Faculty of Resource Science and Technology

WATER QUALITY ASSESSMENT AT RANCHAN WATERFALL, SERIAN SARAWAK

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DECLARATION

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

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
Chl *a*	Chlorophyll *a*
DO	Dissolve Oxygen
DOE	Department of Environment
GPS	Global Position System
Km	Kilo meter
mg/L	Milligram per Liter
NH3-N	Ammonia nitrogen
NO^{3-}	Nitrate
NTU	Neplelometric Turbidity Units
NWQS	National Water Quality Standard
pH	Potential of Hydrogen
SPSS	Statistical Package for the Social Science
TSS	Total Suspended Solid
PO_4^{3-}	Orthophosphate
°C	Degree Celcius

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Water Quality Assessment at Ranchan Waterfall at Serian, Sarawak

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ABSTRACT

This study was carried out at Ranchan Waterfall from November 2013 until March 2014 to assess water quality level based on National Water Quality Standard (NWQS) for Malaysia. A total of three sampling stations covering the study area were selected for water sampling and were signated as Station 1, Station 2 and Station 3. A total of 12 physico-chemical water parameters were analysed based on APHA and HACH standard method. The results obtained then were compared with NWQS. Result shows that the range for temperature during the sampling time was 23.80 to 25.30 ˚C, for turbidity was 0.32 to 3.09 NTU, 4.92 to 7.82 for pH , 4.48 to 9.30 mg/L for DO, 1.00 to 12.00 mg/L for TSS, 0.02 to 0.06 mg/L for nitrate, 0.02 to 0.12 for ammoniacal nitrogen and 0.03 to 0.20 mg/L for orthophosphate. According to NWQS (National Water Quality Standard for Malaysia) classification, the temperature was within the normal ranges, turbidity, conductivity, total suspended solid (TSS), chemical oxygen demand (COD), dissolve oxygen (DO), nitrate, orthophosphate, ammoniacal nitrogen were categorized under class I, while biological oxygen demand (BOD) came under class II and pH under class III. Overall, Ranchan waterfall is safe for recreational use.

Key words: Water quality, waterfall, National Water Quality Standard (NWQS) for Malaysia

ABSTRAK

Kajian ini dijalankan di Ranchan Waterfall dari November 2013 sehingga March 2014 untuk menilai kualiti air berdasarkan Standard Kualiti Air Negara bagi Malaysia. Tiga stesen kajian telah dipilih di kawasan dan dilabel sebagai Stesen 1, 2 dan 3. Sebanyak 12 parameter kualiti air telah dianalisa berdasarkan piawai APHA dan HACH. . Hasil kajian menunjukkan julat suhu sepanjang tempoh kajian ialah 23.80 ke 25.30 ˚C, untuk kekeruhan ialah 0.32 ke 3.09 NTU, 4.92 ke 7.82 untuk pH , 4.48 ke 9.30 mg/L untuk DO, 1.00 ke 12.00 mg/L untuk TSS, 0.02 ke 0.06 mg/L for nitrat, 0.02 ke 0.12 untuk ammoniacal nitrogen dan 0.03 to 0.20 mg/L for orthofosfat. Berdasarkan klasifikasi Standard Kualiti Air Negara bagi Malaysia, nilai suhu masih dalam lingkungan normal, kekeruhan air, konduksi, jumlah pepejal, permintaan kimia oksigen,nitrat, fosfat, ammonia nitrogen dikelaskan dibawah Kelas I manakala oksigen larut, permintaan biologi oksigen dikelaskan dibawah Kelas II dan pH dikelaskan dibawah Kelas III. Secara keseluruhan, Ranchan Waterfall selamat digunakan untuk kegunaan rekreasi.

Kata kunci : Kualiti air, air terjun, Standard Kualiti Air Negara bagi Malaysia.

1.0 INTRODUCTION

Water is the chemical substance that is composed of hydrogen and oxygen and it is important to the existence of all living organism (Mohd Ekhwan *et al.*, 2012). However, this value resource is increasingly being threatened by exploitation and human activity (Efe, 2002a) as human population grow and demand more water of high quality for domestic purpose and economic activities. According to Chin (2006), water covers two thirds of the Earth's surface while the human body consisting 75 percentage of this substance. In the developing countries, good water quality is scarce because of environmental pollution and degradation (Efe, 2002b). The ability of aquatic environments to sustain healthy ecosystem is depend on the availability of water and its physical, chemical and chemical composition. The quality of water necessary for each human use varies, as do criteria used to assess water quality. Good water quality is important for drinking water supply, irrigation, recreations, and other purposes to which the water must have been impounded (Mustapha, 2008).

