WATER QUALITY AND PERCENTAGE OF HARD CORAL COVER IN AMBONG BAY AND USUKAN BAY OF KOTA BELUD, SABAH

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ABSTRAK

Parameter kualiti air perlu diuji di sesuatu kawasan untuk menentukan sama ada kawasan itu tercemar dengan pencemaran seperti koliform najis, dan pencemaran logam berat. Sesetengah bahan pencemar ini tidak bertoksik tetapi jika ia wujud secara berlebihan di persekitaran, ianya akan membawa kemudaratan kepada kehidupan manusia dan organisma laut yang lain seperti ikan, dan batu karang kerana semua ekosistem ini mempunyai kaitan di antara stau sama lain. Kajian ini telah dijalankan untuk menentukan dan untuk membandingkan kualiti air di Teluk Ambong dan Teluk Usukan, di samping untuk menentukan dan untuk membandingkan peratusan taburan batu karang antara Teluk Ambong dan Teluk Usukan. Ia juga telah dijalankan untuk menentukan hubungan di antara kualiti air dengan peratusan taburan batu karang keras dalam dua teluk ini. Analisis makmal koliform najis telah dilakukan dengan menggunakan kaedah Penapisan Membran (MF) manakala bagi menganalisis logam berat ianya dilakukan menggunakan mesin Pasangan Plasma Induktif - Atom Pelepasan Spektroskopi (ICP-OES). Keputusan menunjukkan bahawa parameter air bagi kedua-dua teluk dari segi suhu (°C), pH, kekeruhan (NFU), saliniti (psu), dan oksigen terlarut (mg/L) adalah berada di dalam julat Piawaian Kualiti Air di Malaysia. Perbandingan bacaan bagi koliform najis menunjukkan bacaan yang lebih tinggi di Teluk Ambong berbanding Teluk Usukan dengan bacaan 2.82 ± 1.35. Untuk analisis logam berat, Teluk Usukan menunjukkan bacaan yang lebih tinggi untuk Cd , Cr , Cu, Pb, Zn, dan Al iaitu dengan bacaan 0.003 mg/L ± 0.001, 0.456 mg/L ± 0.058 , 0.991 mg/L ± 0.308 , 0.438 mg/L ± 0.049 , 2.917 mg/L ± 1.245 dan 2.336 mg/L ± 0.344 . Manakala bagi peratusan taburan batu karang keras, Teluk Ambong menunjukkan peratusan yang lebih tinggi tetapi mempunyai kepelbagaian yang rendah berbanding Teluk Usukan. Analisis statistik T-test menunjukkan terdapat perbezaan yang signifikan ($p < 0.05$) untuk suhu , pH, kekeruhan, DO, koliform najis dan lima elemen logam berat yang dikaji. Ujian korelasi Pearson telah dilakukan untuk menguji hubungan antara parameter kualiti air dengan peratusan taburan karang keras dan hanya parameter suhu yang menunjukkan terdapat hubungan ($p<0.05$). Berdasarkan kajian ini, Teluk Ambong adan Teluk Usukan menunjukkan terdapat kandungan bahan pencemaran seperti koliform najis dan logam berat namun, disebabkan kandungan tersebut tidak terlalu tinggi, kualiti air di kedua-dua teluk tersebut berada di dalam keadaan terkawal.

