Faculty of Resource Science and Technology

Impact of Oil Palm Plantation to Fish Fauna at Batang Kerang Floodplain, Balai Ringin, Sarawak

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Declaration

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

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List of Abbreviations

&	and
^{o}C	Degree Celsius
%	Percent
A	Anal fin rays
APHA	American Public Health Association
BOD	Biological Oxygen Demand
D	Dorsal fin rays
DO	Dissolved Oxygen
P_1	Pectoral fin rays
P_2	Pelvic fin rays
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
S.D	Standard Deviation
SL	Standard Length
TL	Total Length
TSS	Total Suspended Solid
W	weight

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ABSTRACT

Fish composition and diversity in Batang Kerang floodplain were documented at brown water habitat and black water habitat. A total of 149 individuals of fish were caught. There were 13 species from 7 family caught for both water. The dominance species is *Cyclocheilichtys apogon* from family Cyprinidae. Data analyzed were compared with previous studies to examine anthropogenic impact regarding on oil palm plantation at Batang Kerang floodplain to fish fauna. However, fish diversity indices are lower compared to previous studies. There were no significant different (t-test, $p<0.005$) in fish composition between brown water and black water. There were significance differences in physicochemical water quality parameters for Total Suspended Solid (TSS), Chlorophyll *a*, Biological Oxygen Demand (BOD) and nutrients including orthophosphate, nitrogen-ammonia and nitrate.

Keywords: anthropogenic, oil palm, fish diversity, floodplain, brown water, black water

ABSTRAK

Kajian komposisi ikan di air keruh dan air hitam telah didokumentasikan di lembah banjir Batang Kerang. Sejumlah 149 individu ikan telah ditangkap. 13 spesis ikan daripada 7 famili telah di sampel di kedua-dua air. Cyclocheilichtys apogon *daripada famili Cyprinidae adalah spesis yang dominan. Data dianalisis dan dibandingkan dengan kajian sebelumnya bagi menentukan kesan antropogenik daripada penanaman kelapa sawit di lembah banjir Batang Kerang terhadap fauna ikan. Walaubagaimanapun, indeks diversiti adalah rendah daripada kajian yang telah dijalankan sebelumnya. Komposisi ikan bagi kedua-dua air tidak menunjukkan perbezaan yang signifikasi (t-test, $p<0.05$). terdapat perbezaan signifikasi untuk kualiti air bagi jumlah bahan terampai (TSS), klorofil* a, *permintaan oksigen biologi (BOD) dan nutrient termasuk ortofosfat, ammonia-nitrogen dan nitrat.*

Kata kunci*: antropogenik, kelapa sawit, taburan ikan, lembah banjir, air keruh, air hitam*

1.0 INTRODUCTION

Industrial and agricultural development such as oil palm plantation is the most common types of anthropogenic pollution that give impact to the riverine ecosystem (Kennish, 1992; Mario, 1998). Farming in a massive scale for opening new oil palm plantation involves huge area for land clearing (Vitalis *et al.*, 2000; Hadil and Albert, 2002). Land exposure and drainage system alteration leads to the increasing of soil erosion and sediments run-off nearby the streams during heavy rain falls. Thus, freshwater stream affected due to turbidity, colour changes and sediment load deposition in water (Hadil and Albert, 2002).

Oil palm plantation likes others agricultural and industrial activities become main factors for pollution (Kennish, 1992). Agrochemicals including chemical fertilizers and synthetic pesticides have become integrals and indispensible components of modern agricultural (Loehr, 1984; Jacobson, 2005). These components introduced in water column cause suspended organic materials within water body increase (Kennish, 1992; Hadil and Albert, 2002; Schwarzbauer, 2006). According to Gurmit (1999), nutrients excessive in the water bodies lead to the eutrophication process. Hence, aquatic ecosystem and water quality are affected when sewage (nutrients excessive) discharge into water column leading to increase level of Biological Oxygen Demand (BOD) in aquatic ecosystem (Gurmit, 1999; William, 2001).

Batang Kerang floodplain connected to different types of rivers which are brown water river and black water river (Khairul Adha *et al.*, 2009). Aquatic fauna especially fish community are largely depends on aquatic vegetation for feeding habitat and breeding ground (William, 2001).

Habitat changes and introduction to exotic species become threats to tropical rivers that are generally known for their diverse ecosystems and biodiversity (Coates *et al*., 2003; Dudgeon *et al*., 2006). According to Zakaria (1994), physical habitat changes associated mainly by human activities are the main factors contribute to alteration of fish composition and distribution. Besides being as sources for protein, fish also play an important role in maintaining ecological balance in aquatic ecosystem (Halls *et al.,* 2008). Fishes at Batang Kerang floodplain used as main protein sources and also sources for income among villages.

