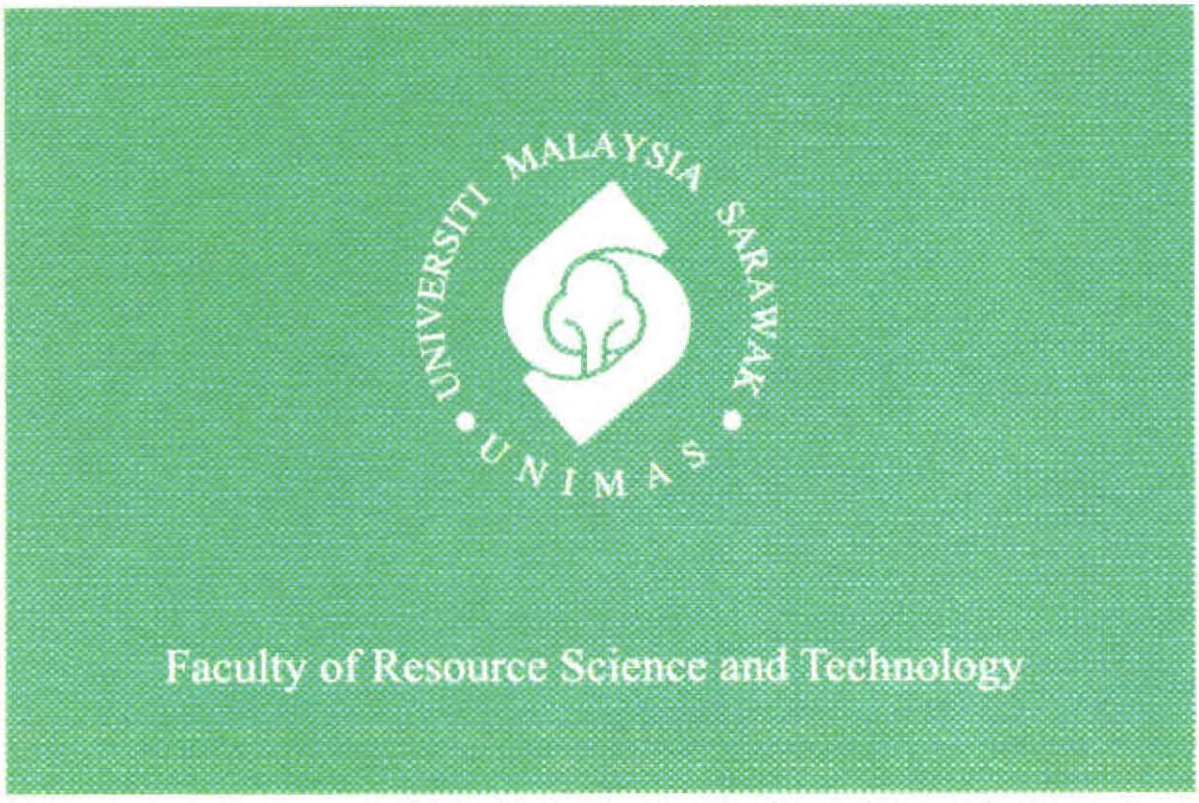

WATER QUALITY AND HEAVY METALS IN THE WATER AND SEDIMENTS FROM BATANG AI DAM AND ITS VICINITY, SARAWAK

Abdullah Dzulhazmi Bin Deraman

Bachelor of Science with Honours
(Resource Chemistry)
2014

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WATER QUALITY AND HEAVY METALS IN THE WATER AND SEDIMENTS FROM BATANG AI DAM AND ITS VICINITY, SARAWAK

ABDULLAH DZULHAZMI BIN DERAMAN

The project is submitted in partial fulfilment of the requirement for the degree of

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LIST OF ABBREVIATIONS

Analysis of Variance	ANOVA
Atomic Absorption Spectrometer	AAS
Department of Environment, Malaysia	DOE
Dissolved Oxygen	DO
Evaluation Capacity Development Group	ECDG
Loss on Ignition	LOI
Organic Matter	OM
Particle Size Analysis	PSA
Statistical Package for the Social Sciences	SPSS
Total Organic Content	TOC
US Environmental Protection Agency	U.S EPA
World Health Organization	WHO

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Water Quality and Heavy Metals in the Water and Sediments from Batang Ai Dam and Its Vicinity, Lubuk Antu, Sarawak.

