UNIVERSITI PUTRA MALAYSIA

DETERMINATION OF SEAWATER QUALITY AT TANJUNG BATU, BINTULU

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DETERMINATION OF SEAWATER QUALITY AT TANJUNG BATU, BINTULU.

By

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A Project Report Submitted in Partial Fulfillment of the Requirement for the Degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences
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I DEDICATE THIS THESIS TO MY
BELOVED PARENTS
MR. GOVAL KRISHNAN AND MRS. ARTHEY,
MY SIBLINGS
AND ALL THE PEOPLE CLOSE TO MY HEART
FOR BEING THE REASON FOR ME TO PURSUE
HIGHER EDUCATION AND EXCEL IN LIFE.

ABSTRACT

The determination of the seawater quality at Tanjung Batu beach was done. The objectives of this study are to monitor the water quality parameters (DO, temperature, pH, turbidity, BOD_5 & TSS) and checking the compliance of the above mentioned parameters to the standards published by the Department of Environment (DOE), Malaysia. The analysis procedure used for this study is according to the standard methods published by APHA, 1995. Sampling was done from 15 September 2006 till 10 November 2006. For all 3 sampling points, the DO level showed compliance to the ASEAN Marine Water Quality Criteria recommendation of a minimum of 4 mg/L. The temperature reading for all points was in the normal range for the tropical seawater conditions of Malaysia at about 28 °C to 32 °C. The pH level at all 3 sampling points are categorized into Class 1 of the Interim National Water Quality Standards for Malaysia. The turbidity level for all sampling points was in the Class II B of the Interim National Water Quality Standards for Malaysia. The BOD_5 analysis revealed that all 3 sampling points are categorized into Class V of the Interim National Water Quality Standards for Malaysia. The waters of Tanjung Batu do not meet the required standards published by the DOE of Malaysia for the TSS and BOD_5 parameters.

ABSTRAK

Kajian bagi penentuan kualiti air laut di pantai Tanjung Batu telah dijalankan. Objektif kajian ini adalah untuk mengkaji parameter kualiti air (oksigen terlarut, suhu, pH, kekeruhan, permintaan oksigen biokimia dan pepejal terampai) dan membuat semakan tentang parameter tersebut dengan piawaian yang dikeluarkan oleh Jabatan Alam Sekitar (JAS), Malaysia. Prosedur analisis yang digunakan untuk kajian ini adalah berdasarkan kaedah piawai yang dikeluarkan oleh APHA, 1995. Pengambilan sampel telah dijalankan dari 15 September 2006 hingga 10 November 2006. Bagi ketiga-tiga lokasi persampelan, tahap oksigen terlarut (DO) menunjukkan nilai yang baik daripada nilai minimum 4 mg/L mengikut Kriteria Kualiti Air Marin ASEAN. Catatan suhu air bagi semua lokasi adalah dalam julat normal bagi perairan tropika di Malaysia iaitu di antara 28 ^{o}C hingga 32 ^{o}C. Nilai pH adalah diklasifikasikan kepada piawaian Kelas 1 dalam Piawaian Kualiti Air Kebangsaan Malaysia. Tahap kekeruhan air di kesemua lokasi persampelan adalah tergolong dalam Kelas II B, Standard Kualiti Air Kebangsaan bagi Malaysia. Analisis BOD_5 menunjukkan bahawa ketiga-tiga lokasi persampelan dikategorikan dalam Kelas V berdasarkan Piawaian Kualiti Air Kebangsaan. Perairan Tanjung Batu tidak menepati piawaian yang dikeluarkan oleh JAS Malaysia bagi parameter TSS dan BOD_5.

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The most important people in my life, my parents, Mr. Goval Krishnan and Mrs. Arthey were the motivators and mentors since birth for helping me to achieve till I received my varsity education, no words can describe my gratitude and love for them.

I certify that this research project report entitled "Determination of seawater quality at Tanjung Batu, Bintulu" has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This research is carried out to determine the status of water quality at Tanjung Batu, Bintulu (N 03° 12' 35.3", E 113° 02' 38.9") and to monitor the pollution level in that area. The water quality level can be known through the measurement of physical, biological and chemical qualities of the seawater. The parameters include biological oxygen demand (BOD), dissolved oxygen (DO), pH, temperature, turbidity and total suspended solids (TSS). This beach site is chosen because it is frequented by the Bintulu community as a spot for picnics, jogging, fishing and swimming. Most importantly, this site is situated not far from the Tanjung Kidurong industrial area along the coastal line of Bintulu. The industrial area houses various factories including big projects such as a liquid natural gas processing facility and a petrochemical complex. Figure 1 showed the location of study area. Effluents discharged from this industrial area can contribute to pollution of the coastal waters which endanger the aquatic organisms and people who frequent the nearby Tanjung Batu beach. The murky river discharge from the Batang Kemena River also contributes to the pollution of the sea. As Bintulu is quickly developing into an industrial city, close monitoring of the environment has to be done as Bintulu is a coastal town and all the effluents are discharged to the seawater.

