Determination of Metals Concentrations and Water Quality Status along Ulu Jempul River

Siti Norhafiza Mohd Khazaai
Siti Anis Amran
Sarah Laila Mohd Jan
Siti Raihan Zakaria
Zurhana Mat Hussin

ABSTRACT

This study was done to determine water quality status and heavy metals concentration along Ulu Jempul River. Samples from five sampling stations were analyzed two times which were on March and April 2013. Eight parameters were analyzed which were temperature, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) by using YSI 556 MPS Handheld Water Quality Meter and two heavy metals which were Chromium and Zinc. Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) was applied to identify heavy metals concentration in the water samples for two difference weather conditions. Agricultural activities were the main causes for the water quality changes. One way analysis of variance (ANOVA) and Microsoft Excel was used to analyze data. The results obtained from ANOVA were compared with the stated value in Interim National Water Quality Standard (INWQS) to determine the river quality status. According to the Environmental Quality Act, 1974, the data collected was complying by the standard A. Almost all parameters showed no significant differences ($P>0.05$) for March and April for each station with confidence level of 95% except for Dissolved Oxygen (DO) which was significant of $P<0.05$. Physico-chemical analysis along Ulu Jempul River at the five sampling stations was categorized under Class II which is slightly polluted based on BOD values.

Keywords: *heavy metal, water quality, Ulu Jempul river*

Introduction

Sources of surface water have crucial role during human civilization development (Jalal and Sanalkumar, 2013). Clean water is not just the basic requirement that human need but it included all the aspects of human life (Farid et al., 2012). Water pollution is the big issue because it will disturb human food chain. It will block some human activities that will give economic source to them. The river quality is depending on the national water quality standards for Malaysia. Water quality can be define as the level of the standard cleanliness of water body especially river (Yusoff and Rashid, 1999). The river is clean and safe to use if it not exceed the standards that have been set by Water Quality Index (WQI). Table 1 shows the water quality index and recommended treatment for contaminated water.

Table 1 Water quality index and recommended treatment (DOE, 2006).

No.	Class	Intended use	Treatment method
1	I	Conservation of natural environment, Water Supply I and Fishery I – sensitive aquatic species	Practically no treatment necessary
2	II	Water supply II, Fishery II—sensitive aquatic species and Recreational use with body contact	Conventional treatment required
3	III	Water supply III, Fishery III—common, of economic value and tolerant species livestock drinking	Extensive treatment required
4	IV	Irrigation	Advanced treatment methods required
5	V	None of the above	Must undergo waste water treatment

Human and all living things need water every day for all activities. Unfortunately, some of the rivers in Malaysia have been polluted due to human activities. Water pollution happens when the water body consist large amounts of foreign materials or substances. Water analysis is important for us to ensure that the main sources of water have high quality. Water body quality is polluted by several natural processes and human activities such as industrial activity, agricultural activity and disposal of wastes. Agricultural activities are contributing to economic sources for the population in the rural area. It is the main economic sector especially at the FELDA area. Normally the population at the FELDA area activity is plantation such as rubber plantation and oil palm plantation. They will use the land appropriately for this activity. It is important to detect any contaminant, heavy metals, sediments and anything that will affect our health and disturbance of ecosystem habitat. Besides that, it is also to verify that some parameters determine in this study are complying with the Interim National Water Quality Standards (INWQS). It is because the river is important sources for the population especially around this area. They use river for their daily activities and their source of water. Jengka is the largest FELDA in Malaysia so the population in this area also increases. Therefore, the consumption of water also increases. Besides that, aquatic organisms also require the suitable water conditions to survive. Some populations in this area also use the river as their source of income. The high water quality is important to ensure that there are no bad effects to the population in this area.