Fish were sampled at 6 stations in brown water river and 6 stations in black water river using difference sizes of gill nets respectively (2.5 cm, 3.5 cm and 5.0 cm) in August 2010 and March 2011. Fishes collected identified and preserved in 10% formalin for further identification purpose. T-test was used to analyze significance differences for physicochemical water quality parameter between brown water and black water. Diversity indices calculated using Shannon Index diversity,H' (Shannon and Weaner, 1963), Margalef's Index richness,D (Margalef, 1958) and Pielou Index evenness, J' (Pielou, 1966). Fish diversity indices are lower for currents study compared to previous studies (Esa, 2005; Ibrahim, 2006).

There were several studies and publications on of fish fauna diversity and composition in ecosystem in Malaysia (Inger and Chin, 1990; Khairul Adha *et al.*, 2002; Lim and Tan, 2002; Coates *et al*., 2003; Tenong, 2003; Rosli, 2005; Nyanti *et al.*, 2006; Kottelat and Britz, 2008; Azmir and Samad, 2010). In Sarawak, although there are many studies were conducted at Batang Kerang floodplain on fish composition and diversity (Esa, 2005; Ibrahim, 2006; Anyi, 2007; Khairul Adha *et al.*, 2009) but there were not enough information regarding on anthropogenic or agricultural impact to fish fauna.

Hence this study was conducted in order to study the impact of oil palm plantation conducted by Sarawak Land Consolidation and Rehabilitation Authority (SALCRA) last for 3 years ago. Although this study only covered a small area, in this case only covered area along Batang Kerang floodplain at Serian but it can provide information to future study on fish composition at Sarawak.

2.0 LITERATURE REVIEW

2.1 Status fish fauna diversity in Malaysia

Abundance and diversity of fish fauna associated to declination of richness, evenness and biomass are mainly depend on riverine condition regarding on changes occurrence in depth, water velocity, substrate composition and nutrients level in water (Lim and Tan, 2002; Tenong, 2003). Martin (1998), documented fishes in Malaysia are more than 600 species including Peninsular, Sabah and Sarawak. Numerous studies were conducted in Peninsular Malaysia regarding on freshwater fishes (Mohsin and Ambak, 1983; Zakaria, 1994; Arshad *et al*., 2008; Azmir and Samad, 2010). According to Lim and Tan (2002), at least 278 species have been recognized as native species and 24 species that were introduced as exotic species in Peninsular Malaysia. Since 1990, there were total of 50 individuals species of fishes listed as new native species and more than half of species are new to science. In Langkawi Island, Azmir and Samad (2010) were documented a total of 619 individuals of fishes comprising 27 species from 14 family as freshwater fishes.

According to Zakaria (1994), species composition of freshwater fish in Peninsular Malaysia is heavily influenced by Siamese and Indonesian elements. In addition, riverine ecosystems are extensive and support extremely high richness of freshwater fishes (Kottelat and Whitten, 1996). Between 1969 and 1990, 41% of native fishes in Gombak River at Peninsular Malaysia lost due to logging activities and land clearing for agricultural (Zakaria, 1994). In Borneo, study on ichthyofauna first recorded by Pieter Bleeker during period of 1851-1850. There are about 155 species of freshwater fishes recorded in North Borneo (Inger and Chin, 1990).

2.2 Status fish fauna diversity in Sarawak.

According to Berra (2007), 23 families of freshwater fishes from primary division were located in Borneo. In Sabah and Sarawak, more than 100 to 200 species of fish were documented (Ahmad and Khairul Adha, 2007). Previous study was conducted by Hadil and Albert (2002) at Batang Lupar regarding on freshwater fishes mitigation. However, Nyanti *et al.* (1999) conducted study on fish composition in Loagan Bunut National Park and Khairul Adha *et al.* (2002) done a survey on freshwater fish fauna in upper rivers of Crocker Range National Park. Meanwhile, most studies also conducted in Batang Kerang floodplain located at Balai Ringin, Serian (Esa, 2005; Ibrahim, 2006; Anyi, 2007; Khairul Adha *et al.*, 2009). In addition, there also studies specialized conducted focused on fish species in Borneo and Sumatera for *Paedocypris carbunculus* and *Tor dourenensis* (Kottelat and Britz, 2008; Kottelat and Tan, 2008).

