STUDY ON SPATIAL VARIATION OF WATER QUALITY IN SUNGAI TUNGGAK, KUANTAN PAHANG

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ABSTRACT

A study on spatial variation of water quality in Sungai Tunggak, Gebeng Pahang was conducted at five sampling stations which were at Padang Tebing Tinggi, Perkampungan Seberang Balok 1, Taman Balok Makmur & Perkampungan Seberang Balok, entrance of Gebeng Industrial Area and Gebeng Industrial Area. A total of twelve water quality parameters were analysed including in situ test and laboratory analysis (ex-situ test). All the parameters were analysed and measured according to standard method. The physical, chemical and biological variables were temperature, pH value, turbidity, total suspended solids (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity (EC), ammonical nitrogen (NH_3-N), total coliform and Escherichia coli (E.Coli). The result show that water quality at Sungai Tunggak is Class III based on Water Quality Index (WQI), which means, Sungai Tunggak is suitable for water supply. However, extensive treatment required for water supply. Human activities at surrounding area near Sungai Tunggak affected water quality there. Agricultural and farming activity also commercial activity at Taman Balok Makmur & Perkampungan Seberang Balok and residential area at Perkampungan Seberang Balok 1 indeed affects water quality in Sungai Tunggak and if these situation continued, may have caused environmental degradation at Sungai Tunggak hence may lead alga bloom in river. Regarding heavy metals values of lead (Pb), cadmium (Cd), ferum (Fe) and manganese (Mn) was recorded in toxic level in the surface water of the river except zinc (Zn).

ABSTRAK

Satu kajian mengenai variasi spatial kualiti air di Sungai Tunggak , Gebeng Pahang telah dijalankan di lima stesen persampelan yang berada di Padang Tebing Tinggi, Perkampungan Seberang Balok 1, Taman Balok Makmur & Perkampungan Seberang Balok, pintu masuk Kawasan Perindustrian Gebeng dan Kawasan Perindustrian Gebeng. Sebanyak dua belas parameter kualiti air telah dianalisis termasuk dalam ujian in situ dan analisis makmal (ujian ex-situ). Semua parameter telah dianalisis dan diukur mengikut kaedah piawai. Antara parameter Fizikal, kimia dan biologi yang telah diuji adalah suhu, nilai pH, kekeruhan, jumlah pepejal (TSS),oksigen terlarut (DO), permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD), kekonduksian elektrik (EC), nitrogen ammonia (NH3-N), jumlah kolifom dan Escherichia coli (E.Coli). Kajian ini mendapati kualiti air di Sungai Tunggak adalah Kelas III berdasarkan Indeks Kualiti Air (WQI), yang bermaksud, Sungai Tunggak sesuai untuk bekalan air. Walau bagaimanapun, rawatan yang luas diperlukan untuk bekalan air. Aktiviti manusia di kawasan persekitaran berhampiran Sungai Tunggak menjejaskan kesan kualiti air di sana. Aktiviti pertanian dan perladangan juga aktiviti komersial di Taman Balok Makmur & Perkampungan Seberang Balok dan kawasan perumahan di Perkampungan Seberang Balok 1 memang memberi kesan kepada kualiti air di Sungai Tunggak dan jika keadaan ini berterusan, mungkin akan menyebabkan kemerosotan alam sekitar di Sungai Tunggak di mana boleh menyebabkan terjadinya pertumbuhan alga di dalam sungai. Mengenai keputusan nilai-nilai logam berat seperti plumbum (Pb), kadmium (Cd), ferum (Fe) dan mangan (Mn) dicatatkan pada tahap toksik di dalam permukaan air sungai kecuali zink (Zn).

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LIST OF ABBREVIATION

AAS	Atomic Absorption Spectrophotometer
AN	Ammonia Nitrogen
APEC	Advanced Purification Engineering Corporation
APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
Cd	Cadmium
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
EC	Electrical Conductivity
E.coli	Escherichia Coli
Fe	Ferum
G	Glass
GPS	Global Positioning System
H_2SO_4	Sulphuric Acid
LCRA	Lower Colorado Riven Authority
LR	Low Range
Mg/L	Milligram per Litre
Mn	Manganese
MPN	Most Probable Number
NaOH	Sodium Hydroxide
NEST	Northwest Environmental Science and technology
NH_3-N	Ammonical Nitrogen

