Faculty of Resource Science and Technology

FISH ASSEMBLAGES IN MURUM HYDROELECTRIC RESERVOIR AND PLIERAN RIVER, BELAGA, SARAWAK

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DECLARATION

I hereby declare that no portion of 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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The project entitled “Fish Assemblages in Murum Hydroelectric Reservoir and Plieran River, Belaga, Sarawak” was prepared by Kirollina Kisun and submitted to the Faculty of Resource Science and Technology in partial fulfillment of the requirements for the Degree of Bachelor of Science (Honours) in Aquatic Science and Resource Management.

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LIST OF ABBREVIATIONS

TL	Total Length
SL	Standard Length
BW	Body Weight
TSS	Total Suspended Solids
H’	Shannon-Weaver’s Diversity Index
D	Margalef’s Species Richness Index
J’	Pielou’s Evenness Index
DO	Dissolved Oxygen
LWR	Length-Weight Relationship
NTU	Nephelometric Turbidity Units
mg/L	Milligram per Litre
Chl-*a*	Chlorophyll-*a*
MW	Mega Watt

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Fish Assemblages in Murum Hydroelectric Reservoir and Plieran River, Belaga, Sarawak

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Abstract

Fish survey and selected water quality sampling were conducted on 7th to 9th of July 2014 and 25th to 27th February 2015 at Murum Hydroelectric Reservoir and Plieran River. Currently, there is not much information available on the fish composition in Belaga area, especially at Murum Dam and Plieran River. Therefore, this study was conducted to determine the fish assemblages and condition of water quality at Murum Hydroelectric Reservoir and Plieran River, Belaga. Data collected could be used as baseline data and also for future monitoring and management purposes. A total of 670 individuals of fishes were caught in July 2014. Based on the identification, a total of 13 species was found from 4 families. The highest number was *Barbodes binotatus* with 46.72% and followed by *Oreochromis niloticus* which was 25.97%. The lowest was *Osteochilus pleurotaenia* with 0.30%. In February 2015, a total of 321 individuals of fishes were caught comprising 14 species and 4 families. The highest number caught was *Hampala bimaculata* with 31.15%, followed by *Barbonymus schwanenfeldii* with 18.69% and *Oreochromis niloticus* with 17.45%. The lowest is shared by *Luciosoma setigerum* and *Macrognathus maculatus*, each with 0.31%. Results shows that in July 2014, the depth ranged from 6.4 m to 11 m whereas in February 2015, depth ranged from 8.4 m to 19.2 m. Temperature in July 2014 ranged from 24.9 °C to 31.6 °C and 28.3 °C to 29.86 °C in February 2015. DO range from 5.2 mg/L to 6.6 mg/L and 4.13 mg/L to 7.5 mg/L in July 2014 and February 2015, respectively. pH ranged from 6.51 to 7.73 in July 2014 whereas in February 2015, it was from 6.07 to 7.7. For chlorophyll *a*, the highest was recorded in July 2014 (3.0719 µg/L) and the lowest was in February 2015 with 0.1294 µg/L.

Keywords: Murum Hydroelectric Reservoir, fish composition, water quality

Abstrak

Tinjauan ikan dan beberapa pensampelan kualiti air telah dijalankan pada 7 hingga 9 Julai 2014 dan 25 hingga 27 Februari 2015 di Empangan Hidroelektrik Murum dan Sungai Plieran. Pada masa kini, tidak banyak maklumat yang ada mengenai komposisi ikan di kawasan Belaga, terutamanya di Empangan Hidroelektrik Murum dan Sungai Plieran. Oleh itu, kajian ini dijalankan untuk menentukan komposisi ikan dan kualiti air di Empangan Hidroelektrik Murum dan Sungai Plieran, Belaga. Data yang dikumpul boleh digunakan sebagai data asas dan juga untuk tujuan pemantauan dan pengurusan di masa hadapan. Sebanyak 670 individu ikan telah ditangkap pada Julai 2014, terdiri daripada 13 spesies dan 4 famili. Bilangan tertinggi ialah Barbodes binotatus dengan 46.72% dan diikuti oleh Oreochromis niloticus iaitu 25.97%. Bilangan terendah adalah Osteochilus pleurotaenia dengan 0.30%. Pada bulan Februari 2015, sebanyak 321 individu ikan ditangkap yang terdiri daripada 14 spesies dan 4 famili. Bilangan tertinggi ialah Hampala bimaculata dengan 31.15%, diikuti oleh Barbonymus schwanenfeldii dengan 18.69% dan Oreochromis niloticus dengan 17.45%. Bilangan terendah dikongsikan oleh Luciosoma setigerum dan Macrognathus maculatus, setiap satu sebanyak 0.31%. Kajian menunjukkan bahawa pada bulan Julai 2014, kedalaman air adalah di antara 6.4 m hingga 11 m manakala pada bulan Februari 2015, kedalaman adalah di antara 8.4 m hingga 19.2 m. Suhu pada Julai 2014 adalah di antara 24.9 ° C hingga 31.6 ° C dan 28.3 ° C hingga 29.86 ° C pada bulan Februari 2015. DO ialah 5.2 mg/L hingga 6.6 mg / L dan 4.13 mg/L hingga 7.5 mg/L pada Julai 2014 dan Februari 2015. pH adalah antara 6.51-7.73 pada Julai 2014 manakala pada bulan Februari 2015 adalah antara 6.07-7.7. Untuk klorofil a, yang tertinggi dicatatkan pada Julai 2014 (3.0719 µg/L) dan yang paling rendah adalah pada bulan Februari 2015 dengan 0.1294 µg /L.