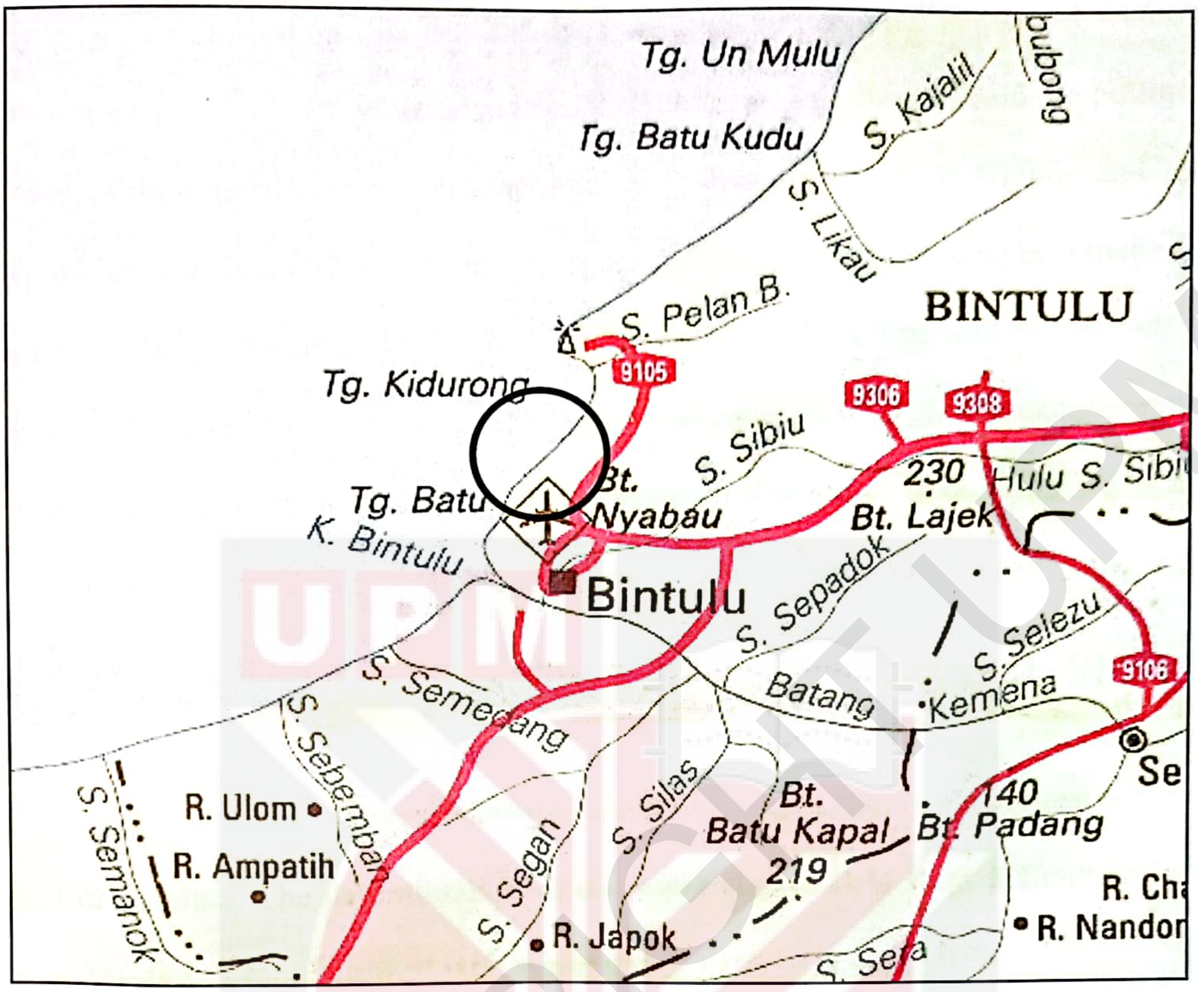

Figure 1: Location of the study area

Coastal waters, estuaries and the open ocean have been the natural recipients of most of man's liquid-borne waste materials, as well as some of the atmospheric-borne and solid wastes. They will continue to be the ultimate recipient of the residual, non-reclaimable fraction of the wastes from man's activities. Rather than simply encouraging greater disposal of wastes to the ocean, we must improve our understanding of the processes of interaction between the wastes and the environment and the characteristics of each. Significant and long term deleterious effects can then be reduced substantially if adequate attention is given to water management systems that results in concentrations and time of contact that maintain and enhance the ecosystem (NAS, 1970)

It is well known that outfall pipes are used to issue the depurated water of cities at a sufficiently long distance from the shoreline, in order to avoid the polluting action of the outfall, the sea currents and the natural processes of dilution and self-depuration which could cause damage to the coastal cities and shorelines which need to be preserved (Roberts, 1980). If the wastewater has been opportunely treated, the quality of the environment, i.e. the sea, will be acceptable, with the exception of a zone very close to the discharge. The ecosystem will continue to be protected against risks and the specific uses of the zone will also be preserved (i.e., tourism, water-skiing, swimming, mussel farms, etc.).

Quality standards are defined in order to preserve the beneficial use of the sea and its product. The determination of the water standards is very difficult and their monitoring is strongly linked with water use.

1.2 Objectives

1. To monitor the water quality parameters (DO, temperature, pH, turbidity, BOD_5 & TSS).

2. To compare the above parameters with water quality standards published by the Department of Environment, Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Pollution

Water pollution is a large set of adverse effects upon water bodies such as lakes, rivers, oceans, and groundwater caused by human activities. Although natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water, these are not deemed to be pollution. Water pollution has many causes and characteristics. Increases in nutrient loading may lead to eutrophication. Organic wastes such as sewage impose high oxygen demands on the receiving water leading to oxygen depletion with potentially severe impacts on the whole eco-system. Industries discharge a variety of pollutants in their wastewater including heavy metals, organic toxins, oils, nutrients, and solids. Discharges can also have thermal effects, especially those from power stations, and these too reduce the available oxygen. Silt-bearing runoff from many activities including construction sites, deforestation and agriculture can inhibit the penetration of sunlight through the water column, restricting photosynthesis and causing blanketing of the lake or river bed, in turn damaging ecological systems. Pollutants in water include a wide spectrum of chemicals, pathogens, and physical chemistry or sensory changes (Pink, 2006).

2.2 Point and Non-point Sources

Two types of water pollutants exist; point source and non-point source. Point sources of pollution occur when harmful substances are emitted directly into a body of water. The oil spill from an oil drilling rig best illustrates point source water pollution. A non-point source delivers pollutants indirectly through environmental changes. An example of this type of water pollution is when fertilizer from a field is carried into a stream by rain, in the form of run-off which in turn affects aquatic life. The technology exists for point sources of pollution to be monitored and regulated, although political factors may complicate matters. Non-point sources are much more difficult to control. Pollution arising from non-point sources accounts for a majority of the contaminants in streams and lakes (EPA, 1996).