NTU	Nephelometric Turbidity Units
NWQS	National Water Quality Index
P	Plastic
Pb	Lead
PBC	Polychlorinated Biphenyl
pH	pH Value
SIAN	Sub index Ammonical Nitrogen
SIBOD	Sub index Biochemical Oxygen Demand
SICOD	Sub index Chemical Oxygen Demand
SIDO	Sub index Dissolved Oxygen
SIpH	Sub index pH Value
SISS	Sub index Suspended Solid
TDS	Total Dissolved Solid
TSS	Total Suspended Solid
USGS	United States Geological Survey
WHO	World Health Organization
WSDE	Washington State Department of Ecology
WQI	Water Quality Index
WWF-Malaysia	World Wide Fund for Nature (Malaysia)
Zn	Zinc
μS/cm	Microsiemens per Centimetre

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Water is one of the most important sources in our daily life because without water, humans, animals and other living things will die. This is because about 70% of human body contains water. The availability and quality of water always played an important part in determining not only where people can live, but also their quality of life. (APEC,2000)

According to Diersing (2009) said that definition of water quality is used to describe the biological, chemical and physical characteristics of water and its general composition. Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics such as drinking, washing, swimming or fishing. Based on Northwest Environmental Science and Technology, NEST, these attributes affect water's ability to sustain life and its suitability for human consumption. Furthermore, water quality also depends on the local geology and ecosystem, as well as human uses such as sewage dispersion, industrial pollution, use of bodies water as a heat sink and overuse which may lower the level of water.

Quality of water is deteriorating all over the world in many ways. Anthropogenic activities are the main causes of water pollution. The end points of effluent discharged from industries are water bodies. (Azhar, 2000). Ever-increasing industries and their effluents are the major threats to the surface water; as the end destination of industrial effluents is the river (Moorthy and Jeyabalan, 2012).

The increasing trend of economy and industry in Malaysia led to environmental degradation including river water pollution. At the same time, the rivers are contributing significantly for the industrial development in Malaysia (Moorthy and Jeyabalan, 2012) and about 98% of the country's water requirements are fulfilled from river water (Azhar, 2000). So, the river water pollution can cause serious health risk as well as environmental threats in the country. The major sources of industrial pollution in Malaysia are food & beverage, chemical & petrochemical, palm oil, textile, paper and rubber processing industries (Iyagba et al.,2008).

Speedy growth in industrial sector generates more wastes which could damage to the environment without having proper treatment plant. Industrialization with an increasing demand for heavy metals results in a high emission of these pollutants into the biosphere. Water bodies with heavy metal pollution are a serious threat to the aquatic ecosystem, human health as well as environment (M. A. Hossain et al., 2012).

In this era of modernization and industrialization, environmental issues often take a back seat in order to show the rapid development and urbanization. In Malaysia specifically, water resources are often taken for granted and as direct result, more and more surface water bodies are becoming contaminated due to heinous and irresponsible acts as certain industrialists and developers. Many factors can affect water quality. Contaminants that may be in untreated water include microorganisms such as viruses and bacteria; inorganic contaminants such as salts and metals; pesticides and herbicides; organic chemical contaminants from industrial processes. (NEST, 2008).

To determine water quality, there are two types of standard which are Water Quality Index (WQI) and National River Water Quality Standard (NWQS). The water quality appraisal is based on Water Quality Index consisting of parameters such as dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonical nitrogen (NH_3-N), suspended solids (SS) and pH. (Lim Fui Ling, 2007).

According to Department of Environment, DOE (2008) state that the WQI serves as a basis for environmental assessment of a watercourse in relation to pollution load categorization and designation of classes of beneficial uses as provided for under the National Water Quality standard for Malaysia (NWQS). NWQS is divided into 5 classes, Class I being the cleanest and Class V being the most polluted.

Water quality standards are important because they help to protect and restore the quality of the Nation's surface waters, consistent with the requirements of the Clean Water Act. (Lisa, 2012). Standards help to identify water quality problems caused by, for example, improperly treated wastewater discharges, runoff or discharges from active or abandoned mining sites, sediment, fertilizers, and chemicals from agricultural areas, and erosion of stream banks caused by improper grazing practices. Standards also support efforts to achieve and maintain protective water quality conditions.