ABSTRACT

Water quality parameters need to be tested in an area to determine whether the area is contaminated with pollution such as fecal coliform and heavy metals pollution. Some of these pollutants are not toxic but if it exist in excess of that environment will lead harm to human life and other marine organisms such as fish, and coral since all these ecosystem linked with each other very well. A study was carried out to determine and to compare the water quality in Ambong Bay and Usukan Bay, besides to determine and to compare the percentage of hard coral cover between the two bays. It is also were carried out to determine the relationship between the water quality of the two bays and the percentage of hard coral cover. Fecal coliform analyses were done by using Membrane Filter (MF) method while heavy metals were done by Inductively Coupled Plasma-Otomic Emission Spectroscopy (ICP-OES). The results obtained showed that the *in-situ* water parameter for both bays in terms of temperature (°C), pH, turbidity (NFU), salinity (psu), DO (mg/L) shows that it is in the range compared to National Water Quality Standards of Malaysia. Meanwhile for fecal coliform, Ambong Bay showed higher reading compared to Usukan Bay which was 1.44 CFU/100mL ± 1.20 to 4.70 CFU/100mL ± 1.03 respectively. For heavy metal analyses, Usukan Bay shows higher concentrations of Cd, Cr, Cu, Pb, Zn, and Al which were 0.003 mg/L ± 0.001, 0.456 mg/L ± 0.058, 0.991 mg/L ± 0.308, 0.438 mg/L ± 0.049, 2.917 mg/L ± 1.245, and 2.336 mg/L ± 0.344 respectively. While for the percentage of hard coral cover, Ambong Bay shows higher percentage but with less diverse type of coral growth compared to Usukan Bay. The statistical analysis of One way ANOVA showed that there were significance difference ($p<0.05$) for temperature, pH, turbidity, DO, fecal coliform and six heavy metals elements. Pearson's Correlation showed that only temperature shows relationship with the percentage of hard coral cover. From this study, it shows that Ambong Bay and Usukan Bay is contaminated with pollutants such as fecal coliform and heavy metals but the contamination is not too high and still can be acceptable.

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LIST OF UNIT, ABBREVIATION, AND TERMS

mg	Miligram
g	Gram
µm	Micro meter
mm	Millimeters
cm	Centimeters
m	Meters
kg	Kilograms
ml	Milliliters
psu	Practical salinity unit
°C	Degree Celcius
±	Plus Minus (Standard Deviation)
mg/L	Milligram per liter
APHA	American Public Health Association
GESAMP	Groups of Experts of the Scientific Aspects of Environmental Problems
DOE	Department of Environmental
CFU	Colony forming unit
DO	Dissolved oxygen
mF-C	Media fecal coliform

CHAPTER 1

INTRODUCTION

1.1 Water quality

Water is an essential element in the maintenance of all forms of life, and most living organisms can survive only for short periods without water. In other words, water is an essential resource that sustains life on earth; changes in the natural quality and distribution of water have ecological impacts that can sometimes be devastating. By doing water quality assessment, one can know what has been going on with the ocean or any water body such as river or lake. According to Bartram and Ballance (1996), water quality assessment can be defined as the overall process of evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses, particularly uses which may affect human health and the health of the aquatic system itself.

The term water quality describes a broad spectrum of items related to how we identify water concerns and how we collectively address them. Thus, the term water quality can be confusing and mean different things to different people. The most widely used definition of water quality is "the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use" (DOE, 2009). Most of study collected water parameters both physical and biological such as temperature, turbidity, pH, salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), heavy metals, and total coliform bacteria.

Marine pollution can occur if any of these parameters exists in a site excessively, insufficient or not suitable for the organisms living in the area until it causes harm or hazardous effect to the environment or to the living organisms including human. United Nation (UN) defined marine pollution as "The introduction by man, directly, or indirectly, of substances or energy to the marine environment

resulting in deleterious effects such as: hazards to human health, hindrance to marine activities, impairment of the quality of seawater for various uses and reduction of amenities".

There are various sources of marine pollution that are still affecting the ocean from both point and non point sources. Point sources referring to source where it is able to identify where the sources are coming from such as direct outfall through pipes discharging contaminated water from coastal industry, sewage discharges and development sites (Clark, 2001). Meanwhile non point source pollution comes from many diffuse sources. It is usually caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water.

These pollutants include excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas, oil, grease, and toxic chemicals from urban runoff and energy production, sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks, also bacteria and nutrients from livestock, pet wastes, and faulty septic systems. Both point and non point sources gives negative effect to the ocean and causes marine pollution.

