality is vital to mankind as it is directly related to human well-being (Ibrahim et al. 2020). Ensuring the quality of clean water resources during flood disaster is difficult to achieve if there is no efficient management to ensure that water supplies are free from contaminants and are safe to be used by flood victims. Malaysia is often hit by flood events each year, particularly in the East Coast of Peninsular Malaysia such as the state of Kelantan. The main factor that leads to the floods is the Northeast Monsoon wind that brings heavy rain from November to March.

The floods often affect flood victims, especially in terms of water supply resources in which flood victims usually face problem with contaminated water resources (Benacer et al. 2016; Kumar et al. 2016; Molla et al. 2016) and lack of water supply (Hossain et al. 2014) at the Temporary Evacuation Centres (TECs). This situation causes the flood victims to resort to using water resources of unknown hygienic status for cooking, drinking, and washing at the TECs. The using of water resources with unknown hygienic status may expose the flood victims to the risk of infectious diseases. Among the diseases that commonly occur during floods are diarrhea, typhoid fever, cholera, hepatitis A and E, hantavirus, leptospirosis, and malaria (Abbas & Routray 2014; Few et al. 2004). In order to prevent flood victims from being exposed to the risk of flood-borne diseases during floods, water resources quality assessment should be conducted to determine the water quality status prior to being used by flood victims. Therefore, Malaysia needs such research to overcome the problem of water supply during floods as Malaysia is often hit by floods during the monsoon season especially Kuala Krai, Kelantan.

Kuala Krai is one of the districts that often have issues with water supply due to the hilly landform. This factor has led to the low water supply accessibility and the residents have to rely on groundwater sources for domestic activities. According to Tokatli (2019), groundwater is the most significant source of drinking water supply for numbers of villages and districts. Water supply to the people becomes worse when Kuala Krai is hit by large-scale floods such that in 2014. Based on the number of evacuees record from the Department of Community Welfare, 93,696 flood victims in Kuala Krai were transferred to the TECs following the increase in the flood water level at that time. The flood water level also reached more than 5 to 10 m that submerged buildings up to the 3rd or 4th floor (Nor Eliza et al. 2016). The huge floods during that year had caused the flood victims facing difficulties in obtaining clean water resources for a long period of time, especially at TECs. This was due to the damage factor of the water supply facility that was submerged by flood water causing the water supply system to be stopped and could not be distributed to the TECs for the flood victims to use. In addition, the increase in flood water levels had resulted in the flood victims at the TECs to lose connection and aids from the outside.

According to March (2002), the loss of clean water resources is the worst long-term effect during a disastrous event. Therefore, this problem causes flood victims to resort to alternative water resources located around TECs to carry out domestic activities. However, the use of water resources with unknown quality status will expose flood victims to the risk of spreading various waterborne diseases. Leptospirosis is a common disease experienced in Malaysia when floods hit (Benacer et al. 2016) as happened in Johor before (Badrul Hashim et al. 2010). The problem is also faced by flood-prone countries like Bangladesh (Shimi et al. 2010), Nigeria (Ubachukwu & Emeribe 2017), India (Sharad et al. 2007) and Sudan (Abbas & Routray 2014). Such conditions can occur as clean water sources are contaminated by flood water which has a high level of bacteriological contamination during flood disaster (Shimi et al. 2010). Whereas clean water supply is important for flood victims as a source of clean water for domestic activities and reducing the risk of flood-borne diseases when floods hit. Therefore, water quality plays an important role during flood disaster to reduce the impact of floods especially on the health aspect of flood victims. Hence, this article will discuss about the assessment of the quality of alternative water resources during flood disaster that focuses on three main water resources, namely groundwater, flood water, and rainwater that can be benefitted by flood victims in the Kuala Krai District based on the Interim National Water Quality Standards (INWQS) set by the Department of Environment (DOE).

