Is flood water safe for consumption at evacuation centre in kuala krai district, kelantan, malaysia?

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Abstract. Clean water supply has an important role among flood victims at evacuation centers during the flood. However, the water supply from various unknown and unverified sources such as hygiene status can affect the flood victims health. Therefore, the purpose of this study is to evaluate the flood water quality in the Kuala Krai flooding areas. The methodology of data collection in this study are fieldwork methods. It has been used to collect flood water samples during the northeast monsoon season in December 2016 and January 2017. A total of four flood water stations have been select based on the four flood evacuation centers based on the number of flood victims. A total of 13 water quality parameters were analyzed: pH, DO, BOD, COD, SS, NH3N, turbidity, NO3, Fe, Mg, Ca, Cu and E. coli bacteria. Flood water quality assessment in this study is based on the Malaysian National Water Quality Standards by the Malaysia Department of Environment (DOE). The results showed that flood water quality was in class III which was considered as moderate pollution. This situation explains that flood water needs to be fully treated for drinking water. To ensure the safe water supply for flood victims, a water supply risk management during floods has to be developed to ensure flood victims will have a good clean water supply and reduce the spread of flood-related diseases.

1. Introduction

Supplying clean water during the floods is a difficult challenge to some parties. But it should be done in order to ensure the flood victims had the clean water supply for their domestic/daily activities during their tenure at the flood evacuation centers. During the flood times, normally the access for a clean water, especially at the evacuation centers are very limited, simply because they’re not available. A normal clean water distribution pipe is simply not working for this time, due to disruption in the water supply system infrastructure following the rise in flood water levels [1,2,3]. McCluskey [4] has stated that floods will always lead to damage of the water pumps and water treatment equipment. It will actually stop the operation of a water treatment plant and will need to be repaired after the flood. At this time, they’re no good clean water will be supply to the affected peoples. The situation lead to some
of the victims to use contaminated water sources such as flood water around the evacuation center. Direct consumption of the flood water resources can affect the health of the victims and increase the risk of spreading waterborne diseases during floods [5,6]. Among the diseases commonly associated with flood events are diarrhea, typhoid fever, years, hepatitis A and E, hantaviruses, leptospirosis and malaria [7,8]. There're a few several research has been done to assess the flood water quality such as Tawari-Fufeyin, and Godleads [9], Mackay and Taylor [10], Pardue et al., [11], Rahman et al., [12]. However, these studies only around the quality of floodwater and there is no explanation of the risks that flood victims may encounter if they use the contaminated flood water. Therefore, this study focuses on assessing floodwater quality and identifying risks that can affect the well-being of flood victims in the Kuala Krai District, Kelantan.

Normally floods event will have a negative impact on humans, especially getting the daily water supply. The problem normally faced by people living in the area affected by floods in the northeast monsoon season every year such as District of Kuala Krai, Kelantan. The frequency and magnitude of flood events has increased from 2001 to 2006 especially in the Kuala Krai district [13]. From 2011 to 2015, the frequency and magnitude of flood events in the Kuala Krai district were different due to quantity of rainfall and the inability of river to maintain the water. Flood events in 2014 are the adverse floods in the State of Kelantan, known as Bah Kuning (yellow floods). The Kuala Krai district was one of the most devastating districts affected compared to other districts in Kelantan. Record of flood victim registration at the relief centers from the Welfare Department in 2014, has shown that more than 93,696 people were evacuated due to the flood. The flood water level rise between 5 to 10 meters and is reaching up to levels 3 or 4 buildings [14]. According to Wan Nur Tasnim et al., [15], the heavy rain has started on December 17, 2014, and eventually caused flash floods in Kuala Krai with nearly 3,390 peoples were forced to be evacuated. The event became catastrophic when the heavy rain continues from 21 to 23 December 2014 in Gua Musang area. Resulted in an increase of river water levels for Galas River, Lebir River, and Kelantan River. The highest river water level of the time was at 46.47 meters (which is danger level is at 38 meters) for Galas River, Dabong (42.17 meters) (which is the danger level at 35 meters), Lebir River and Tualang River at 34.17 meters (which is the danger level is at 25 meters), for Kelantan River at the Krai Staircase [16]. The floods event has caused the clean water supply situation to worsen, and some of the flood victims at relief centers have lost contact and rations from neighboring districts. This has indirectly led the flood victims to use flood water for cooking, bathing and washing activities, causing a health deterioration to the victims. Therefore, this study is conducted to evaluate the quality of flood water quality in Kuala Krai and at the same to identify the risk of flood water use based on the Malaysian National Water Quality Standards by the Department of Environment (DOE).