2.3 Biological Oxygen Demand (BOD_5)

BOD_5 is the amount of oxygen consumed by microorganisms during the oxidation of wastewater for 5 days at 20°C. A 5-day BOD standard value is used to clear up wastewater, to evaluate treatment effectiveness by measuring the permanent oxygen demand in the effluent, and to determine the amount of organic pollution in surface water (Viessman *et.al.*, 1998). It can be used to infer the general quality of the water and its degree of pollution and it is used in water quality management and assessment, ecology and environmental science. BOD is not an accurate quantitative test and should be considered as providing an indicator of the quality of a water body.

BOD is a measure of the quantity of organic material in the water and, therefore, the water's potential for becoming depleted in dissolved oxygen. Since bacteria decompose organic material, water with a high BOD level also generally has a high bacteria count. Although some waters are naturally organic rich, a high BOD often indicates pollution (DEP, 2007). BOD has been widely used as a parameter to assess water pollution where BOD will increase in polluted waters (Kumar, 1996).

2.4 Dissolved Oxygen (DO)

Gas molecules in the atmosphere diffuse or move from an area of high concentration to an area of low concentration. In the same way, oxygen molecules diffuse through the air-water interface into the water where they become dissolved. At the same time oxygen is diffusing in the opposite direction, but when the volume of oxygen diffusing in either direction is equal, then the water is said to be in equilibrium and is therefore saturated with oxygen (Gray, 1999).

The solubility of oxygen depends on three factors, the pressure, temperature and the concentration of dissolved minerals in the water. An increase in the concentration of dissolved salts lessens the saturation concentration of oxygen which is why seawater has lower saturation levels than freshwater at the same temperature and pressure (Gray, 1999).

Dissolved oxygen is an essential indicator in assessing an estuary's health. Oxygen enters the water from the atmosphere and through aquatic plant and phytoplankton photosynthesis. The oxygen is then available for aquatic organisms to utilize in basic metabolic processes. Most plants and animals can grow and do well when the dissolved oxygen level exceeds 5 mg/l. A drop in the level to 3-5 mg/l causes organisms to become stressed. Levels below 3 mg/l cause death in many species. Oxygen is used up during the decomposition of organic material. An overload of nutrients from human activities causes overgrowth of phytoplankton. The phytoplanktons ultimately die and fall to the bottom where they decompose, using up oxygen (DEP, 2007).

2.5 Turbidity

Turbidity is a cloudiness or haziness of water (or other fluid) caused by individual particles that are too small to be seen without a magnification, thus being much like smoke in air. Fluids can contain suspended solid matter consisting of particles of many different sizes (see suspended solids). While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of a container if a liquid sample is left to stand (the settleable solids), very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid. Measurement of turbidity is a key test of water quality.

A property of the particles — that they will scatter a light beam focused on them — is considered a more meaningful measure of turbidity in water. Turbidity measured this way uses an instrument called a nephelometer with the detector setup to the side of the light beam. More light reaches the detector if there are lots of small particles scattering the source beam than if there are few. The units of turbidity from a calibrated nephelometer are called Nephelometric Turbidity Units **(NTU)**. To some extent, how much light reflects for a given amount of particulates is dependent upon properties of the particles like their shape, color, and reflectivity. For this reason (and the reason that heavier particles settle quickly and do not contribute to a turbidity reading), a correlation between turbidity and TSS is somewhat unique for each location or situation (Gray, 1999).

Turbidity is a measure of the suspended particles in water. Several types of material cause water turbidity, these include: silt or soil particles, tiny floating organisms, and fragments of dead plants. Human activities can be the cause of turbidity as well. Runoff from farm fields, storm water from construction sites and urban areas, shoreline erosion and heavy boat traffic all contribute to high levels of turbidity in natural waters. These high levels can greatly diminish the health and productivity of estuarine ecosystems. Turbid waters decrease light penetration, thereby reducing the ability of aquatic plants to grow. Many animals living in estuaries feed by filtering the water; suspended material in large quantities can foul their filter-feeding system. Particles may also accumulate on the gills of fish and inhibit breathing (DEP, 2007).

2.6 Total Suspended Solids (TSS)

Total suspended solids is a water quality measurement usually abbreviated TSS. This parameter was at one time called non-filterable residue (NFR), a term that refers to the identical measurement: the dry-weight of particles trapped by a filter, typically of a specified pore size.

TSS of a water sample is determined by pouring a carefully measured volume of water (typically one liter; but less if the particulate density is high, or as much as two or three liters for very clean water) through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically milligrams per liter or mg/l) (Gray, 1999).

CHAPTER 3

METHODOLOGY

3.1 Sampling Points and Sampling Duration

Three sampling points was chosen along the Tanjung Batu beach. Sampling was done from 15 September 2006 till 10 November 2006, once a fortnight. A total of five sampling was done.