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ABSTRACT

The water and sediment samples were collected from Batang Ai dam and its vicinity. Water quality such as temperature, pH and dissolved oxygen was investigated in eight sampling sites. The dissolved oxygen values ranged from 4.87 mg/L to 7.43 mg/L at station located near the town of Lubuk Antu. The residential area and village along the Lubuk Antu River may give an impact on the water and sediment qualities compared to the other station at Batang Ai Dam. This study were to determine the concentration of heavy metal such as Zn, Cu, Cr, Cd, Fe, Ni, As and Pb in the water and sediment. The ranged concentration of heavy metal values (mg/kg) in water were Cr; (0.0043-0.0094), Ni;(0.0262-0.0364), Zn;(0.0089-0.0211). Fe was detected only at station S6. The ranged concentration of heavy metal values (mg/kg) in sediment were Cu; (1.82-52.40), Cr; (2.68-200.14), Ni; (32.04-105.3), Pb; (1.27-4.5), As; (1.74-10.09), Zn; (11.82-56.09) and Fe; (2291.0-32805.0) in dry weight.

Keyword : Water quality, Lubuk Antu River, Batang Lupar River, Batang Ai Dam, heavy metal, sediments

ABSTRAK

Sampel air dan sedimen telah diambil dari empangan Batang Ai dan kawasan sekitarnya. Kualiti air seperti suhu, pH dan oksigen terlarut telah disiasat di lapan tapak persampelan. Nilai oksigen terlarut adalah di antara 4.87 mg / L kepada 7.43 mg / L di stesen yang terletak berhampiran kawasan perumahan dan bandar Lubuk Antu. Kawasan kediaman dan kawasan kampung di sepanjang Sungai Lubuk Antu boleh memberi kesan kepada kualiti air dan sedimen berbanding stesen lain di empangan Batang Ai. Kajian ini adalah untuk menentukan kepekatan logam berat Zn, Cu, Cr, Cd, Fe, Ni, As dan Pb dalam air dan sedimen. Kepekatan antara nilai-nilai logam berat (mg / kg) di dalam air ialah Cr; (0.0043-0.0094), Ni; (0.0262-0.0364), Zn; (0.0089-0.0211) dan Fe hanya di stesen S6 mengesan bahawa adalah 1.1 dalam berat kering. Kepekatan antara nilai-nilai logam berat (mg / kg) dalam mendapan Cu; (1.82-52.40), Cr; (2.68-200.14), Ni; (32.04-105.3), Pb; (1.27-4.5), As; (1.74-10.09), Zn; (11.82-56.09) dan Fe; (2291.0-32.805.0) dalam berat kering. Cu, dan Zn mencatatkan kepekatan tertinggi berhampiran kawasan bandar yang padat dan kampung.

Kata kunci : kualiti air, Sungai Lubuk Antu , Sungai Batang Lupar , Empangan Batang Ai , logam berat, sedimen .

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Water quality is issues which affect the quality of our food, health and environment in general (Singh *et al.*, 2004). Several human activities such as discharge of untreated waste and raw sewage, urban development, agriculture and aquaculture have directly degraded the natural environment (Sumok, 2001). Wastewaters from residential areas are categorized into grey water and black water. The excessive of nitrogen and phosphorous may contribute to algal bloom that leads to eutrophication. The residential area and industrial discharging directly and indirectly into water resources cause excessive pollution of surface and underground water (Akcay *et al.*, 2003).

Heavy metals are one of the very serious pollutants in the environment. It is because heavy metals can cause toxicity, persistence and bio them. Arsenic (As), cadmium (Cd) and lead (Pb) are classified as a primary contaminant. This is because the metal is not required for metabolic activity and can cause toxic even if it is at very low concentrations (U.S. EPA, 1999). Zinc (Zn) is a biologically important; we must recognize and study the behavior of Zn. It is because the potential to be toxic to biota at specific concentrations (Vallee and Auld, 1990). In the last century, heavy metals are released into aquatic systems as a result of the rapid expansion of the lines. Among them are industry, agriculture and rural areas.