Water pollution occurs when energy and other material are released into the water body and degrading the quality of water for other uses. The term of water pollution is referred to any excessive addition to water in form of material (heat) that are harmful to humans, animal, and aquatic life and also significant departures from normal activities of various living communities in or near the water bodies (Kalff, 2001).

Waterfall, most of which are formed from stream or river which cascade from a high elevation over a cliff or rock, had very little attention from researchers the world over (Offem & Ikpi, 2011). In Malaysia, it is one of famous destination

for public and tourist for leisure time. A good water quality at that area is preferred as to ensure the health of communities. While most waterfall remains more or less in their natural state, many of more the popular ones have undergone some development which may include refreshment outlet of different kind and various accommodation (Hudson, 1998).

As the larger state in Malaysia, Sarawak has many recreational waters such as waterfalls and lakes. They are popular destination among tourist and public especially during the public holiday. Some are unexploited as they are lack of publicity and isolated in rural area and. Apart from Ranchan waterfall, there is also Simunjan waterfall which is located about 7 km from the town of Serian. Besides, at Kuching District, there are also Santubong Falls, Bobak Falls, Skedu Falls, Ban Buan Kukout and Mabi Waterfall (Jasmina, 2008).

Water quality can be defined as a set of parameters or variables, which described the physical characteristics, and the chemical and biological components of the water body to sustain various uses or processes (de Ceballos *et al.*, 1998). According to Prakash (2005), he define water quality as the physical, chemical, and biological characteristic of water that indicates the condition of water bodies whether it is healthy or polluted. Moreover, the quality of water may be described in terms of concentration and state (dissolved or particulated) of some or all of the organic and inorganic material present in the water, together within certain physical characteristic of the water (Meybeck *et al*., 1996).

Limited of water quality study had been done previously, especially in waterfall area have been conducted in Sarawak. Therefore, it is important to assess water quality at waterfall because the water from that area are used by the local communities as daily water supply and are opened as recreational destination. Besides that, waterfall area that is located near the potential water polluting activities such as housing area and agriculture need to examined.

Realizing the important of water quality study at waterfalls in Sarawak, and limited of them, the main objectives of this study were:

i) To assess water quality at Ranchan Waterfall through analysis of some selected physico-chemical water parameters.

ii) To compare and classify the water quality level at Ranchan waterfall with the National Water Quality Standards for Malaysia (NWQS).

iii) To provide the baseline data on water quality status for future study and research.

2.0 LITERATURE REVIEW

2.1 Water

Water is a ubiquitous chemical substance that is composed of hydrogen and oxygen and is vital for all for all known forms of life (Ekhwan *et al.*, 2012). They covered about 71% of the Earth's surface, which constitutes mostly of the oceans and other large water bodies. Oceans hold 97% of surface water, glaciers and polar ice caps 2.4%, and other land surface water such as rivers, lakes and ponds 0.6% (Ekhwan *et al.*, 2012).

As water is essential for human and all lives and has limited resources, therefore it is very important to study about water. Good water quality is important for drinking water supply, irrigation, fish production, recreation, and other purposes to which the water must have been impounded (Mustapha, 2008).

Water quality is defined as a set of parameters or variables, which described the physical characteristics, and the chemical and biological components of the water body (de Ceballos *et al.,* 1998). Water quality also is defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use (Daniels, 1914).

Water pollution can be resulted from natural runoff, dissolve chemical that percolates through the soil, and human resources such as; agriculture, mining, construction, industry, homes, and business (Trivedi & Raj,1992). There are only a few publications on water quality study in Sarawak, particularly in waterfall area. According to Harith and Hassan (2007), Ranchan waterfall is considered healthy except in October and December 2007. However, Ranchan waterfall was classified

as slightly polluted based on the Water Quality Index due to their BOD level (Jasmina, 2008).

2.2 Physical Parameters

2.2.1 Temperature (°C)

The temperature of water is one important parameter, which directly influences some of chemical reaction in aquatic ecosystem (Khare & Jhadav, 2008). Almost all aquatic life depends on water temperature for their optimal health. High water temperature can be occurred as a result of low water level, high air temperature and clean environment. According to Tapase and Kulkarni (2012), the water temperature follows a diurnal variation, increases in daytime and decreases during night. Increase in temperature accelerates the chemical reactions in water and thereby reduces the solubility of gases and imparts taste and odour to the water (Tapase & Kulkarni, 2012).