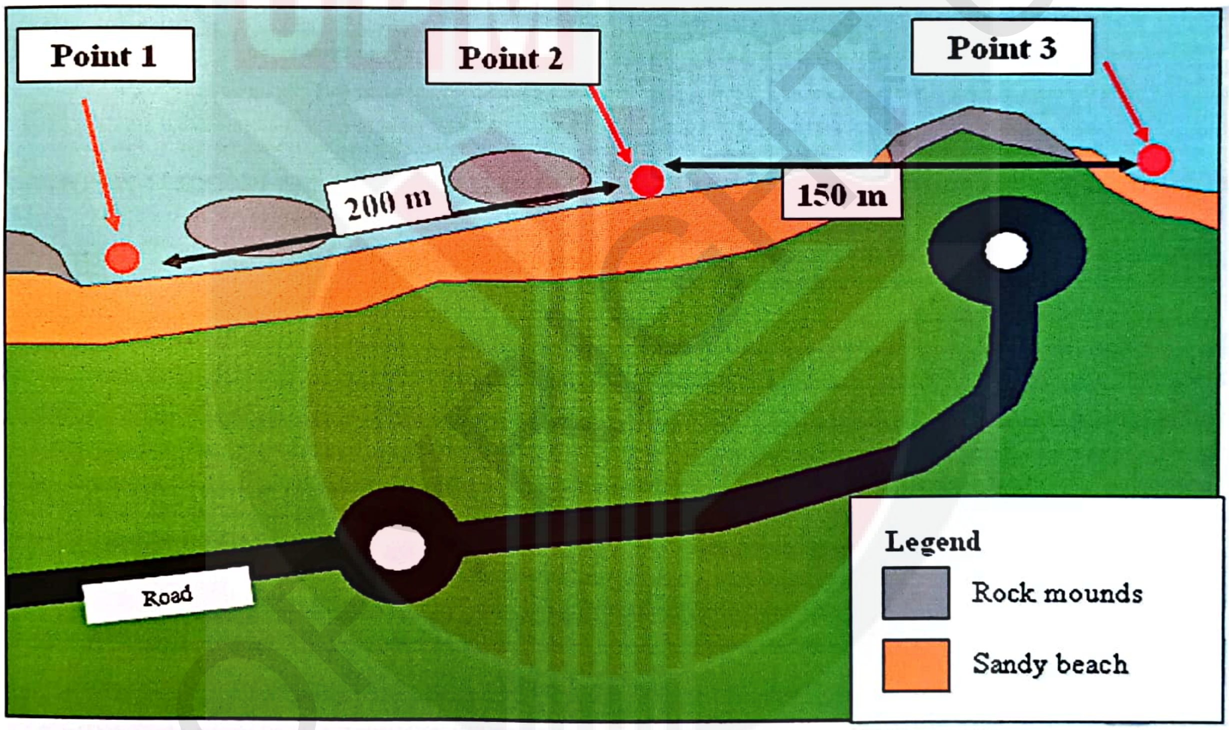

Figure 2 : Schematic map of Tanjung Batu beach

3.2 Cleaning of Apparatus

All sampling bottles and laboratory apparatus are cleansed by immersing in 3% Hydrochloric acid and rinsed with distilled water, later it is dried. For the laboratory apparatus, after rinsing with distilled water, it is dried in the cabinet dryer at the temperature of 60 to 67°C. This is to ensure that the apparatus is completely dry.

Before usage, it must be removed from the dryer and cooled to room temperature. This procedure is done after every analysis done in the laboratory.

3.3 Sampling Techniques and Storage

All the sampling technique and storage that is carried out in this research is based on the standard methods published by APHA (1995). In situ measurement of DO, temperature, pH and turbidity is done using the YSI DO 200, HANNA pH meter and the Hach Turbidimeter respectively. Other parameters (BOD_5 and TSS) are analyzed in the laboratory.

Seawater samples are taken from the surface by using PTE bottles, at a water depth of 1 m at each sampling point and brought back to the laboratory. Samples are taken at three different times on a day; morning (9 am), afternoon (1 pm) and evening (5pm). For BOD_5 and TSS, laboratory analysis is carried out immediately after returning from the sampling site.

3.4 Analytical Method

For physical analysis of water samples, there are a lot of methods that can be applied for the parameters that are being monitored. For this research, the standard methods published by the American Public Health Association (APHA, 1995) were used.

3.4.1 Determination of BOD_5

Determination of BOD_5 is based on the APHA 5210B (1995) method. This analysis is carried out in the lab immediately after returning from the sampling site. A 300 ml capacity BOD bottle is partially filled with dilution water and a measured water sample of 20 ml is pipetted into the BOD bottle. Then it is topped up with more dilution water till full and the DO content is measured with a DO meter. The BOD bottle is then kept in an incubator at the temperature of 20°C for 5 days. The BOD_5 value can be calculated by using the following formula:

$$BOD_5\ (mg/L) = \frac{D_1 - D_2}{P}$$

Where

D_1 = DO of diluted sample immediately after preparation, mg/L,

D_2 = DO of diluted sample after 5 d incubation at 20°C, mg/L,

P = decimal volumetric fraction of sample used.

3.4.2 Determination of Total Suspended Solids (TSS)

The method used for this analysis is the 2450D standard method (APHA, 1995). A measured volume of well-mixed sample is filtered through the 0.45µm cellulose nitrate membrane filter, which is weighed prior to the filtration. After filtration, the membrane filter with the suspended solids is placed into a Petri dish and is dried in the oven at the temperature of 103°C - 105° for 1 hour. The membrane filter is cooled in a desiccator to balance the temperature and weighed. The cycle of drying, cooling, desiccating, and weighing is repeated until a constant weight is obtained. The TSS value can be determined with the following formula:

$$TSS,\ mg/L = \frac{(A - B) \times 1000}{\text{Sample volume, mL}}$$

Where

A = weight of filter + dried residue, mg

B = weight of filter, mg

CHAPTER 4

RESULTS

4.1 Dissolved Oxygen

Table 1: Dissolved Oxygen Concentration at 3 Sampling Points (MORNING)

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1 (mg/L)	6.95	7.21	7.02	7.14	7.41
Point 2 (mg/L)	6.99	7.03	6.94	7.23	7.09
Point 3 (mg/L)	7.01	7.11	7.35	7.34	7.24

Table 2: Dissolved Oxygen Concentration at 3 Sampling Points (AFTERNOON)

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1 (mg/L)	6.81	6.88	6.85	6.93	6.94
Point 2 (mg/L)	6.89	6.91	6.8	6.89	7.04
Point 3 (mg/L)	6.76	7.15	6.86	6.87	7.27

Table 3: Dissolved Oxygen Concentration at 3 Sampling Points (EVENING)

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1 (mg/L)	7.05	6.93	6.93	7.18	7.02
Point 2 (mg/L)	7.13	6.91	6.86	7.16	6.99
Point 3 (mg/L)	6.98	7.05	7.02	7.23	7.13