Kata kunci: Empangan Hidroelektrik Murum, komposisi ikan, kualiti air

1.0 Introduction

Murum Hydroelectric Dam is the third proposed dam-building project after Batang Ai Hydroelectric Dam and Bakun Dam in Sarawak. The dam is located about 70 kilometers upstream of Bakun Hydroelectric Dam and is designed to accommodate four sets of 236 MW Francis turbine generating units with total installed capacity of 944 MW (*Sinohydro Bureau*, 2009). A total of 1,415 people are directly affected by the proposed Murum Dam Project, comprised of Penan and Kenyah Badeng. These communities of people rely on fisheries and hunter-gatherer at the river and forest nearby (*Sarawak Energy*, n. d.).

According to Matthews (1998), an understanding of the dramatic changes towards the environment affecting community structure is a major focus of aquatic ecology. Among the most enormous and drastic disturbances is damming of rivers for hydroelectric power generation, flood control, recreational uses and water storage (Brooker, 1981; Benke, 1990; Collier *et al*., 1996). Hydroelectric dam operation and water extractions for irrigation of agriculture activities have been broadly stated as alterations to natural flow regimes of riverine ecosystem (Ward & Stanford, 1983; Petts, 1984; Poof & Allan, 1997; Magilligan & Nislow, 2005; Jorde *et al*., 2008). As reported by Quinn and Kwak (2003), the impoundment of dam had changed freshwater fish assemblage considerably even in short period of time.

According to Ahmad and Khairul Adha (2007), freshwater fishes of Malaysia are diverse and some species are endemic. Some researches done have shown that more than 100 and 200 species were reported in Sabah and Sarawak respectively. However, the figures are believed to be underestimated as the exact number is actually poorly inventoried. Records of freshwater fish fauna have been documented in certain area in Sarawak such as in lower Baram River (Watson & Balon, 1984) and Bario, Kelabit Highlands (Nyanti *et al*., 1999).

However, in the newly formed Murum Hydroelectric Reservoir, fish composition has not been studied.

Therefore, this study was conducted to document the fish community in Murum Hydroelectric Reservoir and Plieran River.

Thus, the objectives of this study were to:

i. Document the fish composition in Murum Hydroelectric Reservoir and Plieran River,
ii. Record the selected water quality parameters in Murum Hydroelectric Reservoir and Plieran River, and
iii. Provide a baseline data on fish composition with selected water quality parameters in Murum Hydroelectric Reservoir and Plieran River.

2.0 Literature review

2.1 Freshwater Ecosystems

2.1.1 Reservoirs and Dams

According to Soewardi *et al*. (1987), rivers, swamps and lakes are natural water bodies whereas reservoirs are known as artificial water bodies or man-made lake. Based on the original flow of water, there are two types of reservoirs which are riverine reservoirs (from a river) and flood-plain lakes (from a swamp). Basically, reservoirs that serve human purposes came from the riverine reservoirs.

Small reservoirs or known as single-purpose reservoirs are made to serve for water supply (irrigation) whereas larger reservoirs (multi-purpose reservoirs) are made not only for irrigation but also for flood control, hydroelectric power generation as well as water supply for industries and human settlement (Soewardi *et al*., 1987).

