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Freshwater zooplankton of Bakun dam Sarawak, Malaysia

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Abstract

Bakun Dam was fully reached its supply level of 228 m above sea level (ASL) on 9th March 2012. Ever since the forming of Bakun dam as a reservoir, no report on zooplankton is published. Therefore, an initiative has been made to study the zooplankton community and its relation to the subsurface water parameters in the reservoir. Subsurface zooplankton was sampled using plankton net and water parameters were measured using Eutech Instrument. The water parameters recorded in Bakun dam reflected the freshwater lake in tropical countries. Five species of zooplankton were recorded in Bakun Dam, namely *Neodiaptomus handeli*, *Tropodiaptomus* sp. *Daphnia* sp., *Ceriodaphnia cornuta* and *Brachionus quadridentatus splendidus*. Calanoida was recorded as the most dominant (maximum value: $20.49x10^6$) in Bakun Dam, followed by Cladocera (maximum value: $8.91 x10^6$) and Ploima (Rotifera) (maximum value: $1.77x10^6$). The water temperature did influence the species diversity and evenness of the zooplankton. The suitable water temperature in the reservoir possibly increases the phytoplankton densities which serves as food and enhance the density of zooplankton. Furthermore, with low number of zooplankton species, the competition for food amongst the species is also less, thus the opportunist species has an opportunity to increase their population rapidly and become dominant in the area.

Key words : Freshwater zooplankton, water parameters, Bakun Dam

INTRODUCTION

Bakun dam is a hydroelectric power dam located at Bakun, Sarawak. It is an embankment dam which was built on the Balui River, a tributary of Rejang River. It is also the second tallest (235 m ASL) concrete-faced rock filled dam in the world. The reservoir area at 228 m asl is 695 km², with a catchment area of 14,750 km² and the gross storage volume is 43,800 million cubic meters[1].The dam was built to meet the growing demand of electricity in Sarawak and their neighboring states. The impoundment commenced was on 13 October 2010 and it reached its full supply level of 228 m ASL on 9 March 2012 with an area of 695 km[2][2].

Freshwater zooplankton is a microscopic animal that float freely in the water body. Zooplankton is known as pelagic organism which is hard to maintain its position in the water column or against the water flow[3].Freshwater zooplankton is very important in aquatic ecosystem as primary consumers which are converting energy from phytoplankton to a form that can be used by larger animals and important food base for secondary consumers including fish[4,5].Freshwater zooplankton is one of the aquatic organisms that could be used as bioindicator to determine the condition of the water bodies[6]. Freshwater zooplankton responds quickly to the changes of water condition such as dissolved oxygen, pH and nutrient[7].

Freshwater zooplankton comprises a very small part and is not as diverse in species like marine zooplankton[8]. Freshwater zooplankton is dominated by three major groups such as Copepods (calanoid and cyclopoids), Cladoceran and Rotifers [8,9]. There are many freshwater habitats such as rivers, lakes, stream, freshwater swamps, peat swamps, ponds, reservoir and pool which support the freshwater zooplankton[8,9].There is no published report on the freshwater zooplankton of the Bakun reservoir since its impoundment. The aim of this study is to determine the community structure of subsurface zooplankton and its relation to the water parameters of Bakun reservoir.

METHODOLOGY

The sampling of subsurface (1-2 meter depths) zooplankton was conducted on 6th December 2012 at six stations in Bakun Dam, Sarawak (Figure 1, Table 1).Physico-chemical parameters of the subsurface water were measured using Eutech Instrument PCD 650 Cyberscan Series 600. The parameters involved were dissolved oxygen, pH, temperature, turbidity and conductivity. Methods for zooplankton sampling followed those proposed by Perry[10].Plankton net (20 µm mesh size, 40 cm diameter in the opening and 99 cm long) was used to sample zooplankton. Zooplankton samples were transferred into properly-labeled plastic containers. Zooplankton samples were then preserved with 5% formalin before sorting, identifying and counting. In the laboratory, zooplankton was sorted on the petri dish and identified to the lowest practical taxon. Zooplankton was sorted and counted under stereo-microscope. The compound microscope was used for further identification of the zooplankton. Various taxonomic keys in the literature were used for zooplankton identification[3,8,9].