Normally water pollution occurs due to the human activities. At the rural area, water pollution occurs caused by agricultural activities. According to Evans et al., (2012), agricultural production in the region increased by 62% from 1990 to 2002 while fertilizer mineral consumption increased by 15%. The nutrients that exceed high levels were found in 50% of rivers in the region and moderate levels in 25%. It is due to the agricultural drainage which is reaching water bodies that affect water quality. It is also related to fertilizer applications and pesticides in agricultural activities. Fertilizer was used to produce more products. Excessive of chemical fertilizers application will contribute to the large number of environmental problems. Some of the fertilizers consist of heavy metals such as cadmium and chromium and it also has high radionuclides concentration (Savci, 2012). Global population growth has increased the oil palm demand. At the same time, this demand also increased agricultural production (Glavan et al., 2013). Therefore, quality of water and health of aquatic community were analyzed due to the agriculture land influenced (Christensen et al., 2012). River water flow condition has the relation between the physical and chemical factors. Without the natural land cover, the habitat of species, animals, plants and other organisms will reduce. Besides that, hydrological conditions and quality of water also changes. Activities of agricultural will decrease and degrade the water quality.

Meanwhile, the groundwater from agricultural sites has been changes the flow conditions due to the waste discharge, farming and also irrigation (Elhatip et al., 2003). Agricultural activities increase major elements and several of heavy metals concentrations in river water. Variety of heavy metals consists naturally in the earth crust. Heavy metals can enter our bodies by various ways either through respiration, eating food and drinking water (Moosavi et al., 2012). However it occurs naturally in the earth crust, it cannot be degraded or destroyed due to the continuous of environmental contamination (Duruibe et al., 2007). For other high risk heavy metals such as chromium, copper and zinc, it has potential to attack kidney and liver when it accumulates (Omran, 2010), therefore the main objectives of this study are to determine the heavy metals which are zinc (Zn) and chromium (Cr) concentration along Ulu Jempul River in Jengka and to classify the water quality status by using one way analysis of variance (ANOVA).

Methodology

Pre-Treatment

Before the samples have been analyzed, all the apparatus that were used must go through the pre-treatment stage. In this stage, all of them have been soaked in 10% of nitric acid for one week.

Sampling areas

The study of sampling area was along Ulu Jempul River which was started from Water Plant Ulu Jempul. The distance of this site was about 10 km which is taken 22 minutes travelled by car. The famous crops at Felda in Jengka were oil palm and rubber. The location of Ulu Jempul was near to the Bandar Pusat Jengka and Jerik River along the road of Jerantut Maran (Din et al., 1988).

According to Din et al., (1988), FELDA Jengka has changed the environment. The jungles has been cleared for the purposes of planting, construction of the building to improve facilities and infrastructure such as roads, houses, electricity, medical and water supply, factory, and many others provided services. In the planting or agricultural activities, the main crops at the FELDA Jengka were oil palm, rubber, coffee and sugar can. The land acreage was used for planting oil palm at Ulu Jempul was about 5824 hectare. Figure 1 show the water sampling station along Ulu Jempul River in the form of terrain and map from station 1 until station 5.

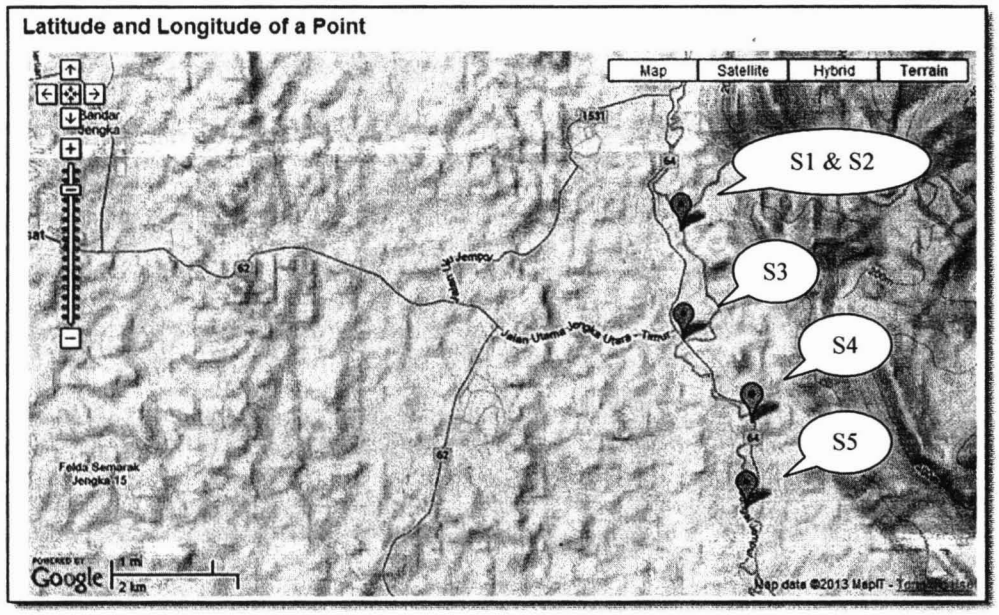

Figure 1 Water sampling stations along Ulu Jempul River (terrain form).