Therefore, heavy metal pollution has become a very serious problem in marine ecosystems around the world and more worrying problem is rampant (Vallius and Leivuori, 1999; Cundy *et al.*, 2003.; Pekey, 2006). Studies done previously been reported that the sediments in the ocean has a huge capacity to store heavy metals from various sources. Like marine sediments can also act as a sink because of the accumulation of heavy metals (Calmano *et al.*, 1993;, Menon *et al.*, 1998). Sediments can be used as a useful indicator to monitor the level of heavy metal pollution in coastal areas.

The level of heavy metals, particularly Pb, Cd and As often observed in aquatic organisms in the estuary. It is observed on aquatic life such as clams and snails to study the standard index of seafood (Wei *et al.*, 2002. Ip *et al.*, 2005). Based on the experiments, it is very important to study the spatial and temporal distribution of heavy metals in the estuary. It indicates the potential sources and historical changes of heavy metals in estuaries. With these experiments, we can provide pollution control strategy and approach to water management in the estuary incredibly luminous quality.

Sediment is a sink for organic materials and other contaminants such as heavy metals, antibiotics and pesticides and these contaminants could affect the quality of water which is in contact with sediment for a long time (Ling *et al.*, 2009). The excessive amount of heavy metal in sediment may lead to toxicity and it is dangerous to aquatic and human health. But certain heavy metal such as Cu and Zn are also essential biological micronutrients that are required for the growth of organisms (Ouyang *et al.*, 2002).

The residential areas including villages and city may give an impact on water and sediment of selected river at Batang Ai Dam and Lubuk Antu. This study will focuses on water quality and heavy metals contain in water and sediment from selected river at Batang Ai and Lubuk Antu. This study also focused on residential area wastewater discharge on the sediment of Batang Ai Dam, Lubuk Antu River and Batang Lupar River since there are residential area and village along the river.

1.2 The Objectives of the Study

This study was carried out according to the following objectives:

a) To perform the *in-situ* analysis of water quality such as pH, temperature and dissolved oxygen in the study area,

b) To determine the concentration of heavy metals (Cd, Cu, Cr, Ni, Pb, As, Zn, and Fe) in the water and sediment from upstream, downstream and vicinity of Lubuk Antu,

c) To compare results of water quality and heavy metals in water and sediments from different sampling sites.

CHAPTER TWO

LITERATURE REVIEW

2.1 Wastewater

Wastewaters generated from residential area are divided into grey water and black water. Black water is generated from personal activities such as urine and faces while grey water is generated from household activities such as laundering, cooking and bathing. In general, wastewater contains substantial amounts of beneficial nutrients and toxic heavy metals, which are creating opportunities and problems for agricultural production (Khan *et al.*, 2008).

According to Ling *et al.* (2009), for residential areas, discharge into the rivers includes untreated or treated sewage and grey water with high organic matter such as nitrogen and phosphorous which may results eutrophication on receiving water bodies. Anthropogenic impact on natural environments and especially on aquatic ecosystem is currently a topic of increasing concern. Deterioration of surface water and especially river water quality has recently been observed in many aquatories (Singh *et al.*, 2004). The increasing industrialization and the rapid growth of the large urban centres have been accompanied by increases in the pollution stress on the aquatic environment.

Rapid population growth, land development along the river basin, urbanization and industrialization have been subjected the rivers in Sarawak to increasing stress, giving rise to water pollution and environmental deterioration (Sumok, 2001). Degradation of river quality particularly in Sarawak includes urban development, infrastructure construction

and discharge of untreated waste and raw sewage from settlement areas and aquaculture farms (Buda *et al.*, 2008).

2.2 Water Quality

Water quality assessment is the way to manage the surface water and assist in decision making for development or protecting the river (Sullivan *et al.*, 2002). There are many factors such as climate change, underlying geology and anthropogenic activities that might influenced water quality of the river. Water quality during influenced by rates of photosynthesis and respiration, water temperature, levels of fertilization and feeding, mechanical aeration and the amount of water exchanged in the culture enclosure daily (Lovshin and Manomaitis, 2000).

Dissolved oxygen (DO) is by far, the most important parameter in aquaculture (Samantha, 2008). Oxygen consumption is directly linked to size, feeding rate, activity level and temperature, and it will surprise some that large fish consume less oxygen than their smaller counterparts which have higher metabolic rates. The amount of dissolved oxygen in water increases as temperature reduces, but decreases when salinity and altitude increases (Samantha, 2008).