Species density was calculated based on the volume of water that flow through the plankton net[10]. Species richness, species diversity and species evenness were calculated based on indices given by Margalef index[11], Shannon-Weaver index[12]and Pielou evenness index[13]respectively. The correlation analysis was used to determine the relationship between water quality parameters and zooplankton community.

RESULTS

The water quality data collected from six stations in Bakun reservoir, Sarawak was summarised in Table 2. The temperature ranged from 26.37±0.058 at station 1 to 32.12±0.006 at station 5. Meanwhile, the dissolved oxygen ranged from 3.69±0.000 at station 6 to 6.11±0.058 at station 5.The minimum pH value was recorded as 6.42±0.000 at station 6 while the maximum value was

Table 1. Table shows the GPS readings and description of the zooplankton sampling stations in Bakun Dam, Sarawak.

Station	GPS reading	Station description
1	N 02º 45' 30.0" E 114º 03' 32.0"	In front of the dam wall
2	N 02º 36' 03.0" E 113º 54' 20.7"	Infront of Long Liko
3	N 02º 39' 37.4" E 114º 02' 43.6"	Upper part of Linau River mouth
4	N 02º 45'.210" E 114º 06'. 877"	Infront of Murum River mouth
5	N 02º 44' 20.6" E 114º 12' 48.2"	UluWat River
6	N 02º 42'35.5" E 114º 10'49.3"	Junction of Murum River and Majoh River

Table 2. Table shows the water quality parameters in Bakun Dam, Sarawak.

Station	Temp (°C)	DO (mg/L)	pH	Turbidity (NTU)	Conductivity (µs/cm)
1	26.37±0.058	4.00±0.100	6.90±0.000	0.59±0.231	43.83±0.057
2	30.03±0.000	4.00±0.100	8.10±0.000	0.68±0.369	39.00±0.000
3	30.67±0.000	5.26±0.006	6.98±0.006	0.40±0.000	33.00±0.000
4	30.76±0.030	4.11±0.011	6.56±0.000	0.80±0.000	36.00±0.000
5	32.12±0.006	6.11±0.058	8.19±0.006	0.53±0.058	36.00±0.000
6	29.90±0.381	3.69±0.000	6.42±0.000	53.67±5.507	36.00±0.000

Note: Temp - temperature; DO - dissolved oxygen

Table 3. Table shows the classification of zooplankton in Bakun Dam, Sarawak.

Phylum	Class	Subclass	Order	Family	Genus	Species
Rotifera	Monogononta		Ploima	Branchionidae	*Brachionus*	*B.quadridentatussplendidus*
Arthropoda	Crustacea	Copepoda	Calanoida	Diaptomidae	*Neodiaptomus* *Tropodiaptomus*	*Neodiaptomushandeli* *Tropodiaptomus* sp.
		Branchiopoda	Cladocera	Daphniidae	*Ceriodaphnia* *Daphnia*	*Ceriodaphniacornuta* *Daphnia* sp.

8.19±0.006 at station 5. The turbidity of water was ranged from 0.40±0.000 at station 3 to 0.80±0.000 at station 4. The last parameter measured was conductivity which ranged from 33.00±0.000 at station 3 to 43.83±0.057 at station 1.

Three orders of freshwater zooplankton were found in Bakun reservoir namely Ploima (Phylum:Rotifera), Calanoida (Subclass: Copepoda) and Cladocera (Subclass: Branchiopoda) (Table-3). Five species were identified namely *Neodiaptomus handeli*, *Tropodiaptomus* sp. (Calanoida); *Daphnia* sp., *Ceriodaphnia cornuta* (Cladocera) and *Brachionus quadridentatus splendidus* (Ploima). The small number of species found in the Bakun reservoir is possibly due to limited depth of sampling which only covered subsurface of the water. Calanoida is dominant in Bakun Dam, followed by Cladocera and Ploima (Table 4; Fig. 2).The species diversity and species number of zooplankton in Bakun reservoir were recorded low (Table 5). The value of species diversity ranged from 1.08 to 1.47 (bits/individuals). The water temperature influenced the species diversity ($r = 0.899$, $P<0.05$) and evenness ($r = 0.895$, $P<0.05$) of zooplankton in Bakun reservoir (Table 6).