Researches in freshwater fishes are well published in Peninsular Malaysia unlike in Sabah and Sarawak. This is because of research on freshwater fishes are still in progress and only few are well published in Sabah and Sarawak (Nyanti *et al*., 1999; Hadil and Albert, 2002; Khairul Adha *et al*., 2002; Ahmad and Khairul Adha, 2007; Kottelat and Britz, 2008; Kottelat and Tan, 2008). However, unlike Sabah, fishes in Sarawak are less been subjected to researchers. This is because of the main focus are normally given to the main state river by researchers and many isolated rivers are unexplored to be studies (Ahmad and Khairul Adha, 2007). Thus, this study on fish diversity and composition Batang Kerang located in Serian hopefully able to provide data for future research on fish distribution in Borneo and for this case study, in Sarawak.

2.3 Floodplain habitat in Batang Kerang

In their natural form, floodplain formed in a constant state of roaming alteration about across unrestricted floodplain (Rasmussen, 1999). This leads on creating and destroying of side channels, backwaters and habitat variation. River function on maintain a relative balance between this various habitats through this process over times of period (Rasmussen, 1999).

Batang Kerang floodplain which is located in Balai Ringin, Sarawak is very unique because it can be classified into two basic types of water which is black water and brown water (Esa, 2005; Anyi, 2007). It is called black water river because of the river look liked black in colour similarly to brown water, where the water is brown in colour. Brown water is due to muddy and high levels of sediments content deposition while black water is due to high concentration of humic acid in the water (Khairul Adha *et al.*, 2009). According to Ahmad and Khairul Adha (2007), only several species of fish are able to adapt to inhibit these acidic and basic water properties.

Information on distribution of freshwater fish fauna inhibited brown water and black water is limited (Ramussen, 1999; Murtedza *et al*., 2000; Ibrahim, 2006) and only few studies were conducted in study area. Floodplain including flooded forest and floated vegetation in Batang Kerang are important habitat for fish fauna (Khairul Adha *et al*., 2009).

3.0 THESIS STATEMENTS

Publication on fish fauna in Sarawak is limited and only few studies were done in Sarawak area regarding to fish fauna diversity compared to Peninsular Malaysia. Only certain area covered for freshwater fishes studied at Borneo including northern and southern part of Borneo (Inger and Chin, 1990; Hadil and Albert, 2002). According to Berra (2007), studies on freshwater fish distribution and diversity are important because freshwater fishes provide relatively conservative systems to determine and examine patterns of fish distribution that may reflect continental changes over time of period. In addition, the family is the taxon that best describe and reflects the evolution and dispersal of a group and in fact able showing zoogeographic pattern. Zoogeographic pattern is strong evidence of evolution often cited and studying by researchers.

Thus, this present study is important in order to study habitat alteration impact on fish fauna diversity. Besides, this study also conducted in order to gain current information regarding on fish fauna diversity and distribution at Batang Kerang floodplain. In addition, Batang Kerang floodplain is the main resources for food among nearer villagers (Khairul Adha *et al*., 2009). Generally, agriculture mainly impact on fish fauna diversity because of the effluents discharge in terms of fertilizers are majority directly into the riverine system (Vitalis *et al*., 2000).

Thus, study on fish composition at Batang Kerang floodplain was conducted to study the impact of anthropogenic pollution regarding to oil palm plantation. The main purpose of this study is to to identify fish composition at Batang Kerang floodplain and evaluate the physicochemical of water parameters in Batang Kerang that are surrounded by oil palm plantation. Lastly, the impact of oil palm plantation was determine through the comparison of fish species and water quality at that area with previous study.