Water sampling and analytical method

Water samples were collected two times from five monitoring sampling stations on the 13 March 2013 and 20 April 2013. The sampling on 13 March 2013 was taken after the rainy day while on 20 April 2013 was taken during the hot day. The distance of every monitoring sampling station was about 2 km. These samples were taken using grab sampling in-situ technique for each sampling station and undergo in-situ analysis. Water samples were collected in polyethylene sampling bottles. Then, the bottles were washed using tap water and then with distilled deionized water (Islam et al., 2008). For every sampling station, polyethylene sampling bottles were rinsed at least three times with the river water at the site before sampling was done. Three sampling replications were analyzed from each monitoring station and the findings were presented by the average of replicate samples. The water samples were taking about half from the top surface of water (Ambedkar and Muniyan, 2012). The polyethylene sampling bottles were labeled and few drops of nitric acid were added immediately to prevent the loss of heavy metals (Farooq et al., 2012). Collected water samples were kept in an ice box before brought to the laboratory (Ewa et al., 2011).The collected samples were carried to the laboratory as soon as possible. After brought to the lab, the samples were kept in the refrigerator at 4^0C for further analysis (Islam et al., 2008). There are eight parameters were analyzed which were temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD) and two types of heavy metals which were Cr and Zn. Only a tool was used for measuring these parameters by using YSI 556 MPS Handheld Water Quality Meter. This meter have multi sensor probe which can analyzed six parameters at the same time like pH, temperature, dissolved solids, electrical conductivity and total dissolved solids except for heavy metals. Heavy metals were analyzed by using inductively coupled plasma mass spectrometry (ICP-MS).

Dark glass bottles were used for biochemical oxygen demand (BOD) samples to incubate in the incubator. Dissolved oxygen reading (mg/L) for Day 1 was taken using YSI 556 MPS Handheld Water

Quality Meter. Then, the water sample was placed in a dark glass bottle and kept in an incubator in complete darkness at 20°C for 5 days. After 5 days, another dissolved oxygen reading (mg/L) was taken using the YSI 556 MPS Handheld Water Quality Meter again. The Day 5 reading was subtracted with the Day 1 reading to determine the BOD level (Ewa et al., 2011). The final BOD result was recorded in ppm.

Heavy metal analysis in water sample

A 500 µL water samples for each station were diluted into 50 mL volumetric flask. After that, 2% HNO_3 was added until the mark. These diluted samples from five sampling stations were analyzed by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS, Agilent 7500, Agilent, USA). The blank, ICP Standard and water samples were analyzed by ICP-MS. The blank used was 2% HNO_3 and ICP Standard was provided by ICP-MS.

Result & Discussion

Water samples were collected from the five sampling stations along Ulu Jempul River. These samples have been analyzed for four physical-chemical parameters which were temperature, pH, dissolved oxygen (DO) and biochemical oxygen demand (BOD). Besides that, these samples also were analyzed for distribution of heavy metals. Two types of heavy metals that have been analyzed which were Chromium and Zinc. The surface water analyzed results for each sampling station were showed in the Table 2 until Table 5. The results from this study were compared and statistically analyzed with the stated values under Interim National Water Quality Standards (INWQS) to determine the status of the river. The results from each sampling stations have the parameter changes during March and April.

Table 2 Ulu Jempul River of surface water analysis in means value (March).

No	Quality Parameter	M.U	Station 1	Station 2	Station 3	Station 4	Station 5
1	Temperature	(^{0}C)	25.74	29.00	27.84	26.76	26.58
2	pH	-	6.78	7.25	5.00	5.08	5.68
3	Dissolved oxygen	(mg/L)	6.8	3.14	1.25	1.49	1.19
4	BOD	(mg/L)	1.17	2.48	2.56	1.88	1.78

Table 3 Ulu Jempul River of surface water analysis in means value (April).