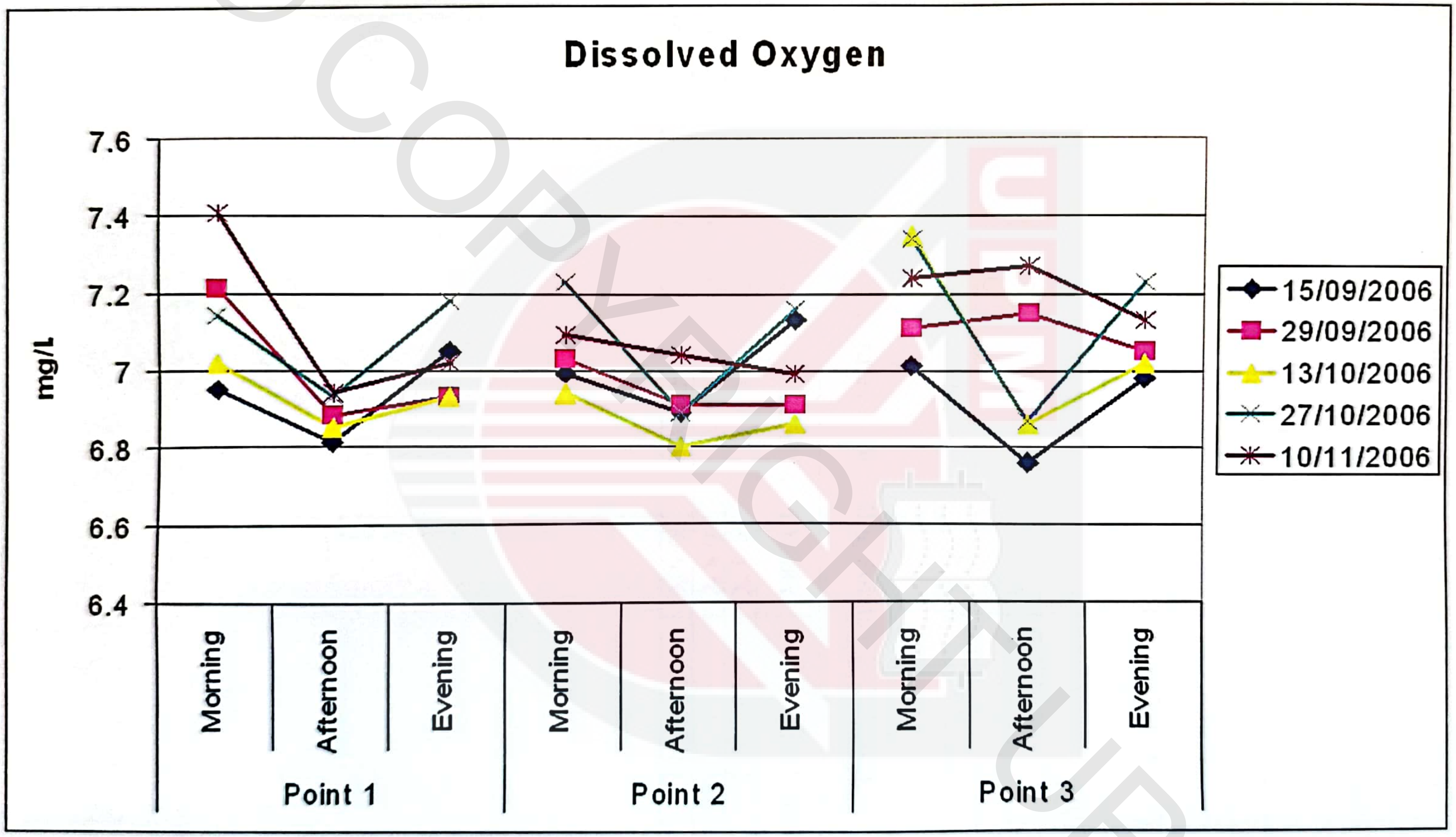

Figure 3: Changes of Dissolved Oxygen during the Study Period

4.2 Temperature

Table 4: Surface Water Temperature at 3 Sampling Points (MORNING).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	28.9 °C	29.2 °C	29.9 °C	30.3 °C	30.3 °C
Point 2	29.1 °C	29.5 °C	30.0 °C	30.4 °C	30.4 °C
Point 3	29.5 °C	29.7 °C	30.2 °C	30.6 °C	30.5 °C

Table 5: Surface Water Temperature at 3 Sampling Points (AFTERNOON).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	30.1 °C	30.5 °C	31.6 °C	31.6 °C	31.6 °C
Point 2	30.3 °C	30.7 °C	32.1 °C	31.7 °C	32.0 °C
Point 3	30.4 °C	31.0 °C	31.9 °C	31.9 °C	32.3 °C

Table 6: Surface Water Temperature at 3 Sampling Points (EVENING).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	28.8 °C	30.9 °C	30.8 °C	30.1 °C	30.6 °C
Point 2	28.6 °C	30.8 °C	30.8 °C	30.0 °C	30.5 °C
Point 3	28.5 °C	30.6 °C	30.6 °C	30.0 °C	30.3 °C