The discharged of organic, degradable wastewaters into flowing water causing the decreasing of dissolved oxygen concentration. Two major causes for oxygen deficit in river water are metabolism of pollutants by microorganisms and chemical oxidation of reduced pollutants (Drolc and Koncan, 1995). Organic matter may be accumulated on the river bottom and oxygen is also consumed because of respiration of plants, algae and

phytoplankton. Besides that, the factors which are beneficial for dissolved oxygen concentration are atmospheric reaeration and production of dissolved oxygen due to photosynthesis (Drolc and Koncan, 1995).

The classes of water quality standard proposed for Malaysia is shown in Table 2.1.

Table 2.1: Interim National Water Quality Standard for Malaysia (DOE, 2006)

Class	Parameter	
	Dissolved oxygen (mg/L)	pH
I	>7	>7.0
II	5-7	6.0 – 7.0
III	3-5	5.0 -6.0
IV	1-3	<5.0
V	<1	>5.0

Class	Category
I	Represents water body of excellent quality
II	Represent water bodies of good quality
III	Is defined with the primary objective of protecting common and moderately tolerant aquatic species of economic value
IV	Defines water quality required for major agricultural irrigation activities which may not cover minor applications to sensitive crops
V	Represents other waters which do not meet any of the above categories

2.3 Sediment in River

Sediments play an important role in elemental cycling in the aquatic environment. Most sediment in surface water derives from surface erosion and comprises a mineral component, arising from the erosion of bedrock, and an organic component arising during soil-forming processes (WHO, 1996). Role of sediment is being transport to materials, either immediately or after further breakdown, and brought to the coast. They are a matrix of materials, comprised of detritus, inorganic and organic particles, and are relatively heterogeneous in term of its physical, chemical and biological characteristics (Boaden and Seed, 1993). Sediments play a variety of roles as follow:

2.3.1 Pollution Sinks

Sediments play a major role in the transport and fate of pollutants and so is clearly a concern in water quality management. Toxic chemicals can become attached to, or absorb by sediment particles and then transport to and deposited in other areas. These pollutants may later release into the environment. By studying the quantity, quality and characteristics of sediment in the stream, scientists and engineers can determine the sources and evaluate the impact of the pollutants on the aquatic environment. Once the sources and the impact are known, action can be taken to reduce the pollutants (Water, 2002).

2.4 Heavy Metals

Heavy metals are defined as metallic chemical element with relatively high density and toxic or poisonous at low concentration. Heavy metals are dangerous because they

tend to accumulate in the marine sediments and cause contamination. Hence, more studies are encouraged to raise the awareness to public on the environmental issue. Human activities in the marine environment cause the heavy metals to accumulate in sediments, and become useful indicators for anthropogenic inputs (Fabbri *et al.*, 2001).

Heavy metals are metal of relatively high density which has high relative atomic weight and are taken up by plants which modifier heavy metal contamination. The example of heavy metals are arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, and selenium. It is called heavy because of their high relative atomic mass which can cause the plants, animals, and human to damage even at very low concentration. Besides, heavy metals have a tendency to accumulate in the selective body organs such as liver and brain their given average safety levels in food or water are often falsely high (Ozuni *et al.*, 2010).

Heavy metals are one of the more serious pollutants in our natural environment due to their toxicity, persistence and bioaccumulation problems (Kamaruzzaman *et al.*, 2010). Heavy metals are present in streams as a result of chemical leaching of bed rocks, water drainage and runoff from the banks, and discharge of urban and industrial wastewaters (Soares *et al.*, 1999). Heavy metal contamination in sediment, soil and ground water is one the largest threat to environmental quality and human health (Li *et al.*, 2000).

The contents of heavy metals in sediments unlikely related to the corresponding contents in the aquatic phase (Cheung *et al.*, 2003). Contamination caused by heavy metal affects both ocean waters, those of the continental shelf and the coastal zone where, besides having a longer residence time, metal concentration are higher due to the input and

transport by river runoff and the proximity to industrial and urban zones (Kamaruzzaman *et al.*, 2010).

Particularly, heavy metals have high affinity for fine sediment particles, which are discharged by rivers and transported into the sea by means of small particulate matter. Correlation has been made between high concentrations of heavy metals and higher content of organic matter (Palanques *et al.*, 1995).