Besides, temperature is important in controlling the rate of biological and chemical process. Most of the aquatic organisms depend on certain temperature range for optimal health. In stream, temperature value will vary with width and depth as temperature decrease as depth increase (Nyanti *et al*., 2012). High temperatures may be as a result of discharge of municipal or industrial municipal. As cited by Shuhaimi *et al*., (2007), many factor such as sampling time, weather condition, location impact, discharge of cooling water, impoundment and removal of shading stream bank vegetation impact on the increase and decrease of temperature. Cold water and fresh water hold more oxygen compare to warm water and salt water hold less oxygen.

2.2.2 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is a volume of oxygen contained in the water (Gandaseca *et al.,* 2012). The dissolved oxygen in water is temperature dependent (Khare & Jhadav, 2008). Dissolved oxygen is an important aquatic parameter, whose presence is vital to aquatic fauna (Medhudula *et al.,* 2012). The DO values varied according to the rate of respiration and decomposition of organic materials in the water (Tapase & Kulkarni, 2012). Amount of oxygen can be hold by water is depends on water temperature, salinity and pressure. Change in DO concentration can be early sign of condition changes in water body and its measurement provided a good indication of water quality.

2.2.3 pH

pH is a measure of the concentration of hydrogen ion in water. This parameter will determine the acidity or alkalinity of the water. Neutral water (distilled) has a pH of 7, acidic less than 7 and alkaline has pH more than 7. According to DOE of Malaysia, a pH range from 6.5-8.5 is acceptable for domestic water supply while pH range 6.5- 9.0 is appropriate for aquatic life (Gandaseca *et al.,* 2011). It is important to monitor pH of the water body because it is closely related to aquatic organism. Higher of hydrogen concentration resulted of photosynthetic algae activities that consume carbon dioxide dissolve in water. Eisakhani and Malakahmad (2009) stated that increase in pH is likely due to anthrophogenic activities, since also the host rock (granite) does not support buffering. Also, increase in pH was associated with increasing use of alkaline detergents in rural areas and alkaline material from waste water in industrial areas (Chang, 2008).

2.2.4 Conductivity

Electrical conductivity (EC) is a numerical expression of ability of an aqueous solution to carry electrical current and is depends on the presence of ions and their concentration in the given material. The inorganic dissolved solids such as aluminum cations, calcium, chloride, iron, nitrate, magnesium sulfate and sodium (Gandaseca *et al.*, 2011) affect conductivity in the water. Besides, organic compound such as oil, phenol, alcohol can influence the water conductivity as well as the temperatures also have an effect on the conductivity (Fawaz *et al*., 2011). Generally, most of the freshwater is ranging from 10 to 1000µScm^{-1}. However, the concentration can over about 1000µScm^{-1} is the water is polluted.

2.2.5 Turbidity

Turbidity is a measure of water clarity or the light scattering properties of water caused by presence of particles and microscopic biota in water column which is measured in Neplelometric Turbidity Units, NTU (Chehalis River Council,2007). From the previous study, Ranchan gives the highest reading of turbidity value during wet season (Jasmina, 2008). According to APHA (1998), clay, silt, inorganic matters are the primary contributor to turbidity. The clarity of water decreased as a result of presence of suspended particles that deposited in the water. The excessive turbidity is generally related to possible microbial contamination because water disinfection contained elevated turbidity is very complicated (Waziri & Ogugbuaja, 2010).

2.2.6 Biological Oxygen Demand (BOD)

Biochemical oxygen demand is defined as the amount of oxygen required by the microorganisms to stabilise biologically decomposable organic matter in wastewater under aerobic conditions (Tapase & Kulkarni, 2012). BOD value will rise when there are more organic matters such as leaves, wood, wastewater or urban storm water runoff took place in the river water (Gandaseca *et al.,* 2011). Chin (2006) stated that water discharges that contain significant amounts of organic matter have high BOD level and consume amount of oxygen from receiving water, therefore lowering the DO level and give the negative impact to aquatic life.