In this study, Ambong Bay and Usukan Bay were chosen as these two bays consist of three different major ecosystems which are; coral ecosystem, coral-seagrass ecosystem, and coral-seagrass-mangrove ecosystem. Besides that, the position of these two bays that located in one district which is Kota Belud makes the study easier as it will save more time and energy when sampling were carried out to take water samples and to do general observation. Water quality of Ambong Bay and Usukan Bay were compared to determine whether it falls in the range of National Water Quality Standard of Malaysia.

1.2 Fecal coliform (CFU/mL)

One of the main sources of fecal coliform comes from sewages mainly from residential areas, and also from agricultural activities. Fecal coliform group is a subset of coliforms and it is a more definitive indicator of fecal contamination and also indicator for possible disease hazards in a body of water. Among the fecal coliforms bacteria, *Escherichia coli* are an even more specific indicator for the presence of fecal contamination (Gleeson & Gray, 1997). Fecal coliform bacteria are non disease causing organisms which are found in the intestinal tract of all warm blooded animals that contains large amounts of these organisms.

Most waterborne disease is discharged from as part of body wastes (Benson, 1997). Due to the relatively small numbers of disease causing organisms, it is very difficult to isolate and identify the specific bacteria. Since fecal coliform bacteria originate in the same location, they are used as an indicator of possible disease hazards in a body of water. The presence of very few fecal coliform bacteria would indicate that a water source probably contains no disease producing organisms, while the presence of large numbers of fecal coliform bacteria would indicate a very high probability that the water source could contain disease producing organisms.

For this reason, regulatory agencies with responsibility for protection of public health have established water quality standards which include maximum levels of fecal coliform bacteria.

1.3 Heavy metals

Definitions of the term "heavy metals" may differ based on own understanding for each person (Duffus, 2002). Most often they are referred to as a group of metallic elements having atomic weights between 63 and 200 and specific gravities greater than 4.0; the term excludes alkali metals, alkaline earths, lanthanides and actinides (Kennish, 2002). Heavy metals are natural components of the Earth's crust. However, trace amounts some of them including cobalt, copper and zinc, are essential

micronutrients maintaining critical metabolic functions is needed in marine organisms, while excessive levels can lead to detrimental effects.

In contrast, other heavy metals such as mercury, lead and cadmium have no known vital or beneficial effect on organisms, but may have severe adverse impacts (Aldo, 1984). Sources of heavy metals can from mining, plating, chemical plant and paper making industry if it exists excessively in marine environment and not essential for the organisms.

Heavy metals generally share most of the features of persistent toxic substances, since they are non-degradable, able to bioaccumulate and can produce acute or chronic toxic effects; it will be hazardous to the organisms such as fish, corals and also bivalves. Toxicity and adverse health effects vary widely depending on the type of metal; for instance, while some forms of mercury, even if absorbed in small doses, cause severe damage to the brain and the central nervous system, short-term exposure to nickel does not produce any effect while long-term exposure may cause skin irritation or liver damage.

1.4 Hard corals

Much remains to be discovered about the biodiversity of coral reefs in Malaysia, making this region a priority for coral reef research. Malaysia is estimated to have a total reef area of 4 000 km^2 with predicted 550 species of hard corals in East Malaysia and 367 hard coral species in Peninsular Malaysia (Fenner, 2008). Sabah contains more than 75 % of all Malaysian reefs and Sabah is the north-westernmost area of the Coral Triangle. This study was conducted to determine and to compare the percentage of hard coral cover between Ambong Bay and Usukan Bay of Kota Belud.