2. Methods

This study employ field work to undertake the flood water quality assessment during the northeast monsoon season which is fall between December 2016 and January 2017. The water quality sampling technique was divided into two techniques which are in-situ and laboratory analysis. 13 parameters were analysis as in WQI standard parameters, namely as the pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS) and ammonia nitrogen (NH₃N), physical parameters including turbidity, the chemicals parameters consist of nitrate (NO₃⁻), iron (Fe), Magnesium (Mg), calcium (Ca), copper (Cu) and Escherichia Coliform (E.coli) bacteria as a biological parameters. The in-situ values are for pH and DO parameters with YSI Multiparameter System tool. While the BOD, COD, SS and NH₃N were analyzed at Physical Geography Laboratory,
Universiti Pendidikan Sultan Idris. Other parameters were analyzed at the Hydrology Laboratory of the Faculty of Social and Humanities, Universiti Kebangsaan Malaysia (UKM).

2.1. Study Area
The Kuala Krai District is one of the districts in the State of Kelantan, located on the east coast of Peninsular Malaysia and comprises three sub-districts namely Batu Mengkebang, Olak Jeram and Dabong (Figure 1). Batu Mengkebang is the most developed sub-district due to the development of Kuala Krai Town which is the main attraction of the Kuala Krai population.

Kuala Krai is among the district in Kelantan which is regularly flooded yearly during the monsoon season. Among the factors which are triggering the flooding in Kelantan was the heavy rain factor which caused the river channel and the reservoir to rapidly occupied with the water and then overflow to the lowlands. Therefore, the lowlands located near the Lebir River, the Galas River, and the Kelantan River are regularly flooded during the flood season which is in part of October, November, December, and part of January. Among the areas that are at risk of flooding identified as Kuala Krai, Pahi, Manek Urai, Dabong, and Kemubu. The flooded normally caused by the heavy rainfall event during monsoon season resulting in the river being unable to cope with the excessive amount of water flow. Figure 2 shows a river system and flooded area coverage in 2014 in the Kuala Krai district.
This study focuses on the four evacuation centers located at the Kuala Krai district namely as SMK Sultan Yahya Petra II, SMK Manek Urai Lama, SMK Laloh and SK Kuala Gris (Figure 3). Selection of the evacuation center is based on, i). centers are affected by the flood and ii). centers with the highest capacity with more than 500 peoples. The higher number of flood victims at the relief center will give a higher demand for water supply. Hence, the flood victims are difficult to obtain a water supply for survival at evacuation centers during floods. The situation will worsen in the event of an extreme flood that will cause long periods of floods.

Figure 2. River system and flooded area in 2014
2.2. Sample water sampling technique

Water sampling technique is done randomly using the HDPE bottle or known as grab sampling. According to Gray [17], flood water is categorized as surface water since flood water is a flowing water body or present on the surface. Therefore, the flood water samples collection is similar to surface water sampling techniques such as rivers and lakes [18]. Then, collecting surface water samples directly into hand-held sample containers is the simplest method, especially small, surface water [19]. Therefore, this study has been adopted this simple method as the floods that occurred during December 2016 / January 2017 were at a small magnitude. This technique has been adapted from Wang et al. [20], American Public Health Association (APHA) [21] and based on a study conducted by Pardue et al., [11] in evaluating floodwater quality using random sampling techniques using a hand when the flood water is shallow. Water preservation techniques of flood samples were also performed so that the contents of the collected water samples did not change when delivered to the laboratory. Samples of water inserted into the HDPE bottle should be avoided from the formation of air bubbles and cured by aluminum paper. The purpose of aluminum paper wrapping is to delay biological activity and reduce physical and chemical changes of water [22,23]. Then, the water sample is placed in an ice box containing ice at 4°C.