No	Quality Parameter	M.U	Station 1	Station 2	Station 3	Station 4	Station 5
1	Temperature	(^{0}C)	26.00	27.27	29.25	28.88	29.10
2	pH	-	7.8	8.9	7.45	7.3	8.7
3	Dissolved oxygen	(mg/L)	6.9	4.51	2.3	3.51	3.48
4	BOD	(mg/L)	1.94	2.90	2.98	2.35	2.89

Table 4 Heavy metals analysis along Ulu Jempul River in means value (March).

Elements	Station 1	Station 2	Station 3	Station 4	Station 5
Zinc, Zn (ppb)	0.321	0.399	0.477	0.114	0.715
Chromium, Cr (ppb)	0.140	0.155	0.198	0.160	0.205
Elements	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**
Zinc, Zn (ppb)	0.541	0.445	0.580	0.233	0.800
Chromium, Cr (ppb)	0.148	0.167	0.204	0.188	0.216

Temperature

Based on the ANOVA statistical results, the changes of temperatures from five sampling stations were not influenced by the changes of weather. It showed that there were a little change of the temperatures between two month of March and April for each station.

Table 6 Means and standard deviations of difference in temperature in March andApril.

Months	Mean	SD	F-statistics (df)	*p*-value
March	27.18	1.26	1.166	0.312
April	28.10	1.42		

The result for the mean and standard deviation of the temperature value was 27.18±1.26, 28.10±1.42 on March and April respectively. The range of temperatures from the five sampling stations in two month was between 25.74°C until 29.25°C. Therefore, these readings were classified under Class II due to the stated value under Interim National Water Quality Standard (INWQS). ANOVA analysis showed the temperature has no significant difference from the three stations in three months along the Relau River at the National Forest Reserve, Merapoh, Pahang (Nadarajah et al., 2012). The range of temperature was between 23.87°C – 24.21°C. This river was categorized in Class I based in INWQS. The results was quite difference in this study due to the difference sampling duration and location. Temperature has a side effect to the aquatic life because it is the crucial physical parameter to determine water quality. High temperature can decrease concentration of dissolved oxygen that consists in water and will cause low amount of oxygen for respiration process. Besides that, temperature also influences the features characteristics of aquatic organisms and gases solubility. In addition, chemical and rates of reaction in the water also influenced by temperature range (Jalal & Sanalkumar, 2012).

pH

From the ANOVA statistical results, the changes of pH from five sampling stations were not influenced by the changes of weather. It showed that there were a slightly change of the pH between two months of March and April for each station.

Table 7 Means and standard deviations of difference in pH in March and April.

Months	Mean	SD	F-statistics (df)	*p*-value
March	5.96	1.01	13.763	0.06
April	8.03	0.73		

However, the range of pH from the five sampling stations in two month was between 5.0 until 8.9. According to the Interim National Water Quality Standard (INWQS), these readings were categorized as Class III. The result showed that the level of pH value in March was lower trend than pH value trend in April. It is because sampling in March was done after rain. Therefore, rain brought the runoff from agricultural area into the water that formed weak acid as dissolved in water. The optimal pH range for best condition of aquatic life is between 6.09 and 8.45 (Ibrahim et al., 2009). Treated water from Water Plant Ulu Jempul was under the good condition. pH or also known as hydrogen ion concentration is act as a key to determine acidity or alkalinity of water. Through this, the hydrogen concentrations or activity in the water can be calculated. Basically, aquatic species can survive at the pH range of 6.5 to 8.5 while only a little species can survive at the pH range of 5 to 9 (Kosamu et al., 2011).

Dissolved oxygen (DO)

The changes of dissolved oxygen (DO) from five sampling stations were influence by the changes of weather. It showed that there were the large changes of the temperatures between two months of March and April. The range of dissolved oxygen (DO) from the five sampling stations in two month was between 1.19 mg/L until 6.90 mg/L. Through this range, this parameter was classified under class III and Class IV due to the same stated value under Interim National Water Quality Standard (INWQS). The result for the mean and standard deviation of the dissolved oxygen (DO) value was 1.80±0.80, 4.14±1.73 on March and April respectively. The data showed that the level of dissolved oxygen (DO) was high at station 1 on April. Nevertheless, the level of DO was low at station 5 on March. It was due to the changes of weather from the rainy day on March and the hot day on April. During rainy day, all the sediments from the land, fertilizer and pesticides that used from the farmers maybe flow to the river. This problem will disturb the components of the river. The population of microorganisms will increase and consume the oxygen gas that consists in the water. The decreasing of dissolved oxygen on March was caused by the changes of weather. Besides that, the amount of dissolved oxygen (DO) will affect the amount of biological oxygen demand (BOD). The high dissolved oxygen (DO) means that the water is in good condition, so the amount of biological oxygen demand (BOD) will decrease.