Hard corals and soft corals are not easily defined because some corals exist which fall into soft coral category are not actually soft. Corals start out as free-floating larvae that eventually attach itself to a hard surface and become individual coral or also known as polyp. The polyp lives side by side in colonies and is a very

tiny animal (a few millimeters in diameter) looking something like sea anemone. The hard coral for example; Brain coral polyp secretes a limestone skeleton cup around itself and lives inside for protection. When the polyp dies, its skeleton or "house" remains intact to that hard surface such as rock. Basically, the name "hard coral" comes from the skeleton around the polyp and they are also known as reef builders due to its structure. Many identical coral individuals live next to each other, forming a texture, pattern or structure characteristics that are determined by the coral's species such as *Acropora* sp., *Montipora* sp., and *Porites* sp. Besides the skeleton structure and characteristics, another one obvious differences between hard and soft coral is that most hard corals have six or multiple of six for its tentacles (Department of Marine Park Malaysia, 2010).

Same as any other diversity of ecosystem, healthy coral reefs represent the most biologically diverse marine ecosystems, with a greater variety of life forms than any other ecosystems on the planet. However, there are many sources of marine pollution than put coral reefs at threat as they are also known for their great sensitivity.

1.5 Objectives

The objectives of this study are:

1. To determine and to compare the water quality between the Ambong Bay and Usukan Bay of Kota Belud, Sabah.
2. To examine and to compare the percentage of hard coral cover between eight stations and the two bays.
3. To determine the relationships of water quality with the percentage of hard coral cover in the two bays.

1.6 Hypotheses

The hypotheses of this study are:

1. Water qualities between the two bays are within the acceptable range as stated in the National Water Quality Standard of Malaysia.
2. The percentage of hard coral cover in Ambong Bay is better due to the geographical features and ecosystem existed in the area compared to Usukan Bay.

1.7 Significance of study

The study was designed for better understanding the conditions of water quality and its relations toward the hard coral diversity in Ambong Bay and Usukan Bay of Kota Belud, Sabah. Through this study, all the data that is collected will provide baseline data for the management. The current conditions of the two bays need to be acknowledging to prevent any pollution or to cure the pollution that may affect coral reefs health and ecosystem.

Since some of heavy metals are essentials, beneficial and some are toxic, this study helps to examine whether there is water pollution caused by heavy metals by determining its concentration. Metal toxicity also can be affected by some *in-situ* parameters such as depth, temperature, salinity, dissolved oxygen, and conductivity. For fecal coliform, determining the concentrations can assume whether coral communities experiencing anthropogenic stress due to excess nutrient influxes from residential sewage around the study area.

Coral communities are home to so many species that gather around or near it, coral reefs are known as rainforests of the sea. As with rainforests which have many valuable medicinal specimens that have yet to be discovered, so do reefs, which provide this opportunity. Most scientists also claim that corals protect coastline from stormy seas. Tourism purposes and money makers who sponge on divers and snorkellers. Furthermore, this study could help to provide data for future

conservation plans and campaigns by the government or non-government organizations (NGO) in planning a better management plan for the coastal zone of Sabah. Since, Sabah is a tourist hot-spot, the beaches need to be kept clean.

CHAPTER 2

LITERATURE REVIEW

2.1 Fecal coliform (CFU/100mL)

Fecal coliforms are a subset of a larger group of organisms known as coliform bacteria. Coliform bacteria are described as facultative anaerobes (organisms which can survive in the absence of oxygen), gram-negative, non-spore forming, rod-shaped bacteria that ferment lactose (a type of sugar), producing gas and acid within 48 hours when cultured at 35 °C (APHA, 1998). Their lack of ability to form spores makes them more susceptible to destruction by environmental conditions. The fecal coliform group is indicative of organisms originating in the intestinal tract of humans and some animals (Thomann and Mueller, 1987).