Materials and Methods

This study was conducted in Kuala Krai District, Kelantan, which is located in the East Coast of Peninsular Malaysia and consists of three sub-districts, namely Batu Mengkebang, Olak Jeram and Dabong. The most developed sub-district is Batu Mengkebang because of the development factor of Kuala Krai Town which becomes the focus of the Kuala Krai people to get facilities and carry out business activities. In the aspect of physical characteristics, this district has a hilly landform. According to the Department of Town and Country Planning (2011), the west and east borders are highland areas of more than 300 m height and the highest peak is the summit of Gunung Stong located in Dabong sub-district with 1,800 m height. Because of that, the lowlands around Sungai Lebir, Sungai Galas, and Sungai Kelantan are often flooded during flood season. Among the areas that are at risk of flooding are Kuala Krai, Pahi, Manek Urai, Dabong and Kemubu. This is due to the heavy rainfall factor during rainy season causing river water to overflow. Figure 1 shows the coverage of the flooded areas in 2014 in Kuala Krai District.

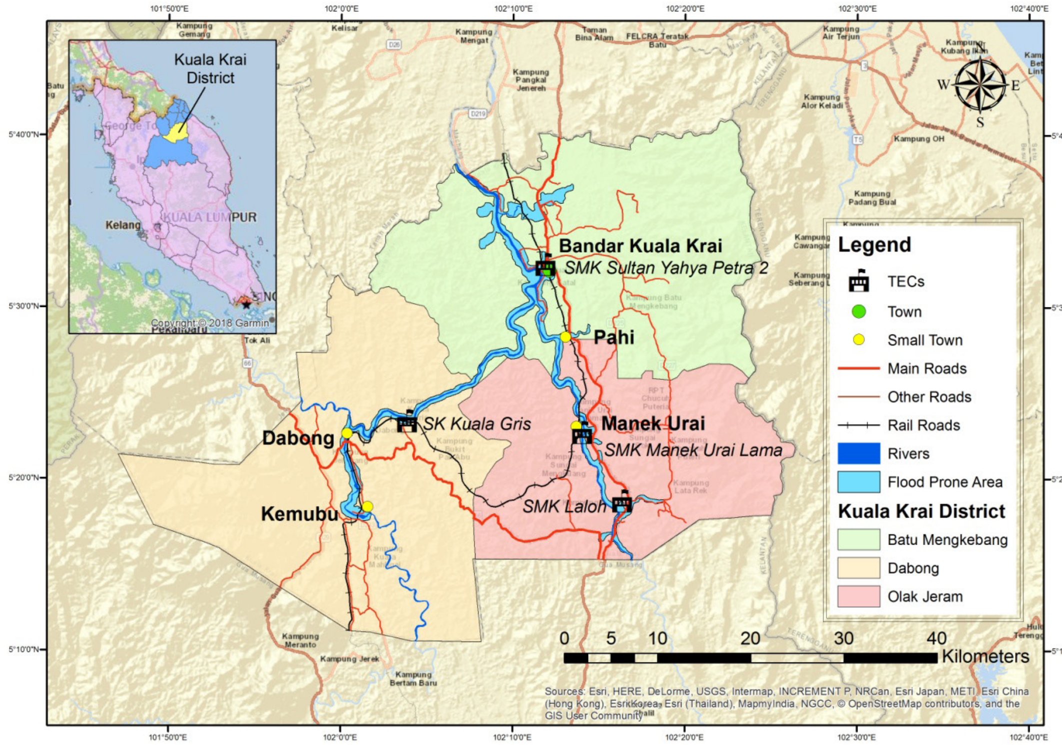

FIGURE 1. Flooded areas in 2014 in Kuala Krai District and four selected TECs

In order to overcome the water supply problems at the TECs during flood season, this study has selected four TECs, namely SMK Sultan Yahya Petra II, SMK Manek Urai Lama, SMK Laloh, and SK Kuala Gris (Figure 1). This selection has been done structurally to meet the two main criteria, namely affected by flood and have the highest load of 500 people. This is because a large number of flood victims at a TEC will result in a high demand for water supply. This will make it difficult for flood victims to obtain water supply for survival at the TECs during flood. The situation will get worse in the event of an extreme flood that may lengthen the period of flood event.

This study used primary data, namely the quality data of well water, flood water and rainwater which were collected via field method. These primary data were needed to identify the quality of water resources that can be used by flood victims at the TECs during flood disaster. The water quality parameters involved were pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solid (SS), and Ammonia Nitrogen (NH_3N). A total of 14 stations were selected including six well water stations, four flood water stations and four rainwater stations for four selected TECs (Table 1).