1.2 PROBLEM STATEMENT

Malaysia is rich with its bounty of water resources. It is contributing to the economic and industrial development of the country (Moorthy R. and Jeyabalan G., 2012). The present situation is also changing day by day with population growth, urbanization and industrialization. According to the Environmental Quality Report 2010, 50% river water of Malaysia is polluted which is higher than previous couple of years. Industries are generating conventional and non-conventional pollutant and discharging into the river flow that causes the deterioration of water quality (M. A. Hossain et al., 2012)

Gebeng is the main industrial park of Pahang Malaysia where Tunggak is a strategic important river. Rapid industrialization at Gebeng producing lots of effluents and they are discharging those effluents into the Sungai Tunggak; as result polluting the water of the river. The real scenario is the rapid developments including the petrochemical, multifarious industries are generating effluent which contains high concentration of conventional and non-conventional pollutant that deteriorating the

water quality of the river. Therefore, the study was conducted to determine water quality characteristic based on selection physic-chemical with DOE-WQI.

1.3 RESEARCH OBJECTIVES

The research is mainly focuses on the quality of water in Sungai Tunggak at Gebeng industry area. The objectives of this resarch are as follows:

i. To determine the water quality status in Sungai Tunggak, Kuantan Pahang.

ii. To classify the water quality based on DOE (Department of Environment) Water Quality Index (WQI).

1.4 EXPECTED RESULT

This research is expected to give several immeasurable benefits to the environment of Gebeng industrial area and also the entire population of nearby. It parallel with the objective of water quality status in which the characteristic of water quality and heavy metal in Sungai Tunggak can be determined.

Furthermore, it must safe from any pathogen microorganism, dangerous organic/inorganic and less mineral substance. Besides that, this project is to obtain information and data gathering based on water sampling and through laboratory analysis is useful for policy making.

1.5 SCOPE OF RESEARCH

In this study, Sungai Tunggak, Gebeng Kuantan Pahang was selected for water quality evaluation which is carrying contaminated water from in industrialization including petrochemical, multifarious industries that generating effluent which contains high concentration of pollutants that deteriorating the water quality. The water samples were collected from different sites along the river.

There are 9 parameters that will be analysed in the laboratory in determine the biological, physical and chemical characteristic of the wastewater which are biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total coliform & e.coli, ammonia nitrogen (NH_3-N), dissolved oxygen (DO), pH value, temperature and selected heavy metals. The selected parameters were analysed based on in-situ and laboratory analysis according to standard method which is National Water Quality Standard and Water Quality Index.

1.6   SIGNNIFICANT OF RESEARCH

This research is very important to determine the water quality at Sungai Tunggak according to the standard that has been mentioned. Due to industrial activities, the study area are more polluted which is carrying waste and there are discharging into the Sungai Tunggak, which is one of the important river in Pahang. So, this study is important to know the water quality status at Sungai Tunggak, before finding a solution of this problem. If the level of water quality in the area is low, the government such as the Department of Environment and Drainage and Irrigation Department to take immediate action to improve water quality.

1.7   SUMMARY OF THE CHAPTER

Water quality used to describe the biological, chemical and physical characteristics of water and its general composition. The quality of water can be determined based on the Water Quality Index (WQI) system for rivers in Malaysia and National water quality standard for Malaysia (NWQS). The purpose of the study for this research is to determine the status of water quality and classify the water quality based on DOE-WQI. The point location already defined, in which water samples will be taken. The point are along the Sungai Tunggak in which adjacent to Gebeng industrial area. The sample tested through the suitable parameter experiments.

Those parameters are biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), ammonical nitrogen (NH_3-N), total suspended solids (TSS), total coliform & E.coli, ph value, temperature, electrical conductivity (EC), turbidity and selected heavy metal. Finally, the results of the tests were to be performed, conclusions and recommendations should be made for action to be taken by the authorities so that water quality of Sungai Tunggak can be improved.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Water is very important for living things, which includes human life, flora and fauna. According to John P.S. (2008), "Water and life are intricately linked. Water makes up about 70% of our bodies. More than half of the world's species of plants and animals live in water, and even our terrestrial-derived food is totally depends on and often large composed by water".

According to Tchobanoglous, G., and Schroeder, E.D. (1985), "A plentiful supply of water is clearly one of the most important factors in the development of modern societies. Availability of water for cleansing is directly related to the control or elimination of disease. The convenience of water available at home improves the quality of life". This quotation shows the important of water in life. However, water quality cannot be ignored because water quality is a measurement how safe the water is.