While WHO (1993) define the fecal coliform as gram-negative bacteria, rod-shaped bacteria, able to grow with the presence of active surface agent that have characteristics that ferment lactose at 35-37 °C with acid formation, and gas in 24-48 hours. Besides lack of ability to form spores, they also undergo B-galactoside activity. This group includes *E.coli, Enterobacter, Klebsiella* and *Citrobacter* (Medema and Schijven 1995; Ifremer *et al.*, 1992). These bacteria are classically used as indicators of fecal contamination or water pollution from sewage and thus are sanitary significance (Christon, 1997; Gabriel, 1994). The coliform bacteria comprise what is also known as the total coliform group form the primary standards for portable water in North America and indeed in most of the world (Christon, 1997). The bacteria organism is an indicator that there is presence of fecal pathogen (Gleeson & Gray, 1997). The presence of the indicator shows that the area affected is polluted. However the absence of it does not guarantee the environment are free from pollution (Bonde, 1977).

(Gleeson & Grey, 1997) Bacterial indicator organisms are very easy to be isolated, known and are also present in large numbers of pathogens. These organisms have ideal properties that can accumulate pollutants without being destroyed. The organism has a size which can provide sufficient information for analysis, easily sampled and less able to survive in the laboratory (Pipes and Christian, 1982). *E. coli* and *Enterobacter aerogenes* has met these properties and confirmed the coliform group (Benson, 1998). This group has been used to confirm the status of water quality. From Enterobacteriaceae family, only *E. coli* was found in human and mammals (Bonde, 1977).

Sewage continues to be the main source of organic pollution as it three times more than the amount of pollution from industry and animal waste. This is due to high population density, the human waste disposal irregular in slum areas, an increasing level of urbanization, dense settlements that many in along the coast and inadequate facilities for sewage treatment (JAS, 2009). Efficient disinfection of *E. coli* in water by silver was found with high temperature and pH value (Qingyun *et al.,* 2005). In other studies, an indicator was used for solar radiation in disinfection of coliform from contaminated water in rural areas of developing countries (Gondal *et al.,* 2009).

2.1.1 Membrane filter method for fecal coliform measurement

This technique has been used widely throughout the world to determine microbiology characteristics for water. Water sample will be filtered by using grid-membrane filter to filter the bacteria and then will be transferred into media that was prepared. Media for fecal coliform contains nutrient that encourage growth of colonies of bacteria (Prescott and Fricker, 1999). Plate counting method has been used for decades to determine water quality for fecal coliform parameter (Pipes and Christian, 1982). The presence of fecal coliform bacteria on the media will shows that the water body might undergo pollution based on the value present.

This technique was chosen as there are lots of benefits that can be gain which are 1) easy to obtain good result, 2) time saving method, 3) able to conduct the experiment in the field work (Prescott and Fricker, 1999). However, there are

also few gaps for this method which are 1) high turbidity of water will causes some limitation during water sample collection, 2) excessive growth in high population bacteria environment, 3) some other elements such as metals and phenol can be absorbed by filter paper will reduce the growth of bacteria needed for counting (Prescott and Fricker, 1999).

2.1.2 Different method used for fecal coliform determination

Besides membrane filter method, there are other techniques that can be used to determine fecal coliform presence in water body. Most Probable Number (MPN) method has been introduced by McCardy (1995) based on dilution principal (Mara and Oragui, 1983). In this method, small quantity of water sample was inoculated in liquid medium and based on assumption where each medium will received one inoculum that contain one or more organisms, which will cause changes in medium characteristics that was used (Gleeson and Gray, 1997). The positive and negative result from the dilution will then used for statistical assumption or also known as most probable number that will be counted by using table that was introduced by McCardy (1995), (Gleeson and Gray, 1997).

Presence–Absence (P–A) technique was developed by Clark (2001) to produce a better economically method for coliform analysis. This technique is an improvisation from MPN where water samples were kept in a cultured bottle that contains P-A media (Gleeson & Gray, 1997). P-A test is based on assumption where there is no fecal coliform exists in 100 mL drinking water (Prescott and Fricker, 1999). Nowadays, this technique has been established by USA as standard method (APHA, 1992) for water treatment plant.