TABLE 1. List of water source observation stations

TECs	Area	Station	Latitude	Longitude
SMK Sultan Yahya Petra II	Kg. Keroh	W1	5° 30’ 51.30”	102° 11’ 54.66”
	Kg. Batu Mengkebang	W2	5° 30’ 51.30”	102° 16’ 22.70”
	Bandar Kuala Krai	F1	5° 32’ 21.51”	102° 11’ 14.46”
	Padang sekolah	R1	5° 32’ 23.61”	102° 11’ 48.09”
SMK Manek Urai Lama	Lepan Meranti	W3	5° 19’ 22.10”	102° 15’ 45.00”
	Kg. Budi	W4	5° 19’ 57.50”	102° 16’ 49.60”
	Kg. Manek Urai Baru	F2	5° 22’ 24.19”	102° 13’ 51.16”
	Padang sekolah	R2	5° 22’ 38.22”	102° 13’ 55.58”
SMK Laloh	Lepan Meranti	W3	5° 19’ 22.10”	102° 15’ 45.00”
	Kg. Budi	W4	5° 19’ 57.50”	102° 16’ 49.60”
	Kg. Laloh	F3	5° 18’ 40.87”	102° 16’ 12.71”
	Padang sekolah	R3	5° 18’ 42.77”	102° 16’ 19.02”
SK Kuala Gris	Kg. Jelawang Tengah	W5	5° 20’ 45.65”	101° 58’ 57.13”
	Kg. Durian Hijau	W6	5° 20’ 26.88”	101° 58’ 58.32”
	Kg. Kuala Gris	F4	5° 23’ 14.45”	102° 3’ 43.83”
	Tempat perhimpunan sekolah	R4	5° 23’ 19.06”	102° 3’ 43.36”

Notes: W1-W6: well water, F1-F4: flood water, R1-R4: rainwater

Collection of water samples was carried out during the Northeast monsoon season in December 2016/January 2017. This study adapted different techniques for the collection of well, flood, and rainwater samples. The collection of well water samples was carried out using bucket method of 0.5 m depth from the well water level. Meanwhile, flood water samples were taken randomly using HDPE bottles. Flood water is categorised as surface water as flood water is a water body that flows or is located on the surface (Gray 2008). According to Alvarez and Jones-Lepp (2011), the collection of surface water samples directly into hand-held sample containers is the simplest method, especially for the surface water that is small and can be waded into. Rainwater samples were collected using containers placed in the field 1.5 m from the ground to avoid rain splashes.

After the water samples were collected, several preservation steps were done to prevent changes in the contents of the water samples. The water samples contained in the HDPE bottles should avoid the formation of air bubbles and be preserved using aluminium paper. The purpose of aluminium paper wrapping was to delay biological activity and reduce the physical and chemical changes of the water (Margaret 2014; Saeed & Attaullah 2014). Then, the water samples were incubated in an ice box containing ice at 4 °C. The measuring of water quality was conducted *in-situ* and in the laboratory. In order to carry out *in-situ* water quality assessment work, *YSI 560 Multi Parameter Probe* was used to obtain DO and pH values. Whereas BOD, COD, SS and NH_3N parameters were analysed at Physical Geography Laboratory, Universiti Pendidikan Sultan Idris using laboratory tools.

This research adapted the WQI analysis method to assess the quality of well water, flood water, and rainwater. According to Jahin et al. (2020), WQI helps in understanding the fitness of water bodies for different purposes, such as drinking, irrigation, and aquatic life. The measuring of water quality was based on the INWQS set by the DOE in classifying water quality status using the WQI formula. This measurement was used as there is no specific water quality measurement to assess the water quality status of well water, flood water and rainwater. In addition, these guidelines are used by DOE in monitoring and controlling water quality so that water contamination can be controlled. Determination of WQI values and classes was based on sub-index of six main parameters, namely DO, BOD, COD, NH_3N, SS, and pH. Once the sub-index of each parameter was obtained, the calculation of WQI can be done using the following WQI formula:

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

where SIDO is the sub-index DO (%); SIBOD is the sub-index BOD; SICOD is the sub-index COD; SIAN is the sub-index NH_3N; SISS is the sub-index SS; and SIpH is the sub-index pH.
$0 \leq WQI \leq 100$

With the WQI values obtained, water quality status was determined according to the five classes of WQI class I - very good (>92.7), class IIA/IIB - good (76.5 - 92.7), class III - moderate (51.9 - 76.5), class IV - contaminated (31 - 51.9) and class V - highly contaminated (<30) (Table 2).