According to Morrow and Fischenich (2000), lentic habitats include natural lakes, small impoundments and parts of most mainstream reservoirs, some low-gradient natural streams, and some canals. A lentic habitat is one in which water does not have a regular and measurable flow. Unlike lotic habitats, the water column in most lentic habitats thermally stratifies. The interaction of stratified water column and water quality, especially dissolved oxygen has profound effects on fish community (Morrow & Fischenich, 2000). However, Richter *et al*. (1997) and Rosenberg *et al*. (1997) stated that reservoirs are the vital threats to aquatic biodiversity at global and regional scales.

Basically, about 39,000 large dams ($\geq$ 15 m in height) has been built worldwide to provide agricultural, hydropower, flood control and recreational benefits (Dynesius and Nilsson, 1994; Rosenberg *et al*., 2000). For the past 20 years, reservoir constructions have decreased (Postel *et al*., 1996; Rosenberg *et al*., 2000). However, projects such as the Three

Gorges development in China and various small projects in northern Canada indicate continued interest in reservoir construction (Rosenberg *et al.,* 1997).

Lots of studies have been done to investigate effects of impoundments towards lotic environments (Agostinho *et al*., 2008). Through their purposes, reservoirs contribute to the development of local and regional economy. However, the process of building up a reservoir has a huge impact towards the aquatic ecosystem of the area (Agostinho *et al*., 2008). In order to build a dam, the area should be cleared and deforestation takes place and this eventually disturbs the natural fish habitat. Agostinho *et al*. (2008) claimed that dams promote discharge control which then alters the seasonal cycles of floods and thus, influence fish composition and assemblages. Besides that, they also stated that among all human activities in the basin, dams have been the most destructive because they modify the regime flow of rivers throughout the region. An avoidable effect is the change in fish composition and abundance and this will eventually increase certain species while decreases others or even cut off the species.

2.1.2 Rivers

Freshwater ecosystems occupy approximately 0.8% of the Earth' surface (Gleick, 1996). According to Ng (2011), the main geographical distribution of freshwater ecosystems consists of lakes, rivers, streams and ponds, which house most of the freshwater fish species. River is a natural water body where it is also known as lotic waters or running waters (Arrignon, 1999). Arrignon (1999) also states that development in lotic waters is dependent on their quality, productivity and ability to provide suitable conditions for fish life where all these parameters are interdependent. Thus, the hydrographic network comprising streams and small rivers is certainly the most fragile.

2.2 Freshwater fish

‘Freshwater fish’ is defined as fish species that spend their adult lives and breed in freshwater beyond tidal influence (Lim & Tan, 2002). Generally, habitats for most freshwater fish are fast flowing water with partially or well-shaded, substrate consists of mud, sand, silt and rocky bottom. According to Agostinho *et al*. (2008), the estimated number of freshwater fish worldwide is 13,000, where most species of freshwater fishes live in tropical regions. Freshwater fish comprised of 42 % among vertebrates which is about 8275 species (Marshall, 2000).

It is believed that the Sunda River which is situated in Indonesia, incorporated all or nearly all of the drainage area of eastern and southwestern Malay Peninsula, northern Sumatra, western and southwestern Borneo and northeastern Java. Mohsin and Ambak (1983) stated that the Sunda River Basin has been populated by the most diverse composition of largely endemic ichthyofauna. Thus, it has been a vital place for lots of fish groups, most notably the ostariophysan family Cyprinidae, Gyrinocheilidae, Homalopteridae, Cobitidae, Bagridae, Pangasiidae and Siluridae, and the non-ostariophysan suborder Anabantoidea.

The beginning of ichthyology work on freshwater fish in Borneo was by Pieter Bleeker from 1851 until 1860 which documented almost all the fish found in Borneo (Inger & Chin, 1990). Malaysia has among the highest distribution of freshwater fish. Khan et al. (1996) recorded about 380 fishes whereas Inger & Chin (1962), Roberts (1989) and Kottelat *et al*. (1993) documented about 300 freshwater fishes. Kottelat *et al*. (1993) stated that 249 are found inhabiting inland water of Sarawak and Brunei.

Several works on documenting freshwater fish in Sarawak has been done. Watson & Balon (1984) have reported that 57 species of fish are found in Baram Basin. About 66% species are dominated by Cyprinidae family in upper rivers of Rajang Basin (Nyanti *et al*., 1995) and Leh (2000) has done the checklist for Lanjak-Entimau Wildlife Sanctuary, which reported the presence of 56 species of fishes from 10 families are found. About 24 species from 7 families and 9 genera was recorded in Loagan Bunut (Nyanti *et al*., 2004) and 33 species from 23 families was recorded at Lutong River, Miri (Nyanti *et al*., 2012).