Rapid methods were used in an emergency situation to determine and to test water quality. However, this method was not sensitive enough for drinking water test. It requires specific chemicals and the technique is not suitable for daily water analysis as routine (APHA, 1992). This technique was developed by Reasoner *et al.* (1980) to test the presence of fecal coliform in water body. This test used only a small portion of lactose media (m-7-hr-FC Medium) and depends on the sensitivity of pH indicator. After 7 hours fermentation at 44 °C, the results show fecal coliform

presence in a yellow color. This procedure shows that rapid methods are only suitable to test water at the surface and treatment water that does not contain chlorine but not preferable for sea water.

2.2 Heavy metals

Heavy metals are metal that have density more than 5 gcm^{-3} and atom number more than 20 (Aldo, 1984). Examples of heavy metals are lead (Pb), copper (Cu), cadmium (Cd), zinc (Zn), nickel (Ni), chromium (Cr), and mercury (Hg). In normal condition, heavy metals exist in low concentration that categorized as trace metals and cause hazardous effects to plants, animals and human in high concentration (Jopony, 2001). Heavy metal pollution assessment in marine ecosystem has usually involved analysis in several species of marine fauna (molluscs, barnacles, mussel, and oysters), sediments and water (Esslemont *et al.,* 2000; David, 2003; Usero *et al.,* 2005; Edinger *et al.*, 2008).

2.2.1 Heavy metal as micronutrients

Some heavy metal such as Zn and Cu are essentials for living organisms in low concentration and known as micronutrient (Zubaidah, 1992). Without the presence of this micronutrients metals in certain quantity will inhibit any processes including growth or feeding behavior for the organisms involves (Nriagu, 1992). A nutrient is considered necessary when the absence or lack of the nutrient intakes in the diet will causes clinical symptoms and can be overcome by consume more nutrients required. Until now, there are numerous experiments that has been conducted based on animals such as fish, clams, corals and some of the results shows the same results as in human (Zubaidah, 1992). This indicates that the lack of nutrients intake may also affect human's health.

Copper (Cu) is one of the micronutrient that is needed for birds and mammals (Novotny, 1995). This metal can be found in enzymes that involves with body metabolism. The effect of copper poisonous was affected by the low intakes of zinc and sulphide (Sarkar *et al.*, 2002). Quantity of Cu required in the body should be low as it will help in the process of formation of hemoglobin, and red blood cells. It also

will function in protein metabolism and wound treatment. Cu works together with vitamin C to form elastine (main component in muscle) in the body (WHO, 1993).

Zinc (Zn) is required in animal and plants and most likely can be found in normal concentration in tissues and enzymes of the organisms such as anhydrase carbonic, RNA, and DNA polymerase (Underwood, 1977). Besides that, it also can be used as substances needed in medicines for wound treatment (Waldichuck, 1974). Zinc can be found in foods and the main sources of zinc are from seafood (Reily, 1980). Pollution of water sources such as ocean, river, and lakes by heavy metals may increase the excessive intakes of zinc by human either directly by drinking the water or by eating seafood.

2.2.2 Heavy metals that are toxic

Meanwhile, there are also some of the heavy metals that are not categorized as micronutrient. Hence, the amount of this metal is not necessarily needed in an organism especially in high concentration as it will cause hazardous effect (Kretchmer, 1997).

Cadmium (Cd) main exposure to public is from food intakes where Cd can be diluted into the organic acid. It is one of the most dangerous polluting metals in food and drinks because it contains of high toxicity. Cadmium has been widely spread into the environment and used in industrial activity (Reiley, 1980). Cd plays an important role in controlling blood pressure. However, according to Suriah Abdul Rahman (1993), natural concentration of cadmium is not hazardous to organism health.

Lead (Pb) concentration in natural environment that is not polluted should be low. In industrial areas, Pb will be released into the environment including water, air, and soil hence, causing pollution (O'Brien *et al.*, 1980). Lead is essential in balancing micronutrient inside the body. However, same as cadmium, this metals also has toxic characteristics but not as hazardous as cadmium and mercury. It only causes toxicity when there are excessive intakes into the body through food or breathing by inhaling polluted air.

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