Table 4. Table shows species density (ind./m^3) of zooplankton in Bakun Dam, Sarawak.

Species	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
B.quadridentatus splendidus	$0.72x10^6$	$1.77x10^6$	$0.84x10^6$	$1.47x10^6$	$1.77x10^6$	$1.44x10^6$
N.handeli	$6.15x10^6$	$10.99x10^6$	$13.66x10^6$	$20.49x10^6$	$14.55\ x10^6$	$1.15\ x10^6$
Tropodiaptomus sp.	$5.56x10^6$	$4.11x10^6$	$10.26x10^6$	$7.07x10^6$	$10.05\ x10^6$	$5.91\ x10^6$
C.cornuta	$2.53x10^6$	$2.15x10^6$	$2.75x10^6$	$7.18x10^6$	$7.79\ x10^6$	$5.09\ x10^6$
Daphnia sp.	$3.45x10^6$	$4.46x10^6$	$4.43x10^6$	$7.34x10^6$	$8.91\ x10^6$	$6.40\ x10^6$

Table 5. Table shows the zooplankton community structure parameters in Bakun Dam, Sarawak.

Index	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Species Richness(D)	0.24	0.24	0.23	0.23	0.23	0.24
Species Diversity(H')	1.08	1.39	1.31	1.36	1.47	1.43
Species Evenness(J')	0.67	0.86	0.81	0.85	0.91	0.89
Species Number	5	5	5	5	5	5

Table 6. Table shows the correlation between zooplankton community structure and water quality parameters.

Parameter	Temperature	DO	pH	Turbidity	Conductivity
Species Richness, D	-0.684	-0.732	-0.074	0.448	0.679
Species Diversity, H'	0.899*	0.321	0.329	0.318	-0.696
Species Evenness, J'	0.895*	0.299	0.299	0.332	-0.695

Strength of correlation as stated by Fowler and Cohen [17].

Value of coefficient *r* (positive or negative)	Meaning
0.00-0.19	A very weak correlation
0.20-0.39	A weak correlation
0.40-0.69	A modest correlation
0.70-0.89	A strong correlation
0.90-1.00	A very strong correlation

Notes: * Represents the correlation was significant at the 0.05 level
Negative symbols (-) represents negatively correlated.

DISCUSSION

The pH value recorded was above 6 for all stations. This might be due to the photosynthetic activity by algae and high water temperature at subsurface that reduce the solubility of CO_2 concentrations[18]. Low value of DO was due to decomposition of submerged carbonaceous materials[2].The values of subsurface water quality in Bakun reservoir recorded in present study were not much different with the values recorded during the impoundment of the dam in 2011[2]. Overall, the water at Bakun reservoir falls into class III based on Water Quality Index of