2.3. Water Quality Site Selection

The flood water station selection is in the compound of four flood relief centers in Kuala Krai, normally at the football field. Table 1 shows the list of flood water stations and Figure 4 shows a picture of a floodwater station in December 2016 / January 2017. Determination of flood water stations is determined based on the nearest distance to the selected evacuation center.

Table 1. List of flood water observation stations
### Table 1: Nearest Flood Relief Area

| Sub-district       | Flood relief     | Area                      | Station | Latitude       | Longitud       | Nearest flood relief (km) |
|--------------------|------------------|---------------------------|---------|----------------|----------------|---------------------------|
| Batu Mengkebang    | SMK Sultan Yahya Petra II | Kuala Krai Town | B1      | 5°32'21.51"   | 102°11'14.46" | 1.002                     |
| Olak Jeram         | SMK Manek Urai Lama | Kg. Manek Urai Baru      | B2      | 5°22'24.19"   | 102°13'51.16" | 0.496                     |
|                    | SMK Laloh         | Kg. Laloh                | B3      | 5°18'40.87"   | 102°16'2.71"  | 0.097                     |
| Dabong             | SK Kuala Gris     | Kg. Kuala Gris           | B4      | 5°23'14.45"   | 102°3'43.83"  | 0.174                     |

**Figure 4.** (a) station B1, (b) station B2, (c) station B3 and (d) station B4

2.4. *Water Quality Index Analysis (WQI)*

This study adapted the WQI analysis method to assess the quality of flood water based on the Interim National Water Quality Standard (INWQS) for Malaysia by the DOE. This analysis being used as there are no specific water quality measures to assess the status of flood water quality yet. The following are
the formulas employed by DOE for water quality, consisting of six parameters i.e. DO, BOD, COD, NH3N, SS and pH in determining the value and class of WQI. The river water quality status is calculated in the form of Microsoft Office Excel 2007 version provided by the DOE, which is to calculate the sub-index (SI) and WQI values. With the value of WQI obtained, the water quality status is determined according to five specific WQI classes as in Table 2.

Table 2. Classification of water quality and its use

| Class | WQI (%) | Water Status | Uses |
|-------|---------|--------------|------|
| I     | > 92.7  | Very good    | Suitable for drinking water supply, water treatment is almost unnecessary. |
| IIA/IIB | 76.5 – 92.7 | Good | The water source for drinking water supply, regular treatment is necessary. The water source for recreational use with body contact. |
| III   | 51.9 – 76.5 | Moderate | The complete treatment is required for drinking water sources. |
| IV    | 31 – 51.9 | Polluted    | Suitable for drainage. |
| V     | < 30    | Highly Polluted | Not suitable for any use. |

Source: DOE [23]

3. Results and Discussions

3.1 Flood water quality by WQI parameters

The parameters of WQI consist of six main parameters, DO, pH, BOD, COD, NH3N and SS. Table 3 shows the value of the DO, pH, BOD, COD, NH3N and SS parameters at every station. The DO is a measure of free oxygen amount found in the water when it get contact with the atmosphere in the atmosphere [25,26]. Normal DO values need to be 7 mg/l and above [25]. However, DO values for each station are between 3.30 mg/l to 4.13 mg/l, which is below the DOE standards. The pH value is an important measure of water quality in measuring acidity or water acidity levels. A good pH value is between 6.5 to 8.5 [25]. The results showed that the pH values were between 8.15 to 9.24 where stations B2 (8.15) and B4 (8.21) met the DOE standards, except stations B1 (9.24) and B3 (8.56) had high pH values. This condition shows that flood water is slightly alkaline. Normally, BOD is the dissolved oxygen content measurement used by some microorganisms with the decomposition activity of organic compounds found in water. A good water BOD values should be below 1 mg/l [25]. However, the BOD water concentration values are between 1.15 mg/l to 2.79 mg/l. This situation explains that every flood water station has a high BOD content and exceeds the DOE standard. The COD is the measurement of the amount of oxygen required for the compound material oxidation [26]. A good water COD values are below 10 mg/l [25]. The results showed that the value of the COD concentration was between 11 mg/l to 31 mg/l where all stations did not meet the DOE standards.