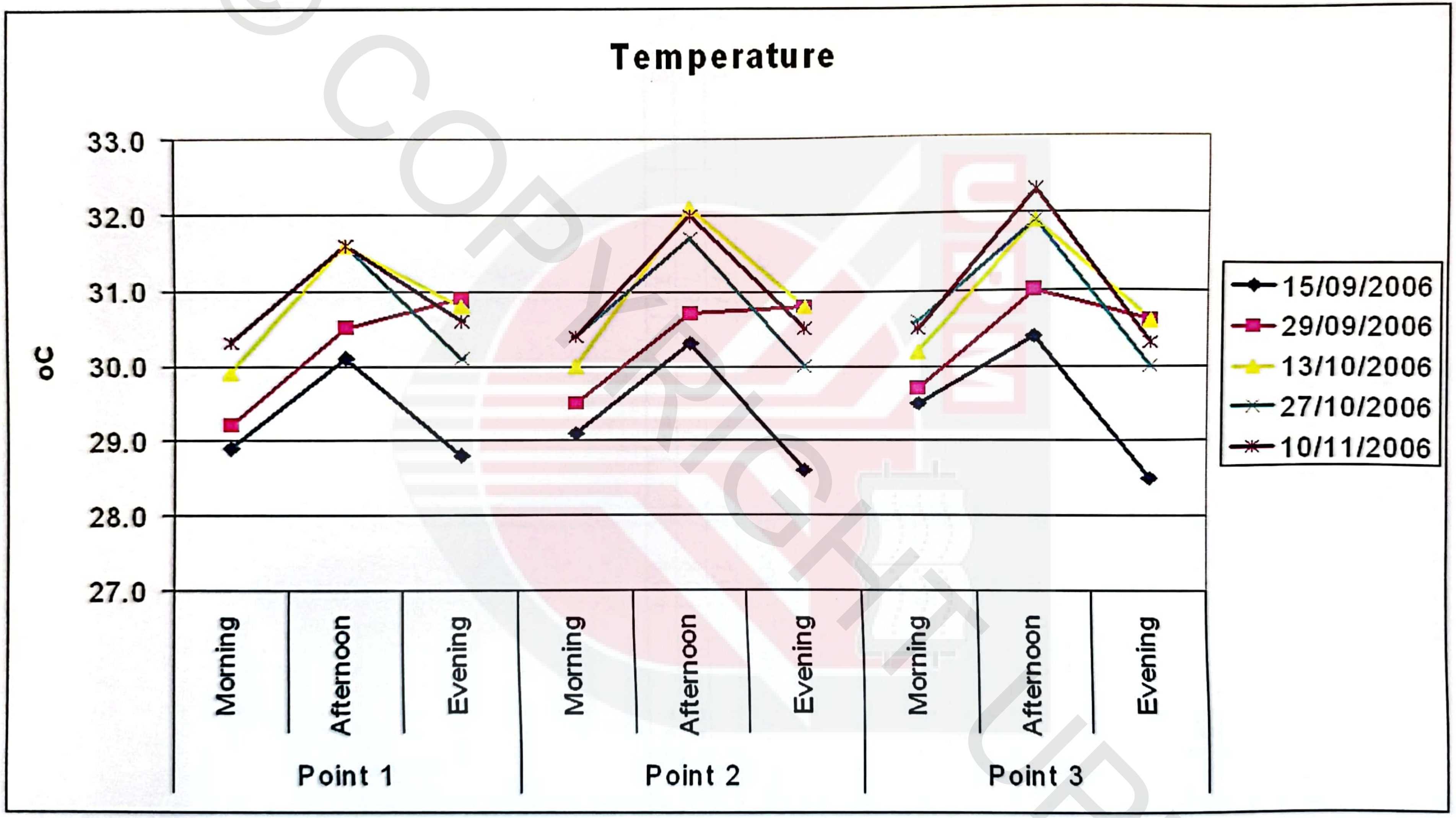

Figure 4: Changes of Temperature during the Study Period.

4.3 pH

Table 7: pH at 3 Sampling Points (MORNING).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	7.9	7.9	7.9	7.9	7.9
Point 2	8.0	7.9	7.9	8.0	7.9
Point 3	8.0	8.0	8.0	7.9	7.9

Table 8: pH at 3 Sampling Points (AFTERNOON).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	7.9	7.9	7.9	7.9	7.9
Point 2	8.0	7.9	7.9	7.9	8.0
Point 3	7.9	8.0	8.0	8.0	8.0

Table 9: pH at 3 Sampling Points (EVENING).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	7.9	7.9	7.9	7.9	7.9
Point 2	7.9	7.9	8.0	7.9	7.9
Point 3	7.9	7.9	8.0	7.9	8.0