Other studies include the Kelabit-Bario Highland River (Nyanti *et al*., 1998), Katibas River (Rachmatika *et al*., 1998), Layar River and Spak River, Betong (Kelvin *et al*., 2002), and Ba' Kelalan Highland (Kelvin *et al*., 2003a). Besides that, checklists have also been done at Bakong River (Kelvin *et al*., 2003b), Lemanak River, Engkilili (Lee, 2004) and Batang Kerang, Balai Ringin (Khairul Adha *et al*., 2009).

2.3 Alterations in Natural River Environment

Damming of river creates a new ecosystem with different biodiversity and new structure (Agostinho *et al*., 2008). Thus, the impoundment creates an impact towards the natural river flows. Though describing a single hydrological attribute, water flow represents the main force behind freshwater ecosystems, and it is responsible for their geological/hydrological structure, productive dynamics (matter and energy), nutrient cycling and the distribution and evolution of the biota (Poff *et al.*, 1997).

According to Nilsson *et al*. (2005), the consequence of losing the natural river flows has high impact due to the alterations being made to the hydrological ecosystems, historical patterns of biological production, distribution of biodiversity in spatial and temporal elements, and changes in functions of aquatic ecosystems. Agostinho *et al*. (2008) stated that due to the impoundment, fish diversity will be greatly reduced as some species are locally eliminated and others become dominant and numerous. In addition, rivers that have been dammed would trap populations within segments with inadequate conditions for development, feeding and recruitment, thus promoting local extinctions. The alterations on natural river flow affect aquatic habitat and also disturbs the biodiversity of organisms of the area (Agostinho *et al*., 2008).

2.4 Length-Weight Relationship (LWR)

Study on the length-weight relationship is important in fish biology as a tool to indicate fatness, well-being, gonadal development with relation to the environment and fluviatile condition of their habitat (Kohler *et al*., 1995). Krause *et al*. (1998) stated that LWR can be used to estimate the length and age, and the dynamic in a population. The growth rate and mortality rates can also be derived from LWR (Kohler *et al*., 1995). According to Anderson & Gutreuter (1983) and Gayanilo *et al*. (1997), the biomass from length frequency distribution can be recorded from LWR. Besides that, fish conditions (Petrakis & Stergiou, 1995), stock assessment (Abowei *et al*., 2009), management of population of fish and estimating standing stock biomass, and comparing the development history of fish community from different regions can also be derived (Petrakis & Stergiou, 1995).

From the LWR, the well-being of the fish can be recorded (Le Cren, 1951). Thus, it reflects the condition of fish in its habitat; the heavier the fish, the better the psychological condition, which means that fish in the area feeds more (Bagenal & Tesch, 1978). Besides that, from the coefficient values derived from LWR data, it shows the index in understanding lifecycle of fish (Schneider *et al*., 2000). Both biotic and abiotic factors affect condition factor of fish. Thus, this parameter can be used to determine the level of condition of the aquatic ecosystem; whether it is good or bad (Anene, 2005).

The relationship between the weight and length of a fish can be expressed by the equation $W = aL^b$ (Ricker, 1973). Then, a logarithmic formula will be used to obtain a linear expression. The b value indicated the type of growth of fish, $b = 3$ (isometric or normal growth rate), $b > 3$ (positive allometric or over growth rate) and $b < 3$ (negative allometric or poor growth rate). A formula, $K = 100\ W/L^3$ will be used to determine the Fulton's condition factor (K). According to the metric indicator, the higher the value of K, condition of fish will be better.

2.5 Food and Feeding Habit

According to Hartley (1948) when one species of fish dominates an area, the other members of the community in which that species live are considered chiefly as predators or as potential foods. Schrader (1989) divides fish into 4 categories based on the diet of the fish; invertivores, herbivores, omnivores and piscivores. Invertivores are fish that consume mostly invertebrates, whereas omnivores consume invertebrates, fish and plant. Herbivores consume mostly plants, whereas piscivores consume mostly fish.

2.6 Water Quality and its Parameters

Rivers frequently act as conduits for pollutants by collecting and carrying waste water from catchments and ultimately discharging it into the ocean. Water quality is closely linked to the surrounding environment and land use. Other than in its vapor form, water is never pure and is affected by community uses such as agriculture, urban and industrial use, and recreation. The modification of natural stream flows by dams and weirs can also affect water quality (Kumar & Dubey, 2006). In addition, low abundance and types of fish species may be a result of water quality and habitat that can be affected by the surrounding land use (Deacon & Mize, 1997).