From this result, treated water from Water Plant Ulu Jempul also in good condition with the amount of dissolved oxygen was about 6.8 mg/L on March and 6.9 mg/L on April. Dissolved oxygen was increasing from March to April. The increase amount of dissolved oxygen will increase the amount of oxygen in the water. Dissolved oxygen is the amount of oxygen that consists in water. This component is crucial for the aquatic life and the process involved such as cellular respiration. Dissolved oxygen act as a source of indicator for water quality and it have an optimum range. The function of dissolved oxygen is to determine and calculate the percent of pollution from organic matter. It is essential requirements for organic matter oxidation process when the dissolved oxygen concentration is high. Otherwise, it will kill or give the adverse effect to the aquatic life when dissolved oxygen concentration is low (Ewa et al., 2011).

Biochemical Oxygen Demand (BOD)

The changes of Biochemical Oxygen Demand (BOD) from five sampling stations were not influence by the changes of month. It showed that there were a little change of the BOD between two months of March and April. The range of BOD from the five sampling stations in two month is between 1.17 mg/L to 2.98 mg/L. For the values range of BOD, it was classified under Class II due to the stated value in INWQS. The result for the mean and standard deviation of the Biological Oxygen Demand (BOD) value was 1.97±0.57, 2.61±0.45 on March and April respectively. It showed that the level of BOD was high at station 3 on April while the level of BOD was low at station 1 which was treated water on March. Therefore, the treated water

was under good condition. The lower values of BOD indicate the high water quality. Station 3 has the high BOD because it faced of dissolved oxygen depletion. BOD has the relationship with the DO. DO will decreasing by the increasing of BOD.The Value of BOD along three stations of Relau River at National Forest Reserve, Merapoh, Pahang was about 7.0 mg/L - 8.77 mg/L in three months. These results also have no significant differences in three stations within three months. It was categorized as Class III based on INWQS. Biological Oxygen Demand is the parameter to estimate the amount of oxygen that consume by microorganisms in the water body for organic material oxidizing process (Nadarajah et al., 2012). The BOD was higher in the station 3 perhaps due to high the organic matter contents.

Zinc (Zn)

Meanwhile, the changes of Zn concentration from five sampling stations were not influence by the changes of month. It showed that there were a little change of the temperatures between two months of March and April for each station. The range of zinc (Zn) concentration from the five sampling stations in two month was between 0.321 ppb until 0.800 ppb. The result for the mean and standard deviation of the Zn concentration value was 0.041±0.022, 0.052±0.021 on March and April respectively. The data showed that the level of zinc (Zn) concentration was high at station 5 because of fertilizer and pesticide was directly discharged into the river. There were many oil palm trees situated nearby the river bank. Perhaps this situation will make the runoff water consisting acidic substances from fertilizer and pesticides to become available in the river. However, the level of Zn was low at station 4 due to the oil palm plantation. The number of plantation was influence fertilizer application. Therefore, it was decrease zinc concentration at station 4. According to Voica et al. (2011), the amount of Zn that consists in natural waters was lower compared than sewer water. Nevertheless, these ranges were under the stated value of World Health Organization (WHO) which was below 15 mg/L. Therefore, water consumer will not get the dangerous effects such as diarrhea, headache and mucus membrane damage. It can be simplified that agricultural activities along Ulu Jempul River only release a small amount of fertilizer and pesticides. The use of fertilizer and pesticides maybe reduced because the oil palm and rubber tree has the good growth.