TABLE 2. Water quality classification and the uses

Class	WQI (%)	Status	The uses
I	> 92.7	Very good	Suitable for drinking water supply, almost need no water treatment
IIA/IIB	76.5 - 92.7	Good	A good source for drinking water supply, normal water treatment is needed. A good source for recreational uses which water contact needed
III	51.9 - 76.5	Moderate	Full treatment is needed and source for drinking water
IV	31 - 51.9	Polluted	Suitable for drainage uses
V	< 30	Highly polluted	Not suitable for any uses

Source: DOE (2015)

Results and Discussion

WATER QUALITY ASSESSMENT BASED ON INWQS

The measuring of water quality includes well water, flood water, and rainwater. Table 3 shows the value of the DO, BOD, COD, NH_3N, SS, and pH parameters at each observation station. Dissolved oxygen (DO) is a measurement of the amount of free oxygen found in water when in contact with air in the atmosphere (Department of Irrigation and Drainage 2009; Nurain & Ang 2015). Elkiran et al. (2019) explained that DO depends on several physical, chemical and biological factors, namely temperature, depletion of oxygen, salinity and sufficient DO amount is vital for the survival of aquatic animals and basic for decomposition of the organic matter. According to DOE (2015), a normal DO value has to be at 7 mg/L and above. However, it shows that most DO values for all three water resources are at 1.83 to 4.42 mg/L which are below the standards set by the DOE. Low DO values indicate that the free oxygen content found in the well water, flood water and rainwater is very low.

Biochemical Oxygen Demand (BOD) refers to the measurement of dissolved oxygen content used by some microorganisms for the decomposition activity of organic compounds found in water (Nasir et al. 2012). By referring to DOE (2015), a good BOD value of water should be at levels less than 1 mg/L. Table 3 shows that the BOD concentration values for each observation station are at 0.00 to 4.94 mg/L. The stations that met the DOE standards were W3 (0.18 mg/L), W5 (0.76 mg/L), W6 (0.70 mg/L), and R1-R4 (0.00 mg/L). The other stations showed high BOD values of W1 (3.39 mg/L), W2 (4.94

mg/L), W4 (2.39 mg/L), F1 (1.36 mg/L), F2 (2.79 mg/L), F3 (2.30 mg/L), and F4 (1.15 mg/L). These high BOD values are usually associated with the presence of organic contaminants from domestic waste disposal activities especially garbage (Nasir et al. 2009). Such conditions can lead to health problems of the flood victims if they use water resources with high BOD because the water contains high organic contaminants.

As for the Chemical Oxygen Demand (COD) parameter, it refers to the amount of oxygen required for the oxidation of a compound material (Nurain & Ang 2015). According to DOE (2015), a good water COD value is below 10.00 mg/L. Based on Table 3, it shows that the COD concentration values for all observation stations are at 0.00 to 43.00 mg/L. Eight observation stations had low COD concentration values and met the DOE's standards, namely W2 (4.00 mg/L), W4 (5.00 mg/L), W5 (9.00 mg/L), W6 (2.00 mg/L), and R1-R4 (0.00 mg/L), while six observation stations had high COD concentration values, namely W1 (43.00 mg/L), W3 (20.00 mg/L), F1(31.00 mg/L), F2 (27.00 mg/L), F3 (11.00 mg/L), and F4 (20.00 mg/L). This condition explains that well and flood water were contaminated with high organic residues. Based on a research done by Rahman et al. (2002) in measuring the quality of flood water in Dhaka City, India, it was found that flood water had high concentration for BOD and COD parameters due to the presence of organic contaminants from various resources such as sewerage systems, direct discharge of human faeces and household solid waste. Therefore, water resources with high COD values such as flood water are not suitable to be used as domestic water supply resources for flood victims unless a water treatment is performed.