2.6.1 Temperature

Deacon and Mize (1997) stated that water temperature is inversely related to elevation in the basin; as elevation decreases, water temperature increases. According to Arrignon (1999), the temperature of water affects its density and viscosity, the solubility of gases, especially oxygen, and the rate of chemical and biochemical reactions. Its variations may destroy certain aquatic species but also be favorable for the development of other species, resulting in an ecological imbalance. Each species, in order to exist, can do so only within a certain temperature range and is otherwise likely to disappear. It has its thermal preference that corresponds to the temperature zone in which it finds the easiest to exist (Arrignon, 1999). An increase in temperature, for example, 10 ºC, will eventually cause the biological and chemical reactions rate to double or triple.

2.6.2 Total Suspended Solids (TSS)

Water carries small particles of solid matter in suspension that can be assessed. The amount of tiny particles (normally tiny particles of eroded soil or small organic matters) held in water can be totaled up and recorded. TSS comprised of degraded dead leaves, detritus and sewage which have been broken down into small particle of organic matters and soil particles. According to Ali and Murtedza (1999), the measurement of total suspended solids (TSS) is used to determine soil erosion in the area.

As long as it can be filtered by using filter paper, it is called suspended solids (Cheremisinoff, 1993). High value of TSS means that the area involves in high erosion where it blocks light from reaching the lower parts of the water body. As some aquatic vegetation needs photosynthesis process in order to make its own food, high TSS can affect the process greatly, causing less production of oxygen in the area.

2.6.3 Chlorophyll *a* (Chl *a*)

Chlorophyll *a* is the green pigment/ color found on most plants, be it terrestrial or aquatic. For the aquatic ecosystems, especially for the phytoplankton organisms, this pigment is essential for photosynthesis process. They are the producers that make up the base of food web in an aquatic ecosystem. Zooplankton will feed on them and the fishes will feed on the zooplankton. Certain studies reported that the abundance of fish in an area is related to the concentration of chlorophyll *a*.

In order to measure the chlorophyll-a concentration in the water column, a standard method of APHA (2000) will be used. The analysis should be conducted in subdued light to avoid degradation because chlorophyll-a will degrade faster under the presence of light.

2.6.4 Turbidity

According to Lawson (1995), high turbidity due to suspended solids is very harmful to the fish as it may clog the gills of small fish and settle onto the smother the fish egg and cover food organisms.

2.6.5 Dissolved Oxygen (DO)

Ambak & Jalal (2006) suggested that when the values of dissolved oxygen at a certain reservoir are high, there are photosynthesis activities occurring at the reservoir that increased the concentration of dissolved oxygen. Besides that, another factor that may increase the amount of dissolved oxygen is low temperature (Mustapha, 2008; Khare & Jadhav, 2008). According to Turyk *et al*. (2007), when the DO is high, it means that the reservoir is suitable habitat for fish because the fish will be greatly affected when DO value is below 5 mg/L.

2.6.6 Biological Oxygen Demand (BOD_5)

BOD readings are related to the amount of dissolved oxygen. When the value of DO is significantly lower, it means that the BOD reading is high. This is due to the high density of fish that used up oxygen for respiration and high decomposition of organic matter from fish wastes and uneaten pellets (Namrata, 2010).

2.6.7 pH

According to Trivedi and Gurdeep (1992), carbon dioxide is the main producer of weak carbonic acid which results in acidity in unpolluted water. During the decaying process of organic matters, organic acids are released and thus, will result in the acidity of water. Organic acids also contribute to low pH values (Allan, 1995).

3.0 METHODOLOGY

3.1 Study Site

This study was carried out at Murum Hydroelectric Reservoir, Belaga, Sarawak. Two sampling periods were carried out on 7^{th} to 9^{th} July 2014 and 25^{th} to 27^{th} February 2015. Murum Hydroelectric Reservoir is situated at Murum River, which is the upper catchment of Balui River, upper river of the Bakun Dam, Belaga District, Kapit Division, Sarawak as shown in Figure 1. It is located at 2º 38’ 48” to the north and 114º 21’ 57” to the east. Plieran River is one of the tributaries that flow into Murum River. It is located upstream of the Murum Dam. Seven stations were selected as sampling sites, situated from upstream of Plieran River towards Murum Reservoir. For the second period of sampling, only 6 stations were sampled (station 1 to station 6) because downstream of Station 7 was blocked by fallen trees and debris.