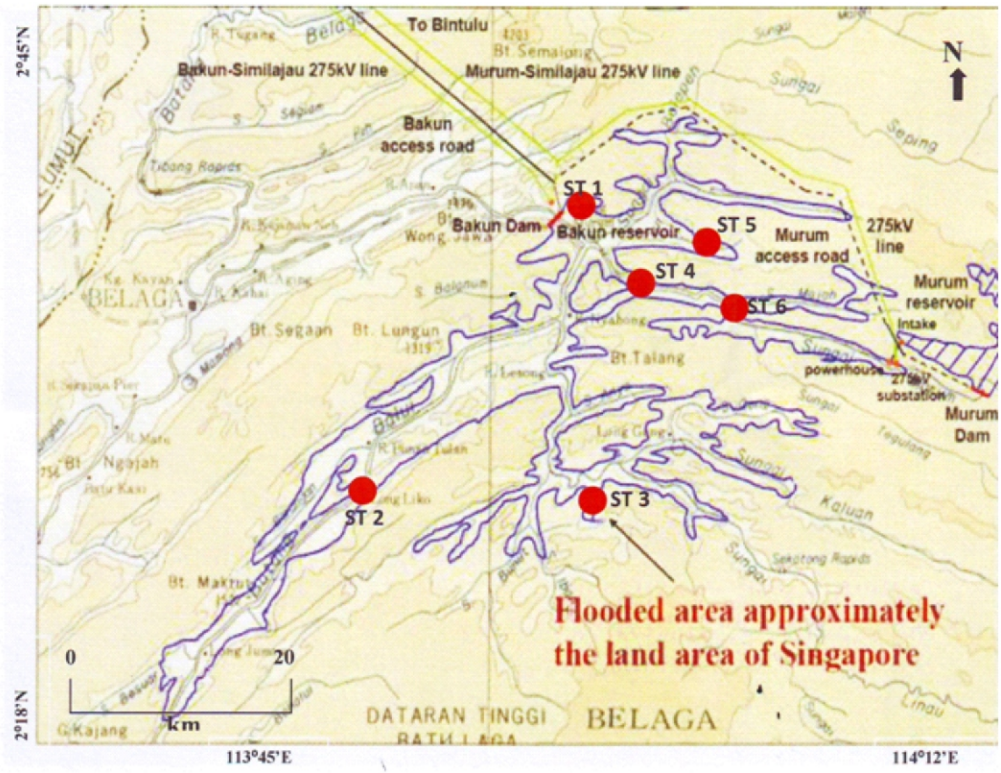

Figure 1: Map shows the location of sampling stations in Bakun Dam, Sarawak [18]

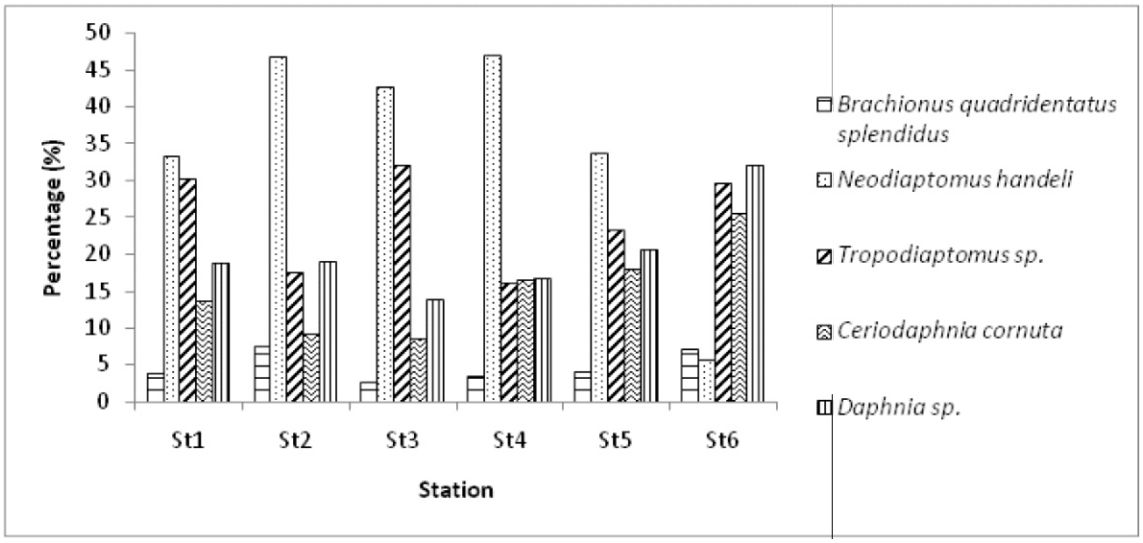

Figure 2: Figure shows the comparison of zooplankton percentage (%) in each station at Bakun Dam, Sarawak.

Department of Environment, Malaysia[18] that requires extensive water treatment. The water quality parameters recorded in Bakun dam were also quite similar with other freshwater lake in tropical countries [14].

Three orders of zooplankton namely Ploima, Calanoida and Cladocera were recorded in Bakun reservoir. These three orders of zooplankton were commonly found in most of the tropical freshwater ecosystems. Their dominance were possibly due to their ability to adapt with suitable water quality and high food availability of phytoplankton (15 genera) [15] in the Bakun reservoir. Water temperature is a crucial factor for zooplankton to survive in any freshwater environment or their biological processes can be affected [14,16]. Relatively stable temperature and other physico-chemical parameters of the subsurface water in the Bakun reservoir will increase the phytoplankton density which serves as food and enhance the density of zooplankton community. Furthermore, with a number of five species, the competition for food amongst the zooplankton species was also less. This on the other hand would give the opportunist species opportunity to increase their population rapidly and become dominant. Zooplankton community acts as the primary consumers in the food webs of the freshwater ecosystems. They contribute significantly to the biological productivity of the lentic

ecosystems[4]and play vital role in recycling the organic matter in the freshwater ecosystems.