2.2 SURFACE WATER

Surface water is water above land surface. (Chin, D. A., 2006). Surface water body is potential to receive pollutant from many sources. Characteristics of surface water are change with time and space. Mineral pick up from surface runoff, silt and debris are carried by surface water, will increased the concentration of impurities in water, these, will caused, muddy or turbid streams. Stagnant water or slow moving areas changing the aesthetic characteristics by plants and algae grow. Most of waste will

discharged towards surface water. Thus, caused major impact on water quality and add greatly to the spectrum of impurities. (Tschobannoglous, G. and Schroeder, E. D.,1985).

2.2.1 River

River is a natural watercourse usually freshwater, flowing towards on ocean, a lake, a sea or another river. Rivers are part of the hydrological cycle. Water within the rivers is generally collected by the precipitation through s drainage basin form surface runoff and other sources. A river is also surface water that finds its way over land from a higher altitude to lower altitude due to the gravity (United States Geological Survey, USGS).

According to World Wide Fund for Nature Malaysia (WWF-Malaysia), beside of being the main water sources, river also contributes to our life in numerous ways. Rivers provide food resources and also the live hoods of riverine communities are significantly depending on rivers. Rivers also provided the important habitat and serve as feeding and breeding ground for a wide range or riverine biodiversity that lives in the river. The phrase 'river of life' is not just a word. It has been essential to not only human but also to all life on earth (USGS).

The highland forests are often referred to as natural 'water towers'. This is because most rivers originate from there and a significant amount of water from rainfall is captured and accumulated by these forests. In fact, a large proportion of the river volume originates in the highlands. According to World Wide Fund for Nature Malaysia (WWF-Malaysia), about 97% of raw water supply for agricultural, domestic and industrial needs are derived from the surface sources primarily rivers. Malaysia has 189 river basins which are 89 in Peninsular Malaysia, 78 in Sabah and 22 in Sarawak. All the rivers originate and flow from the highland. The highland forest and wetland constitute key fresh water ecosystem in the country that deliver a multitude of benefits from providing natural resources, gene pools and habitats for flora and fauna, to enabling purification and flood control.

Although river is the largest sources for freshwater, it still cannot avoid the river from being polluted. River pollution is one of the largest threats to the river. The sources of pollutions come from domestic and industrial sewerage, effluents from livestock farms, manufacturing and agro based industries, suspended solids from mining, housing and rood construction, logging and clearing of forest and heavy metals from factories.

2.3   WATER POLLUTION

There are different definition of water pollution, depending on the approach and field of specialization of the author. Ellis (1989) formulates surface water pollution as "the alteration in composition or condition of surface water, either directly or indirectly, as the result of the activities of man, which initiates modification of ecological systems, hazard to human health or renders the stream less acceptable to downstream user". There are three points of this formulation, which clarify the pollution is defined as a consequence of human activities. The natural water is polluted not only in the cases of public health hazard, but when natural environment is modified. Pollution is an act leading to the impairment of subsequent water use for a stated purpose.

Although this definition is formulated for surface water only it can be applied to ground water resources as well as, and it could be stated that water pollution is the alteration in the composition or condition of natural water, either directly or indirectly, as the result of human activities, which initiates modification of ecological system, hazards to human health and impairs the subsequent water use. The process of the evaluation of the pollution status of a water resources system requires information regarding its natural (background) quality, in order to evaluate how much it has been affected by human activities.

Pollution represents the physical, chemical and biological composition of surface or ground water, which could result from natural causes and factors. It varies with climatic, geographic and soil conditions and it is an indicators of the level of contamination of water in its pristine status, uninfluenced by human activities. Surface

natural water quality is more prone to variation compared to ground water, the natural composition of which is dependent mostly on the geological formation of the aquifer.

Pollution contributed to water resources could be expressed in term of pollution loads received by the corresponding natural water body from a specific source. Pollution loads represent the mass quantity of pollution discharged per unit time into water bodies and are equal to the product of pollution concentration and the flow rates during a stipulated period of time. The "term pollution" load in cases where an external sources (a water discharge, a tributary of a river, or a river itself) contributes pollution to a given water body (natural stream, river, lake or aquifer). Pollution loads contributed by different media within the water body could be regarded as pollution flux.