4.0 OBJECTIVES

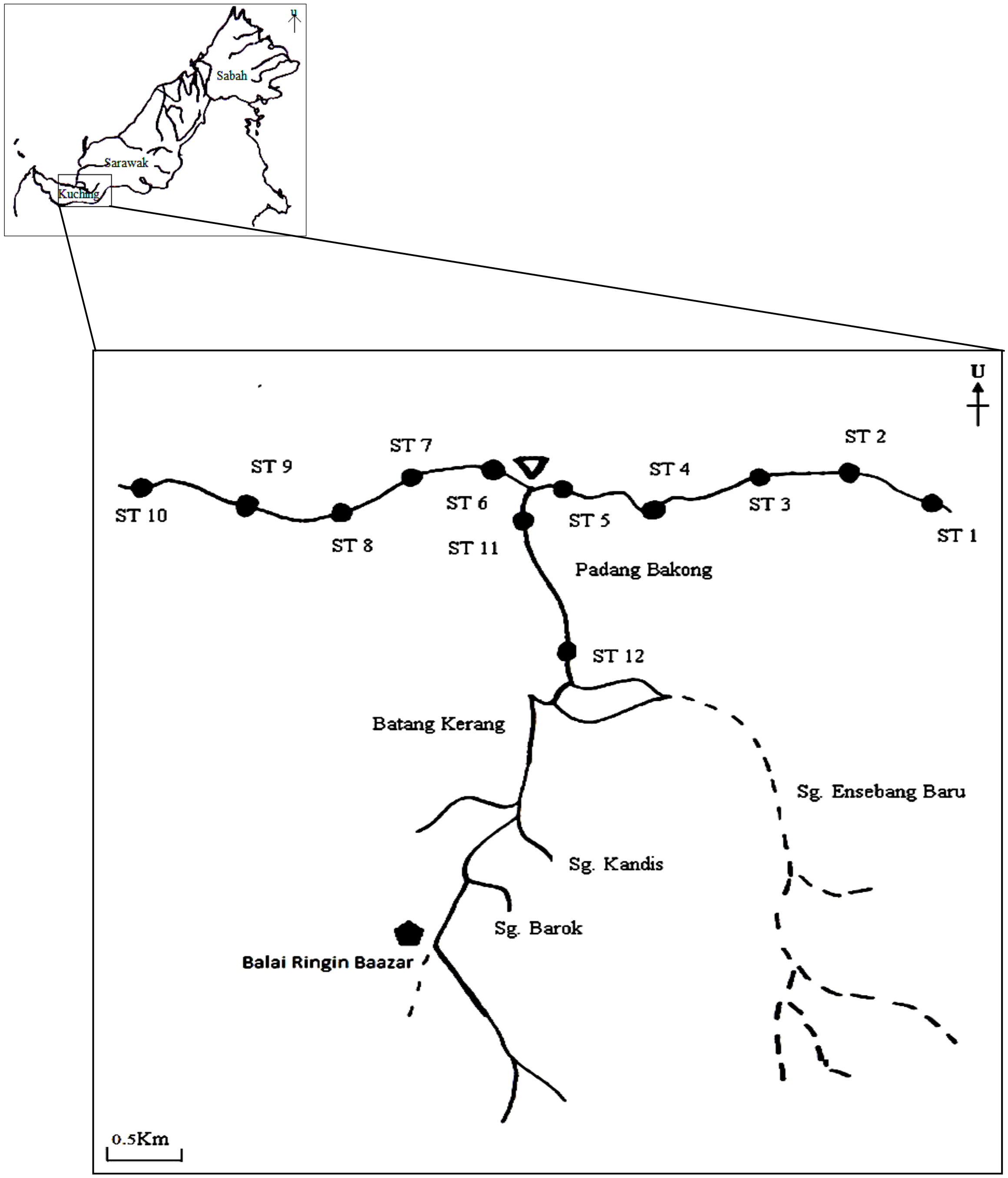
1. To identify fish fauna species composition at Batang Kerang floodplain.
2. To evaluate physicochemical of water quality parameters in Batang Kerang between brown water and black water surrounded by oil palm plantation.
3. To compare fish diversity from present study with previous study of Batang Kerang floodplain.

5.0 MATERIAL AND METHODS

5.1 Study site and field sampling

Study was carried out in Batang Kerang floodplain located at Balai Ringin in Serian area. Batang Kerang floodplain is economically important in terms of transportation and also as food sources to villagers. Batang Kerang floodplain connected villagers from Kg Semada to Balai Ringin Bazaar. Fish fauna at Batang Kerang floodplain have unique characteristic of habitat because of combination of two different types of water habitats (Brown water and black water). This study was covered along floodplain and also tributaries in Batang Kerang (Figure 1).

Fish sampling and water quality parameter study were carried out for both brown water and black water. The water samples were taken from 12 different stations along Batang Kerang floodplain; 6 stations at brown water and 6 stations at black water. Location for 12 stations water sampling determined using Global Positioning System (GPS) summarized in Table 1.



S1, S2, S3, S4, S5, S6: Brown water; S7, S8, S9, S10, S11, S12: Black water

Figure 1: Maps showing sampling stations at brown water and black water in Batang Kerang floodplain, Balai Ringin, Sarawak. Modified from (Khairul Adha *et al*., 2009)

Table 1: Physicochemical water quality parameters coordinate for water sampling stations at brown water and black water in Batang Kerang floodplain, Balai Ringin, Sarawak.