Chromium (Cr)

The data recorded for chromium (Cr) concentration from five sampling stations also were not influence by the changes of month. It showed that there were slightly change of the temperatures between two months of March and April for each station. The range of chromium (Cr) concentration from the five sampling stations in two month was between 0.140 ppb until 0.216 ppb. The result for the mean and standard deviation of the chromium (Cr) concentration value was 0.017±0.028, 0.018±0.027 on March and April respectively. The chromium concentration was high at station 5 which was same station with the high Zn concentration. There were many oil palms along this station. Therefore, it will increase the fertilizer and pesticides application and contributes to the high Cr concentration. Nevertheless, the level of Cr was low at station 1 which was treated water on March. However, these value ranges also were a little bit above the stated value of World Health Organization (WHO) which was under 0 mg/L. Therefore, water consumers may have the low risk to get kidneys damage, lung cancer and face to death if badly exposed. It can be simplified that agricultural activities along Ulu Jempul River slightly affected the river water quality. The use of fertilizer and pesticides could disturb the river water quality. According to Lim et al., (2012), the average of chromium concentration in Langat River was between the range 0.32 ppb 0.467 ppb Therefore; this value was quite same with this study. The concentrations of metals in Langat River were low, except for As and Pb. These results were compared by the Malaysia National Standard for Drinking Water Quality proposed by the Ministry of Health (MOH).

Parameter comparison with standards A

According to Malaysia's Environmental Law, Environmental Quality Act, 1974, the Malaysia Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979, Malaysia must comply by this act for standard methods of analysis of effluents. From data that have been collected, the water was safe for water supply because the discharges into the river have complied by the Environmental Quality Act, 1974. The data analysis was not exceeding the standard A.

Table 8 Parameter comparison with standard method of analysis of effluents.

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	Standard A
Temperature (^{O}C)	25.74[a] 26.00[b]	29.00[a] 27.27[b]	27.84[a] 29.25[b]	26.76[a] 28.88[b]	26.58[a] 29.10[b]	40
pH	6.78[a] 7.80[b]	7.25[a] 8.90[b]	5.00[a] 7.45[b]	5.08[a] 7.39[b]	5.68[a] 8.70[b]	6.0 – 9.0
DO (mg/L)	6.8[a] 6.9[b]	3.14[a] 4.51[b]	1.25[a] 2.3[b]	1.49[a] 3.51[b]	1.19[a] 3.48[b]	Not reported
BOD (mg/L)	1.17[a] 1.94[b]	2.48[a] 2.90[b]	2.56[a] 2.98[b]	1.88[a] 2.35[b]	1.78[a] 2.89[b]	20
Zn (mg/L)	0.000321[a] 0.000541[b]	0.000399[a] 0.000445[b]	0.000477[a] 0.000580[b]	0.000114[a] 0.000233[b]	0.000715[a] 0.000800[b]	1.0
Cr (mg/L)	0.000140[a] 0.000148[b]	0.000155[a] 0.000167[b]	0.000198[a] 0.000204[b]	0.000160[a] 0.000188[b]	0.000205[a] 0.000216[b]	Cr^{3+} (0.20) Cr^{6+} (0.05)

Notes: a – collected parameter analysis in March
b – collected parameter analysis in April

Conclusion

Based on the physicochemical analysis along Ulu Jempul River at the five sampling stations, the river was categorized under Class II which is slightly polluted in term of BOD values. From the results obtained by using one way analysis of variance (ANOVA) and Interim National Water Quality Standard (INWQS) the stated value along Ulu Jempul River is considered sensitive to aquatic species and to recreational use with body contact. According to the Environmental Quality Act, 1974, the data collected was complying by the standard A. Therefore, this water is safe for water supply. Through one way analysis of variance (ANOVA), almost all the parameters showed no significant difference which is ($P>0.05$) except for Dissolved Oxygen (DO) which is significant ($P<0.05$). Heavy metals for chromium (Cr) and zinc (Zn) concentration also showed no significant difference which is ($P>0.05$). The ranges of zinc and chromium concentration were below the stated value of World Health Organization (WHO).

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SITI NORHAFIZA BINTI MOHD KHAZAAI, SITI ANIS AMRAN, SARAH LAILA MOHD JAN, SITI RAIHAN ZAKARIA, ZURHANA MAT HUSSIN.
Universiti Teknologi MARA (Pahang).
ctnorhafiza@pahang.uitm.edu.my,aniz_sparkle@yahoo.com.my,sarahlaila@pahang.uitm.edu.my, sitiraihan@pahang.uitm.edu.my, zurhana_mhussin@pahang.uitm.edu.my.