Ammonia nitrogen (NH_3N) parameter was also measured to assess the amount of ammonia or toxic contamination in the water body due to sewage, liquid fertilisers, and other liquids associated with organic waste and may exist in surface water and well water. Based on the standards, a good NH_3N value should be less than 0.1 mg/L (DOE 2015). Table 3 shows the NH_3N values are at 0.00 to 0.49 mg/L. There were eight stations that had recorded zero value, namely W1, W2, W4, W6, R1, R2, R3, and R4, while other stations recorded NH_3N concentration values above the set limit, namely W3 (0.40 mg/L), W5 (0.15 mg/L), F1 (0.49 mg/L), F2 (0.26 mg/L), F3 (0.21 mg/L), and F4 (0.41 mg/L). These high NH_3N concentrations were influenced by the use of ammonia fertilisers around wells and flood areas. High NH_3N could also be caused by contamination from domestic waste (Suhaimi et al. 2005). Hence, the results of this study explain that the flood water resources with high NH_3N values are not suitable to be used as alternative water resources for flood victims compared to the well water because the flood water contains high toxic contaminants that can affect the health of flood victims.

In addition, Suspended Solid (SS) parameter involved measuring of the draughtiness and weight of particles with sizes larger than 0.001 mm (Nurain & Ang 2015). The net SS value measurement level is less than 25.00 mg/L (DOE 2015). Table 3 shows the SS values for each station are at 10.00 to 330.00 mg/L. There were nine stations that recorded the values of SS concentration at 0.00 to 25.00 mg/L and met the DOE standards, namely W1, W2, W4, W5, W6, R1, R2, R3, and R4, while other stations recorded high concentration values of W3 (40.00 mg/L), F1 (330.00 mg/L), F2 (140.00 mg/L), F3 (150.00 mg/L), and F4 (240.00 mg/L). This is caused by rainwater activity that eroded the soil surface structure resulting in well water and flood water to become turbid. According to Suhaimi et al. (2006), rainwater plays an important role in carrying solid substances from the land into the river. This situation shows that the presence of suspended solids or sediment in river water contributes to flood water turbidity.

The pH value is the measurement unit for water acidity or alkalinity based on a scale of 0 to 14 in which 7 is considered neutral (good). Based on the standards set by DOE (2015), a good pH value is between 6.5 and 8.5. Based on Table 3, the pH values of all observation stations are between 5.23 and 9.24. The findings discovered that the stations that met the DOE standards were stations F2, F4, R1, R2, R3, and R4. The stations with lower pH values than the set limits were W1 (5.26), W2 (6.03), W3 (5.27), W4 (5.23), W5 (5.31), and W6 (6.21), while stations with high pH values were F1 (9.24) and F3 (8.56). This indicates that the well water (W1-W6) was slightly acidic and had similarities with a research conducted by Wan Ruslan et al. (2007) where the pH value of the well water was lower than the river water quality that was in the range between 6.04 and 7.02. Therefore, the well water resources with low pH value and acidic are not suitable to be used as resources for domestic water supply for the flood victims unless a neutralisation process is done. While flood water showed high pH value and was slightly alkaline. This situation is contrary to the research conducted by Tawari-Fufeyin et al. (2015) in Nigeria where the pH value of flood water was low and slightly acidic. According to Saeed and Attaullah (2014), high alkalinity water of between 10 and 12.5 is not suitable to be used for domestic activities as it may cause hair problems, skin problems, and stomach disorders. The pH value of rainwater was balanced and suitable for the flood victims.

TABLE 3. Concentration value of DO, BOD, COD, NH_3N, SS and pH

Station	DO (mg/L)	BOD (mg/L)	COD (mg/L)	NH_3N (mg/L)	SS (mg/L)	pH
W1	2.08	3.39	43.00	0.00	20.00	5.26
W2	2.23	4.94	4.00	0.00	0.00	6.03
W3	2.09	0.18	20.00	0.40	40.00	5.27
W4	1.83	2.39	5.00	0.00	10.00	5.23
W5	1.89	0.76	9.00	0.15	0.00	5.31
W6	2.51	0.70	2.00	0.00	0.00	6.21
F1	4.13	1.36	31.00	0.49	330.00	9.24
F2	3.79	2.79	27.00	0.26	140.00	8.15
F3	3.30	2.30	11.00	0.21	150.00	8.56
F4	3.34	1.15	20.00	0.41	240.00	8.21
R1	4.06	0.00	0.00	0.00	0.00	7.00
R2	4.42	0.00	0.00	0.00	0.00	7.58
R3	4.11	0.00	0.00	0.00	0.00	7.45
R4	4.36	0.00	0.00	0.00	0.00	7.28