In addition, the NH3N is also measured to assess the amount of ammonia or toxic contamination in the body of water as a result of sewage, liquid fertilizer and other liquids associated with organic waste. A good NH3N values should be less than 0.1 mg/l [25]. The results showed the NH3N value of flood water was between 0.21 mg/l to 0.49 mg/l. This indicates that all flood water stations do not meet the
DOE standards. While, SS parameters is a measurements of drought and particle-size resistances larger than 0.001 mm [26]. The level of net SS value measurement should be less than 25 mg/l [25]. However, the SS value of flood water is at a very high concentration between 140 mg/l to 330 mg/l.

Table 3. DO, pH, BOD, COD, NH$_3$N, and SS concentration values

| Station | Parameter | DO (mg/l) | pH | BOD (mg/l) | COD (mg/l) | NH$_3$N (mg/l) | SS (mg/l) |
|---------|-----------|-----------|----|-----------|------------|----------------|-----------|
| B1      |           | 4.13      | 9.24 | 1.36      | 31         | 0.49           | 330       |
| B2      |           | 3.79      | 8.15 | 2.79      | 27         | 0.26           | 140       |
| B3      |           | 3.30      | 8.56 | 2.30      | 11         | 0.21           | 150       |
| B4      |           | 3.34      | 8.21 | 1.15      | 20         | 0.41           | 240       |

3.2 Flood Water Quality by Physical and chemical parameters

Table 4 shows the turbidity, NO$_3$, Fe, Mg, Ca and Cu concentrations for all flood water station. Turbidity is a physical measurement of water quality in determining the clarity of the water. The turbidity value allowed by the DOE is less than 5 NTU. However, every flood water station recorded a very high turbidity value, up to 500 NTU. Nitrate (NO$_3$) is the primary form of nitrogen that can be used as nutrients for plant growth. The results showed that NO$_3$ concentrations were between 1.3 mg/l to 2.5 mg/l, which was less than the 7 mg/l from the DOE standard. While iron (Fe) is the metal element required in the biological system and naturally came from the earth's surface such as soil. The results showed that all stations had a high concentration of iron between 2.200 mg/l to 4.420 mg/l which exceeded the DOE standard of less than 1mg/l. Exposure to human over these elements will cause the content to turn into toxicity. While, magnesium (Mg) is the required element in the human body of about 25 gram for human bones, muscles, and other tissues. The results of the analysis showed that the Mg element could not be detected in every flood water sample which is no content of Mg in the water. Calcium (Ca) is also an element required by humans in bone formation. However, excessive Ca taking in drinking water will harm human health. Based on the concentration of Ca, the lowest value is at B1 station (0.82 mg/l) while the highest value is at 4.57 mg/l. Meanwhile, copper (Cu) is a heavy metal component needed by humans for the formation of blood hemoglobin. Excessive Cu intake can cause lung damage, lung cancer, tuberculosis, weight loss and anemia [27]. Therefore, DOE standard for Cu elements is less than 0.02 mg/l [25]. The findings show that two flood water stations with a Cu concentration value exceeding the DOE standard, namely B3 stations (0.035 mg/l) and B4 (0.032 mg/l).

Table 4. Turbidity, NO$_3$, Fe, Mg, Ca and Cu concentrations
### Station Data

| Station | Turbidity (NTU) | NO\textsubscript{3} (mg/l) | Fe (mg/l) | Mg (mg/l) | Ca (mg/l) | Cu (mg/l) |
|---------|-----------------|-----------------|----------|---------|---------|---------|
| B1      | 573             | 2.5             | 4.420    | ND      | 0.82    | 0.018   |
| B2      | 266             | 1.8             | 4.130    | ND      | 1.17    | 0.020   |
| B3      | 279             | 1.3             | 2.200    | ND      | 0.85    | 0.035   |
| B4      | 412             | 2.1             | 2.320    | ND      | 4.57    | 0.032   |

Note: ND Not Detect

### 3.3 Flood Water Quality by Biological parameters

For a biological parameters, this study only focuses on the content of bacteria E.coli in flood water. Based on Table 5, the value of E.coli bacterial content of each flood water station. Bacteria E.coli is a group of bacteria present in the water, from the human and animal waste. The presence of certain types of E.coli bacteria in drinking water can cause people to experience diarrhea, abdominal cramps, and vomiting [27]. DOE standard for the E.coli content value is less than 100 MPN/100ml. The results showed that the highest E.coli content was 18.1 MPN (station B4), followed by 8.5 MPN (station B2), 7.4 MPN (station B1) and 5.2 MPN (station B3).