The sources of heavy metal contamination are differ which abundant naturally in volcanic basalts to contamination from non – point sources of pollution. Lead and cadmium are distributed to the environment from airborne chemicals that are natural and man – made, industrial airborne chemicals, and forestry. Cadmium, zinc, copper and nickel are used in fertilizers, fungicides and pesticides. Lead is found in areas near roadways where inleaded fuel is used. A significant amount of total lead present in surface water exists as suspended matter (McMurtry *et al.*, 1995).

2.5 Toxicity of Heavy Metals

Toxicity effects of the pollutants to a living marine organisms that was recognized as early as the early decade of the 20th century. It is affected to the marine pollution which can reduce of the aquatic amenities and hampering of the customary of marine activities. There was a growing concern regarding to the toxic contaminants and toxic of the heavy metals in the seawater. The toxicity cause the disease that caused by the poisoning human with seafood that are contaminated with mercury and cadmium (Al-Sulami *et al.*, 2000).

Heavy metals are group of elements that are potentially toxic to estuaries and marine organism available above a defined threshold (Kennish, 1991). Heavy metals naturally occur in the crust of the earth. However human activities have introduced high loads of these elements in the environment making the differentiation of natural and anthropogenic contributions difficult.

Anthropogenic sources of heavy metals include mining and subsequent processes such as smelting, coal burning and metallic corrosion, product of cement, bricks, solid dumps and antifouling paints (Baoden and Seed, 1993).

2.6 Effects of Heavy Metals

Certain heavy metals such as Cu and Zn, are essential biological micronutrients required for the growth of organisms but other heavy metals such as Hg, Pb and Cd are not required for growth and have been considered to be most noxious with respect to human health and aquatic life (Ouyang *et al.,* 2002). High levels of lead, copper and iron have been found to bring rapid physiological changes in river and lake fish and continuous exposure to organisms in low concentration may result in bioaccumulation, and subsequent transfer to man by the food chain (Mendil *et al.,* 2010). Therefore, enrichment of metal in the bed sediment proved an important factor for detecting the sources of heavy metal in an aquatic ecosystem because suspended particles carried by industrial effluents and domestic sewage are ultimately deposited as the sediments containing measurable quantities of Cd, Cr, Co and Cu (Abdul Rauf *et al.,* 2009).

A study in Almendras river, Cuba by Olivares-Rieumont *et al.*(2005) reported that metal concentration (μg/g) in sediments ranged from 86.1 to 708.8 for Zn, 39.3 to 189.0 for Pb, 71.6 to 420.8 for Cu, 84.4 to 209.7 for Cr, 1.5 to 23.4 for Co and 1.0 to 4.3 for Cd. It has been reported by Cheung *et al.* (2003) that the frequency of metals detected in the samples was Zn>Cu>Ni>Pb>Cr>Cd at different locations in Pearl River Delta, China. A study by Marcussen *et al.* (2008) on the distribution of elements of river receiving water in Hanoi, Vietnam showed that the sediment was polluted with potentially toxic elements (PTEs) with maximum concentration of 73 As, 427 Cd, 281 Cr, 240 Cu, 218 Ni, 363 Pb, 12.5 Sb and 1240 Zn mg kg^{-1} d.w.

The average concentration of Pb and Cu at Pahang River Estuary were 74.31±22.97 μg/g and 18.65±7.65 μg/g (Kamaruzzaman *et al.*, 2010). A study by Ouyang *et al.*, (2001) at Cedar and Ortega river sub basin showed that concentration of Pb ranged from 4.47 to 420.0 mg/kg dry weight and Cd from 0.07 to 3.83 mg/kg in dry weight. In the study at surface sediments (0-5 cm) from 59 stations within the Yangtze River intertidal zone by Zhang *et al.*, (2009), the concentration ranged in (mg/kg dry weight) : Al; 40803-97213, Fe; 20538-49627, Cd; 0.12-0.75, Cr; 36.9-173, Cu; 6.87-49.7, Mn; 413-1112, Ni; 17.6-48.0, Pb; 18.3-44.1, and Zn; 47.6-154.

2.7 Pollution Index

An index is presented to analyze the quality of the river. It is based on an aggregation of four different components of vulnerability, to test the physical system response to change, water quality, trophic status and also in terms of eutrophication. This also includes sediment quality, benthic fauna and trophodynamics. Tests on ecosystems