Notes: W1-W6: well water, F1-F4: flood water, R1-R4: rainwater

WQI ASSESSMENT FOR EACH OBSERVATION STATION

Table 4 shows the values of SI, WQI, water classes, and quality status of each observation station. The results of the analysis showed that well and flood water stations were in class III where the WQI values were at 61.31 to 75.95% except station W6 which was found to be in class II with 80.99% WQI value of good status. This condition causes well and flood water resources to require a complete treatment to become drinking water resources. According to Sanaullah et al. (2016), contamination on well water quality is usually influenced by the various concentration of chemical compounds derived from geological origin. Similarly, flood water is influenced by contaminants found in the land or on the ground. The use of flood water and well water contaminated with toxic substances will cause flood victims to be exposed to water borne diseases and may harm the health of flood victims.

While all rainwater stations were in Class II with WQI values at 87.85% to 89.10% of clean status. However, the rainwater still needs to undergo a common treatment process to be used as water resources, especially for drinking purposes. The main findings of this study show that the rainwater resources have better quality than the well and flood water resources. Therefore, rainwater can be used by the flood victims when transferred to TECs. According to Fewkes (2012), Law and Bustami (2013), and Pachpute et al. (2009), rainwater also has a potential to be used by humans for a variety of purposes, especially for domestic, agricultural, environmental, and industrial.

Therefore, flood victims may use rainwater for domestic activities at TECs during floods such as for cleaning and washing by catching methods or applying rainwater harvesting methods at TECs. However, Islam et al. (2010) emphasise that the quality of rainwater varies according to the atmosphere. If rainwater is to be used for cooking and drinking, then a common treatment process such as boiling should be done on the rainwater collected to ensure the rainwater quality is safe to be used, as recommended by Amponsah et al. (2015) and Apraku and Adu-Kumi (2014).

TABLE 4. Value of SI, WQI, Class and water quality status

Station	SIDO	SIBOD	SICOD	SIAN	SISS	SIPH	WQI	Class	Status
W1	17.34	86.06	50.72	100.50	86.17	65.62	65.02	III	Moderate
W2	19.10	79.50	93.78	100.50	97.50	91.34	75.95	III	Moderate
W3	17.07	99.64	72.50	66.75	76.40	65.98	64.44	III	Moderate
W4	14.67	90.29	92.45	100.50	91.63	64.56	72.81	III	Moderate
W5	16.02	97.19	87.13	84.75	97.50	67.41	72.33	III	Moderate
W6	23.25	97.44	96.44	100.50	97.50	93.83	80.99	II	Clean
F1	48.86	94.65	62.07	63.44	36.92	60.16	61.31	III	Moderate
F2	42.72	88.60	66.33	73.22	54.65	88.70	67.21	III	Moderate
F3	34.23	90.67	84.47	78.45	53.60	81.04	68.34	III	Moderate
F4	35.96	95.54	72.50	66.37	44.76	87.71	65.31	III	Moderate
R1	46.91	100.40	99.10	100.50	97.50	99.35	87.85	II	Clean
R2	53.50	100.40	99.10	100.50	97.50	95.98	88.90	II	Clean
R3	49.61	100.40	99.10	100.50	97.50	97.09	88.17	II	Clean
R4	53.20	100.40	99.10	100.50	97.50	98.23	89.10	II	Clean

Notes: W1-W6: well water, F1-F4: flood water, R1-R4: rainwater

CONCLUSION

In conclusion, water resources play an important role among flood victims during flood events, especially those who are being transferred to TECs. The difficulty in obtaining water supply during flood disaster is a serious problem that needs to be addressed by an efficient and systematic water supply management that covers the aspect of water quality control. The results of the water quality assessment in this study explain that rainwater has the potential to be a resource of clean water supply for flood victims which can be obtained through rainwater harvesting practices. Meanwhile well and flood water need to undergo several full treatment processes for domestic use. To ensure that flood victims receive clean and adequate water supply to accommodate the flood victims at TECs, an efficient water supply risk management during flood is urgently needed. With the presence of such studies, flood disaster management party can take systematic management measures to ensure that flood victims receive clean water supply during flood disaster. Indirectly, this approach will reduce the risk of the spreading of water borne diseases among flood victims during and after flood events.

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