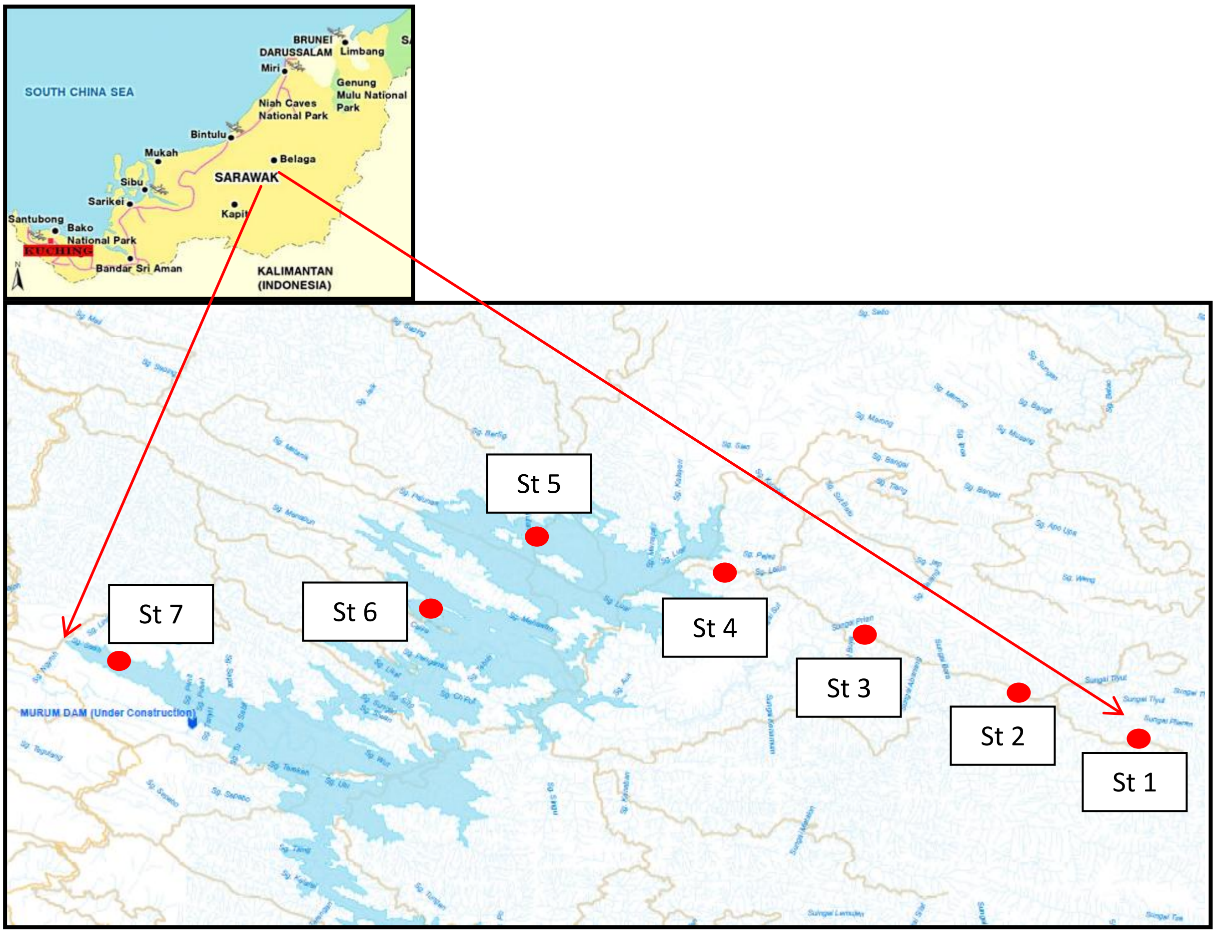

Figure 1: Map of Murum Dam and Plieran River (Source: Google Maps).

Station 1 was where the fast-flowing water can be found, Station 2 was the area of stagnant water, and Station 3 was below stagnant water. All the three stations were situated along Plieran River, started from the upstream and to the downstream. Station 4 was at the mouth of Plieran River where it was connected to the reservoir. Stations 5, 6 and 7 were located towards the edge of the reservoir. Table 1 shows the stations with each coordinate with respective net with mesh sizes and their coordinates. The samplings were done at two periods, 7th to 9th July 2014 and 25th to 27th February 2015, which was during the dry and wet seasons respectively.