2.3.1 Point Sources

Point source defined as wastewater that is discharged from known sources at an identified point. Based on Purohit and Agrawal (2004) stated that point sources pollution means any wastewater discharged directly towards water bodies for example, discharge pipes, where they can be easily measure. There are sources associated with man-made discharged of pipelines and canals also known as "end of pipe" sources of pollution. There are identifiable discrete discharges from municipal and industrial wastewater collection and treatment systems. They could be broadly subdivided into two categories, based on origin which is municipal wastewater and industrial wastewater.

2.3.2 Non-Point Sources

Non-point source pollution does not have one specific source, such as a factory. They are associated mainly with land drainage and surface runoff, which enter the water body by dispersed and poorly defined ways. According to Purohit and Agrawal (2004) stated that non-point sources pollution, hard to identify, measure and control than point sources pollution. Non point sources pollution also known as diffuse source pollution, which come from human activities for which pollutants have no obvious point of entry receiving watercourses.

Municipal wastewater applied to land may become non-point sources of pollution in runoff if not handled properly. Agriculture sources are associated mainly with runoff and leachate from agriculture lands and animal operation and are generates by the access application of fertilizers, pesticides, herbicides, as well as increased salinity of return flow. Diffuse pollution in urban area is associated mainly with polluted urban runoff (drainage), contaminated with material washed up from streets, roads, roofs, open spaces and others.

2.3.3 River Water Quality and Pollution

According to Lenntech, B.V, (1998) stated that a river is defined as a large natural stream of water emptying into an ocean, lake, or other body of water and usually fed along its course by converging tributaries. Rivers and streams drain water that falls in upland areas. Moving water dilutes and decomposes pollutants more rapidly than standing water, but many rivers and streams are significantly polluted all around the world. A primary reason for this is that all three major sources of pollution (industry, agriculture and domestic) are concentrated along the rivers.

Chemical waste products from industrial processes are sometimes accidentally discharged into the river. Example of such pollutants including cyanide, zinc, lead, copper, cadmium and mercury. These substances may enter the water in such high concentration that fish and other animals are killed immediately. Sometimes the pollutants enter a food chain and accumulate until they reach toxic levels, eventually killing birds, fish and mammals.

Many types of pollution are discharged into rivers, and the purification processes remove them at various speeds. Some heavy metals, for example, are removed relatively quickly because suspended clay and organic particles have a slight electric charge and adsorb the metal atoms. When the clay or organic particles settle out of the water, they take the metal atoms with them. Unfortunately some pollutants are very persistent in the water and can accumulate downstream causing great hazard.

2.4 INDUSTRIAL WATER POLUTION

According to Department of Environment (2007) stated that the biggest sources of industrial water pollution in Malaysia are food and beverage industries, chemical based industries, textile, paper, palm oil and rubber processing industries. Such rapid development of industries however has increased the water pollution level in Malaysia. Rapid growth within the industrial sector, where more and more hazardous industrial wastes are being generated could damage to the environment when improperly treated and disposed. Industrialization in developing countries with an increasing demand for heavy metals results in a high emission of these pollutants into the biosphere. Heavy metals pollutions in water bodies are a serious environmental problem, threatening the aquatic ecosystem and human health. Water pollution is caused by emission of domestic or urban sewage, agricultural waste, pollutants and industrial effluents into water bodies.

Nowadays, its main source is the waste material discharged by industrial units. Waste materials like acids, alkalizes, toxic metals, oil, grease, dyes, pesticides and even radioactive materials are poured into the water bodies by many industrial units. Some other important pollutants include polychlorinated biphenyl (PCB) compounds, lubricants and hot water discharged by power plants. The pollutants unloaded into the water bodies usually dissolve or remain suspended in water. Sometimes, they also accumulate on the bottom of the water bodies.

In the United States industry is the greatest source of pollution, accounting for more than half the volume of all water pollution and for the most deadly pollutants. Some 370,000 manufacturing facilities use huge quantities of freshwater to carry away wastes of many kinds. The waste-bearing water, or effluent, is discharged into streams, lakes, or oceans, which in turn disperse the polluting substances. In its can concluded that approximately 40% of the nation's surveyed lakes, rivers, and estuaries were too polluted for such basic uses as drinking supply, fishing, and swimming. The pollutants include grit, asbestos, phosphates and nitrates, mercury, lead, caustic soda and other sodium compounds, sulphur and sulphuric acid, oils, and petrochemicals.