2.2.7 Total Suspended Solid (TSS)

Total Suspended Solids includes organic particles and minerals those are transported in the water and can be the indicator of erosion taking place (Gandaseca *et al.*, 2011). The total suspended solids are composed of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium, manganese, organic matter, salt and other particles. High concentration of TSS can influence the water quality and can cause many problems in public health and aquatic life. Trivedi and Raj (1992) cited that high amount of suspended solid in water indicates that water bodies are contaminated with particles which cause the low clarity of water.

2.3 Chemical Parameter

2.3.1 Chemical Oxygen Demand (COD)

APHA (1998) stated that chemical oxygen demand as "a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant such as potassium dichromate in sulphuric solution". According to Ballance (1996), COD is defined as the amount of oxygen required by organic matter in water for its oxidation by a strong chemical oxidant. The assessment of COD level in water enable the assessment of BOD wastewater pollution level as COD is related with BOD, organic carbon or matter content.

2.3.2 Nitrate

Nitrate is a compound originates from nitrogen, which is commonly present on the surface and ground water because it is the end product of the aerobic decomposition of organic nitrogenous matter (Chin, 2006). Nitrite and ammonia is another compound that originates from nitrogen. Dojlido and Best stated that nitrate concentration influence by weathering process of rocks and soil, fertilizer run off and bacteria that have gone through the autolysis process. River water with high in nitrate level is potentially harmful to human and animal health which can cause lethal. Nitrate is toxic compound, but it is much less toxic than ammonia and nitrite (Fawaz *et al*., 2013)

2.3.3 Ammonical Nitrogen

Ammonia acts as indicator of the pollution from the excessive usage of ammonia especially from fertilizers. It is important in water monitoring because the biological reaction will be at maximize rate with the sufficient nitrogen. The level of ammonia must not exceed the recommended limit because it is very dangerous and can give impact to aquatic life (Gandaseca *et al*., 2011). Higher level of ammonia can be toxic to fish, but in small concentrations, it could serve as nutrients for excessive growth of algae.Natural source that contribute significant quantities of nitrogen compound included rainfall and runoff. Besides, domestic and industrial waste, run off from agricultural land, urban runoff, farm animal was also another factor that influence the ammonia nitrogen level in water.

2.3.4 Orthophosphate

Orthoposphate is one of the limiting nutrient in the water. It is appear to be preferred form of phosphorus by phytoplankton (Kennish, 1990). Both phosphorus and nitrogen are essential nutrient for the aquatic life. High concentration of phosphates is generally the indication of the pollution association with eutrophication condition (WHO, 1998). In addition, as cited by Gasim *et al*. (2012), domestic effluent particularly which contain detergents, fertilizer, industrial waste water and run off are the main reason of high phosphate level in surfaces water such as lake and river.

2.4 Water Quality Monitoring in Sarawak

Natural Resource and Environment Board (NREB) had started River Water Quality Monitoring at Sarawak since 1998. Due to rapid increasing of population and industrial development nowadays, the river in Sarawak have subjected to water pollution. Sumok (2001) stated that the state of Government had directed NREB to ensure that water qualities in all rivers of Sarawak are maintained at least to class IIB of INWQS of Malaysia. The table below shows the classification of river by National Water Quality Standards in Malaysia.

Table 1.0: Classification of river by National Water Quality Standards in Malaysia.

Class	Uses
Class I	Conservation of natural environment. Water Supply 1-practically no treatment necessary Fishery 1 – very sensitive aquatic species.
Class IIA	Water Supply II- conventional treatment required. Fishery II – sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – extensive treatment required Fishery III – common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation.
Class V	None of the above.

3.0 MATERIALS AND METHODS

3.1 Sampling site

The study was done at Ranchan waterfall, Serian Sarawak (Figure 1). It is located approximately 80 km from Kuching City. Ranchan waterfall is popular recreational area (many visitors) and well known among tourist and also by the local communities. Amenities such as shower room, canteens, picnic areas and accommodation services are available for the visitor (Harith & Hassan, 2007). Besides, this waterfall is shaded heavily by vegetation along the watercourse. This long waterfall were divided into three (3) which were station 1, station 2 and station 3 (Refer to Appendix I).

Table 2: Global Position System (GPS) reading for each station.

Stations	GPS reading	
1	N 01º 08’ 29.6’’	E 110 º 34’ 44.8’’
2	N 01 º 08’ 34.8’	E 110 º 34’ 44.6’’
3	N 01 º 08’ 38.0’’	E 110 º 34’ 44.6’’