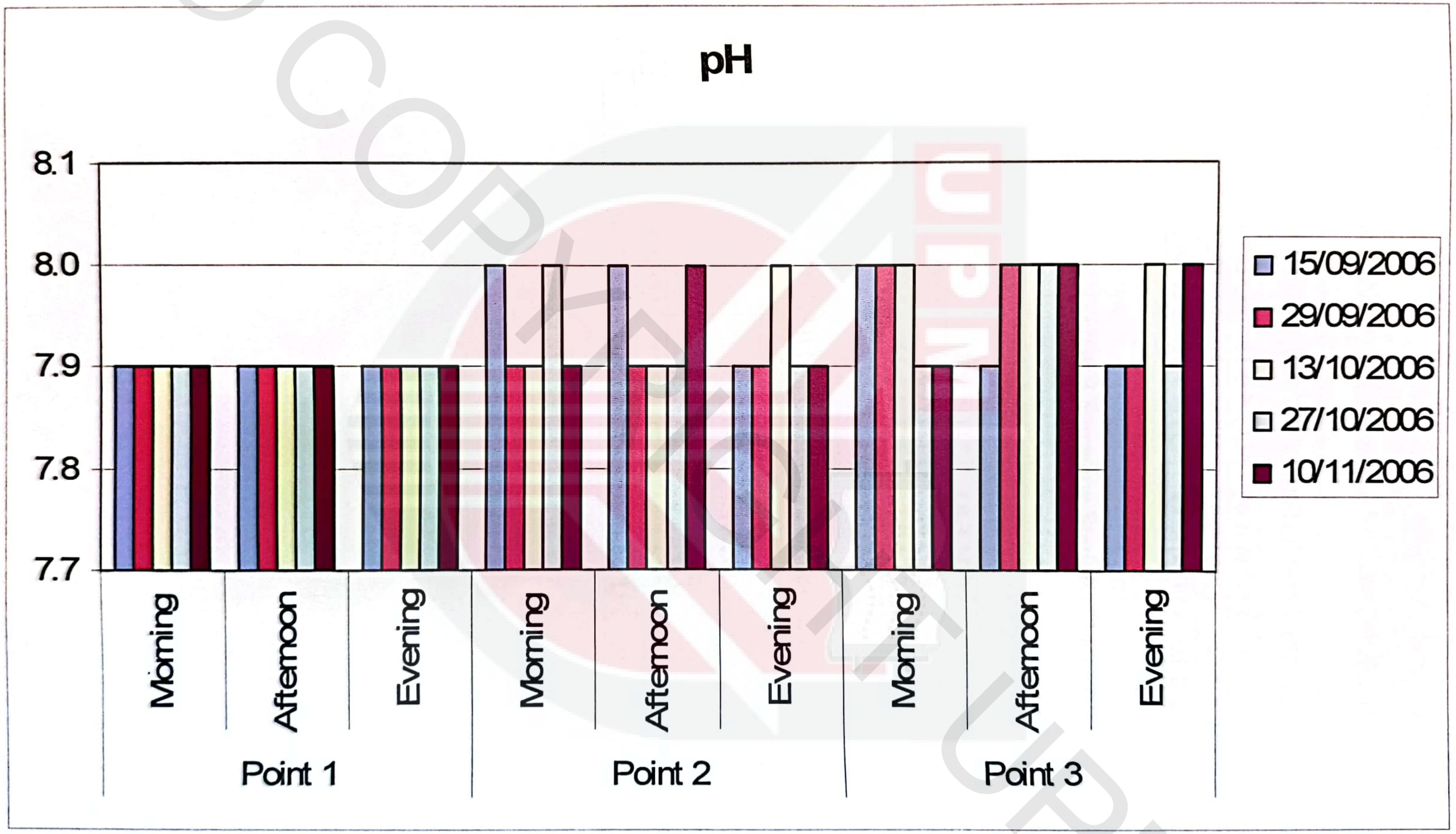

Figure 5: Changes of pH during the Study Period.

4.4 Turbidity

Table 10: Turbidity units (NTU) at 3 Sampling Stations (MORNING).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	26.4 NTU	41.0 NTU	36.6 NTU	67.4 NTU	55.1 NTU
Point 2	24.8 NTU	29.6 NTU	18.0 NTU	43.1 NTU	29.5 NTU
Point 3	29.2 NTU	41.4 NTU	19.1 NTU	61.8 NTU	12.9 NTU

Table 11: Turbidity units (NTU) at 3 Sampling Stations (AFTERNOON).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	26.9 NTU	57.0 NTU	18.3 NTU	53.9 NTU	44.0 NTU
Point 2	30.9 NTU	45.6 NTU	22.8 NTU	29.2 NTU	33.4 NTU
Point 3	40.7 NTU	55.0 NTU	13.0 NTU	36.5 NTU	17.2 NTU

Table 12: Turbidity units (NTU) at 3 Sampling Stations (EVENING).

Sampling Point	15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	53.2 NTU	19.8 NTU	25.1 NTU	47.2 NTU	45.4 NTU
Point 2	43.8 NTU	17.3 NTU	18.3 NTU	32.1 NTU	37.3 NTU
Point 3	44.6 NTU	19.3 NTU	17.6 NTU	38.0 NTU	22.2 NTU

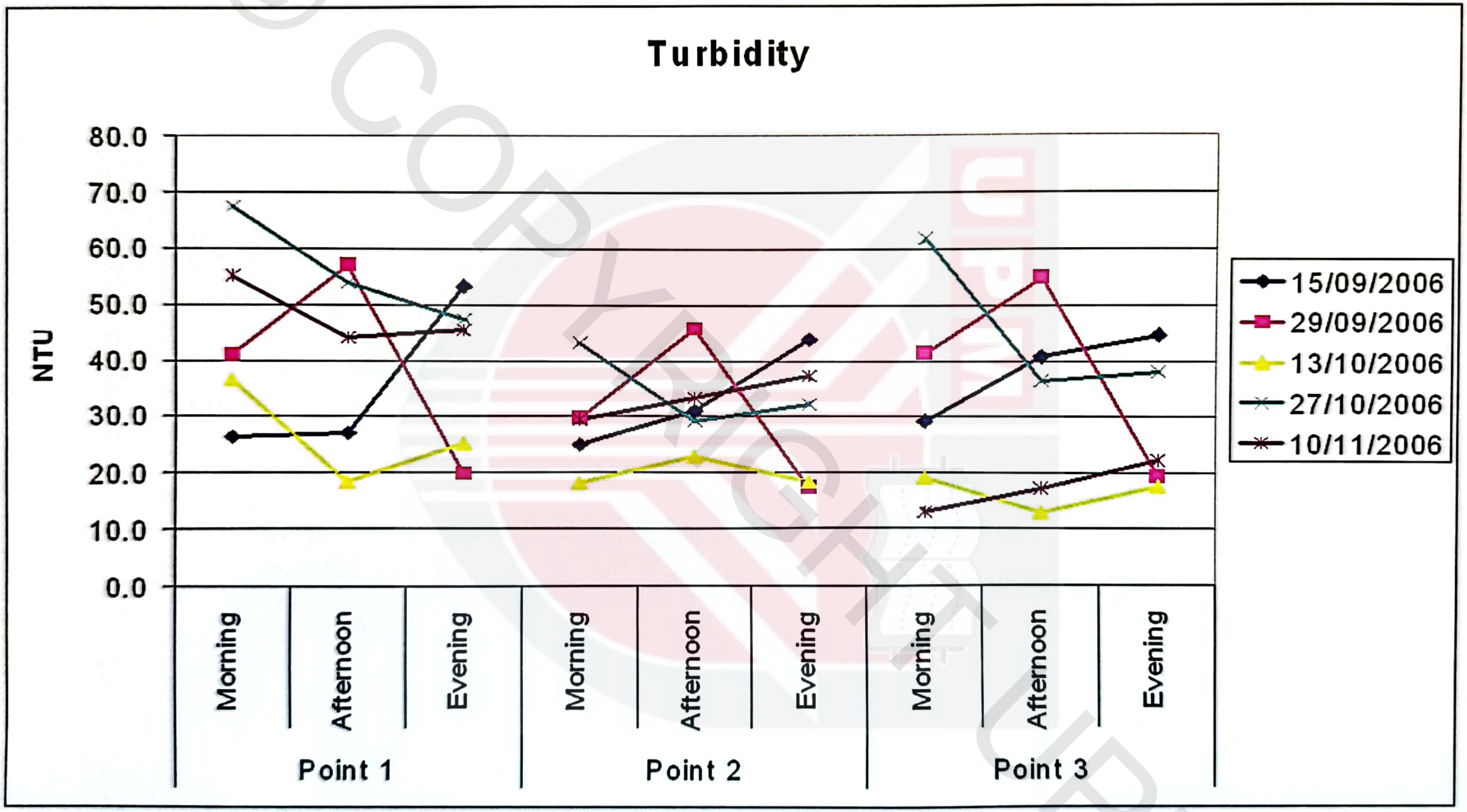

Figure 6: Changes of Turbidity during the Study Period.