#### Table 5. E. coli bacterial concentration

| Station | E.coli (MPN/100ml) |
|---------|-------------------|
| B1      | 7.4               |
| B2      | 8.5               |
| B3      | 5.2               |
| B4      | 18.1              |

### 3.4 Flood Water Quality by stations

Table 6 shows the SI, WQI, class, and water quality status for each flood water station. The findings show that all flood stations are in class III where the highest value of WQI is at 68.34% (station B3),
67.21% (station B2), 65.31% (station B4) and 61.31% (station B1). This condition indicates that flood water needs to be fully treated for drinking water sources.

Table 6. SI value, WQI, class, and status of flood water quality

| Station | SIDO | SIBOD | SICOD | SIAN | SISS | SIPH | WQI % | Class   | Status         |
|---------|------|-------|-------|------|------|------|-------|---------|----------------|
| B 1     | 48.86| 94.65 | 62.07 | 63.44| 36.92| 60.16| 61.31 | III     | Moderate pollution |
| B 2     | 42.72| 88.60 | 66.33 | 73.22| 54.65| 88.70| 67.21 | III     | Moderate pollution |
| B 3     | 34.23| 90.67 | 84.47 | 78.45| 53.60| 81.04| 68.34 | III     | Moderate pollution |
| B 4     | 35.96| 95.54 | 72.50 | 66.37| 44.76| 87.71| 65.31 | III     | Moderate pollution |

The flood water analysis result collected in Kuala Krai in December 2016 / January 2017 shows that the water quality is moderately contaminated. This is due to the presence of high pollutant elements such as DO, BOD, COD, SS, and NH₃N. Flood water also possess high turbidity, Fe, and E. coli bacteria. The presence of flood-induced floods causes flood victims to be susceptible to disease risk by touch or drink. The findings of this study have similarities with previous studies conducted by Pardue et al. [11] in New Orleans found that flood water quality caused by Hurricane Katrina caused human exposure to water pollution with high concentrations of pollutants. Similarly, studies conducted by Rahman et al., [12] in the eastern part of Dhaka City, India where the results of the study show a sample of flood water contaminated with organic waste and has a very high concentration of coliform bacteria. Additionally, floodwater will also have high turbidity due to the flood properties of floodwater that has washed away dirt and solid wastes along the flow path. Overall, this study clearly shows that flood water has a high pollutant content because the flood water is transporting the impurities found in the land such as solid waste, sewage, and soil-derived elements. Therefore, flood victims are not encouraged to use flood water during floods. This is because the use of dirty flood water will cause flood victims to be exposed to waterborne diseases. Typically, diseases associated with flood events are diarrhea, years, skin diseases and other diseases due to the contact and use of contaminated flood water. This condition can be proven by the study conducted by Shimi et al., [6] where flood disaster in 2004 in Bangladesh caused 25 percent of households using contaminated flood water surrounding it caused various water-borne diseases that were spread like diarrhea, dysentery, fever, eye, and skin infections and others. This condition clearly shows that the use of contaminated water sources such as flood water can lead to the risk of spreading the disease during the flood disaster.

4. Conclusion

In conclusion, contaminated floodwater has indeed been a detrimental effect on the health of flood victims who use it for domestic activities such as cooking, washing, and bathing. Hence, future research proposals are to develop a water supply risk management during the flood disaster to overcome water supply problems at the evacuation centers and to prevent flood victims using contaminated flood water. Inefficient management, the cooperation, and roles of various flood disaster management agencies are
essential to ensure that flood victims receive clean water supply despite floods occurring on a large scale.

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