Station	**Coordinate**	**Location**
S1	N 01˚05.485' E 110˚47.175'	Brown Water
S2	N 01˚05.299' E 110˚46.556'	Brown Water
S3	N 01˚05.288' E 110˚46.231'	Brown Water
S4	N 01˚05.441' E 110˚47.026'	Brown Water
S5	N 01˚05.362' E 110˚46.768'	Brown Water
S6	N 01˚05.292' E 110˚46.361'	Brown Water
S7	N 01˚04.667 E 110˚46.029	Black Water
S8	N 01˚05.291' E 110˚45.858'	Black Water
S9	N 01˚05.388' E 110˚45.582'	Black Water
S10	N 01˚05.300' E 110˚46.137'	Black Water
S11	N 01˚05.293' E 110˚45.862'	Black Water
S12	N 01˚05.338' E 110˚45.724'	Black Water

5.2 Specimen collection

Fish collection at brown water and black water were using three layer gill nets with difference size (2.5 cm, 3.5 cm and 5.0 cm). Nets are set up and left for a night at stations with selected depth. First sampling was done in August 2010 and second sampling in March 2011 at Batang Kerang floodplain. Each fish samples collected were separated in plastic bags according their sampling site to differentiate fish collection between brown water and black water.

5.3 Field identification and measurement

Fishes were caught and identified immediately during first sampling (August 2010) using Inger and Chin (1990) and fixed in 10% formalin then brought to Aquatic laboratory in UNIMAS for further identification and preserved in 70% ethanol. However, fish samples were kept in a cooler box with ice during second sampling (March 2011) and brought to Aquatic laboratory for fish identification using several references (Inger and Chin, 1990; Kottelat and Whitten, 1996; Martin, 1998; Berra, 2007) and preserved in 70% ethanol.

Total Length, TL (cm), Standard Length, SL (cm) and weight, W (g) were measured during fish identification process. Besides, the Dorsal fin rays, D (n), Pectoral fin rays, P_1 (n), Pelvic fin rays, P_2 (n) and Anal fin rays, A (n) also calculated. Figure 2 described technical measurement of the fish length in identification purpose for bony freshwater fish. The identification was conducted following measurement by Geowater (2010), during the identification process in laboratory.

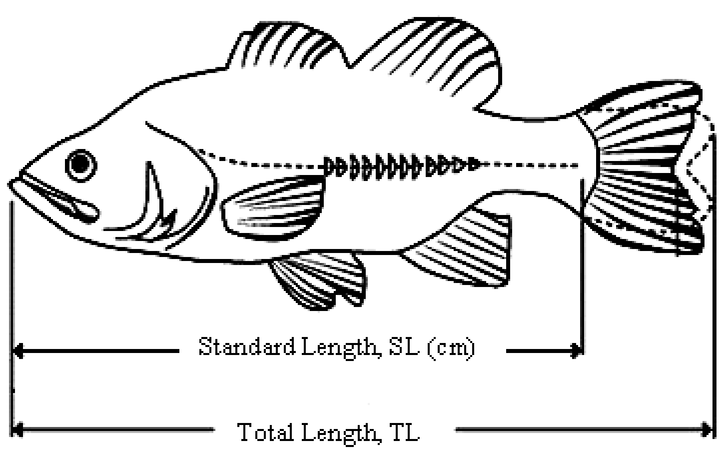


Figure 2: Technical measurement for bony fish (Geowater, 2010).

5.4 Physicochemical water quality parameters

Physicochemical water quality parameters were measured for *insitu* and *exsitu*. The readings for water quality were taken in three times (three replicates) for each parameter. For *insitu* parameters, water quality measured for pH, temperature (^{O}C), dissolved oxygen (DO), turbidity, water transparency and depth. EUTECH INSTRUMENTS, Multiparameters Cyberscan Model PCD 650 (2010) was used to measure pH, temperature and turbidity. In addition, secchi disk used to measure water transparency (MLSA, 2010). The secchi disk was lowered slowly into the water until the black and white colour of disk cannot be seen anymore. Then, the length of the rope that connected the disk was measure using measuring tape. Reading was taken at the point where the black and white colour appeared to be vanished for certain depth (MLSA, 2010).