CONCLUSION

Five zooplankton species namely *Neodiaptomus handeli*, *Tropodiaptomus* sp. *Daphnia* sp., *Ceriodaphnia cornuta* and *Brachionus quadridentatus splendidus* are recorded in Bakun Dam. Calanoida is dominant followed by Cladocera and Rotifera. The water temperature influences the zooplankton species diversity and evenness. The suitable temperature in the reservoir possibly acts as a factor in increasing the phytoplankton densities in which serves as food and enhance the zooplankton population densities. The low number of zooplankton species reduces the competition for food amongst the species and triggered the opportunist species to increase their population rapidly and become dominant in the Bakun Dam.

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REFERENCES

1. Tan ESP, Nyanti L, Shabdin ML, Norhadi I, Abang F, Chernoff B, Chin PK. Environmental Impact asessment of the Bakun hydro-electric project: Appendix 4 Aquatic Resources. Centre for Technology Transfer & Consultancy, Universiti Malaysia Sarawak, 1995. p. 69.

2. Nyanti L, Yee LT,Grinang J. Physico- chemical characteristics in the filling phase of Bakun Hydroelectric Reservoir, Sarawak, Malaysia. *InternationalJournal of Applied Science and Technology*, 2012: 2(6): 92-101.

3. Idris BAG. Freshwater zooplankton of Malaysia (Crustacea: Cladocera). Malaysia : Penerbit Universiti Pertanian Malaysia, 1983.p.153.

4. Wetzel RG. *Limnology; Lake and River Ecosystems, 3rd Edition.* Academic Press; San Diego CA, 2001.p. 1006.

5. Roberto ETB, Sandra AZ. Species composition, abundance and distribution of zooplankton in a tropical eutrophic lake: Lake Catemaco, Mexico. Revista De Biologica Tropical.1998: 46(2): 285-296.

6. Webber MME. Phytoplankton and zooplankton as indicators of water quality. Primary Research Paper.2005: 183:1-3.

7. Dulic Z, Tutundzic VM, Markovic Z,Zivic I. Monitoring water quality using zooplankton organism as bioindicator at the Dubica Fish Farm, Serbia, Archive Biology Science, 2006:58(4): 245-248.

8. Yule MC,Yong HS. Freshwater Invertebrates of the Malaysian Region. Malaysia: Academy of Science Malaysia; Kuala Lumpur, 2004. p.861.

9. Fernando CH. A guide to tropical freshwater zooplankton: identification, ecology and impact on fisheries. Backhuys Publisher; Netherlands, 2002.p. 225-280.

10. Perry R. A guide to the marine plankton of southern California, 3rd edition, UCLA Ocean globe and Malibu High School, 2003. p. 23

11. Margalef R. Perspectives in ecological theory.University of Chicago Press; Chicago, 1968.P. 111.

12. Krebs JC. Ecology :The experimental analysis of distribution and abundance. Harper & row publishers; New York, 1978.p. 678.

13. Pielou EC. An introduction to mathematical ecology.John Wiley and Sons; New York,1969.p. 286.

14. Manickam N, Saravana BP, Santhanam P, Chitrarasu P,Ali JJ. Zooplankton diversity in a parennial freshwater lake. Diversity and Physiological Processes.2012. p. 25-37.

15. Delim BH. Phytoplankton and zooplankton composition in Bakun Reservoir, Belaga, Sarawak. Final Year Project Report, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 2013.p.44

16. Epps D. *Water Quality Assessment and Objectives for Comox Lake.* Burke Phippen: Canadian Cataloguing, 2011. p 74.

17. Fowler J,Cohen L. Practical Statistics for Field Biology. Open University Press; Milton Keynes, Philadelphia,1990. p. 1-227.

18. Muan T. Water quality of Bakun Reservoir, Belaga, Sarawak. Final Year Project Report, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 2013. p.81.