The DO Meter was used to determine dissolved oxygen in riverine system. The DO Meter's prop immersed in water column and waited to stable before the reading were taken in three times. For water turbidity, water samples were taken and filled into the turbidity bottles to read water turbidity using HANNA INSTRUMENT model HI 98703 (2008). For precaution, the turbidity bottles need to keep in dry and wiped before reading taken to avoid the turbidity meter from broken and for accurate reading. During the sampling, the instruments need to handle in care to avoid it from broken. Depth finder was used to find the depth of water for each station. The Depth finder was half-submerged into the water and switched on. Then, the readings of the depth for locations were obtained.

The water samples taken also measured in lab analysis for Total Suspended Solid (TSS), Chlorophyll *a* and nutrients such as nitrogen-ammonia, orthophosphate, nitrate and nitrite. For TSS, APHA (1998) method was applied involving filtration process using filter papers. Before water filtering proceeded, filter paper already wet in filter water and then wrapped with aluminum foil. Wrapped filter paper left in oven for a night before weighing again. Then, water filtering process proceeded. Water filtering was done using 500 mL water samples in this study and the filter paper used wrapped again with same aluminum foil before weighing for second time (final weight). TSS calculation using formula:

$$\text{TSS (mg/L)} = \frac{\text{Final weight } (f) - \text{Initial weight } (i)}{\text{Volume water used } (V)}$$

Where: *f* final weight gained after filtration

i initial weight after filter paper dried in oven a night

V Volume water used in filtration (L)

Water samples for nutrients and chlorophyll *a* was kept in deep freezer under $-20^{O}C$ for a night. This is because to maintain the nutrients and chlorophyll *a* retain in the water samples from damaged. Samples then filtered using water filter for nutrients analysis. Analysis conducted for nutrients were summarized in Table 2.

Table 2: The method used for nutrients analyses.

NO.	PARAMETERS	METHOD	DESCRIPTION
1	Ammonia-Nitrogen	8038	Nessler method
2	Nitrate	8192	Cadmium reduction method
3	Orthophosphate	8048	Powder pillow method/ Phos Ver3 (Ascorbic Acid method)
4	Nitrite	8307	Deionization Method

Nutrients such as nitrogen-ammonia (NH_3-N), phosphate (PO_3^{4-}) and nitrite (NO_2^-) nitrate (NO^{3-}) were analyses. Spectrophotometer was used and for nitrate, Standard Method 8192 was applied based on Cadmium Reduction method (HACH, 2000). Wavelength used is 351-507 nm and it required 30 ml of water sample. Then, 30 ml water sample mixed with *Nitra Ver 6* and left for three minutes for homogenized. After three minutes, sample is reduced to 25 ml for analysis in the cell before added with *Nitra Ver 3*. Cell then shaken until mixture are well and totally mixed and left for 10 minutes for reaction. In a same time, blank sample was prepared in 25 ml of water sample. Lastly, blank sample was put in the spectrophotometer for reading followed for mixture sample for nitrate reading.

For ammonia-nitrogen, program used is Standard method 8038 based on Nessler method where 380-425 of wavelength used (HACH, 2000). 25 ml of sample was prepared in the cell while the other 25 ml distilled water prepared as a blank sample. Both cells added with three drops of mineral stabilizer and shaken until it well dissolved. Then, three drops of polyvinyl alcohols was added for both samples before 1 ml of Nessler Reagents mixed. Both cells were shaken and leave for one minute for overall reaction taken place. Lastly, reading for nitrogen-ammonia obtained with calibrating it with blank cell first before proceeds with water sample.

Standard Method 8048 was used to determine reactive phosphorous in water samples (HACH, 2000). 490-890 nm of wavelength was used with 10ml of samples. Cells was filled with 10ml water sample and added with *Phos Ver 3*. Samples then shaken continuously and left for two minutes for the reaction complete. For the blank sample, add other 10 ml of samples into blank cell and start calibrate the spectrophotometer for reactive phosphorous analysis. Then, mixture sample used to read reactive phosphorous using spectrophotometer.

5.5 Statistical analysis

Data collection were analyzed using SPSS V.17 (SPSS, 2011) to calculate Shannon Index Diversity (H'), Pielou Index evenness (J') and Margalef Index richness (D).

5.5.1 Shannon Index diversity, H'

Shannon Index diversity, H' was used as a mathematical measure of species diversity in a community (Shannon and Weaver, 1963). Diversity indices provide more information on community composition and take relative abundances of different species into accounts. Diversity index can be measured following formulae:

$$H' = \frac{n \log n - \sum fi \log fi}{N}$$

Where	n	sample size
	fi	numbers of individuals of species i
	n	total numbers of individuals in the collection of S species