4.5 Biological Oxygen Demand, BOD5

Table 13: Biological Oxygen Demand at 3 Sampling Points during Study Period.

Sampling Time		15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	M (mg/L)	36.67	15.61	42.57	21.52	39.39
	A (mg/L)	44.54	32.27	45.91	26.97	35.54
	E (mg/L)	39.84	21.36	38.94	23.33	35.45
Point 2	M (mg/L)	42.88	16.97	43.64	25	33.78
	A (mg/L)	43.64	30.15	45.75	17.88	30
	E (mg/L)	44.69	25.91	40.91	23.94	33.48
Point 3	M (mg/L)	40.30	21.06	43.64	29.4	35
	A (mg/L)	43.94	27.73	47.12	35.45	36.06
	E (mg/L)	42.57	24.85	42.27	31.67	31.51

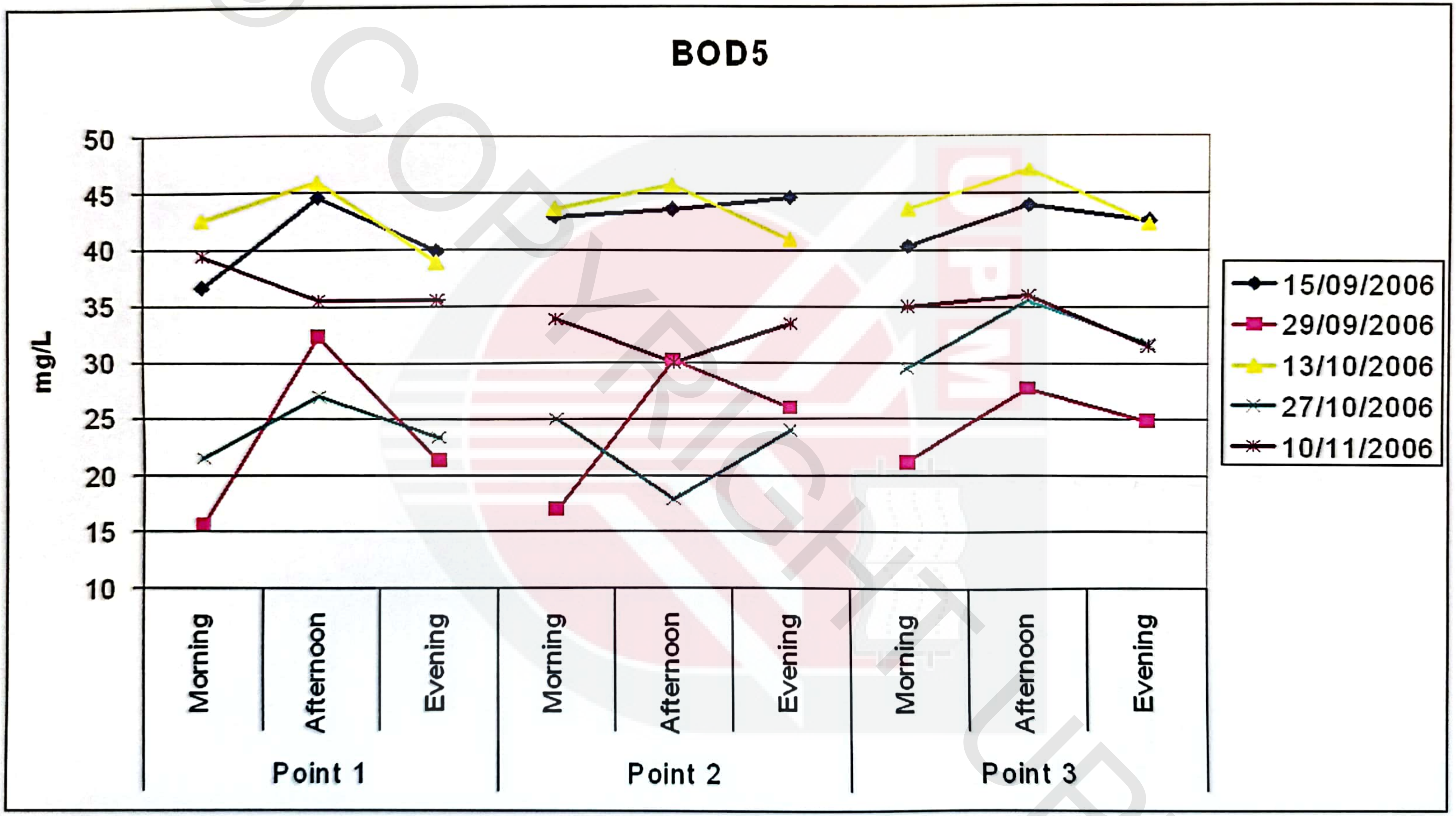

Figure 7: Changes in Biological Oxygen Demand during the Study Period.

4.6 Total Suspended Solids (TSS)

Table 14: Total Suspended Solids at 3 Sampling Points during Study Period.

Sampling Time		15/09/2006	29/09/2006	13/10/2006	27/10/2006	10/11/2006
Point 1	M (mg/L)	9.9	8	4	7	7
	A (mg/L)	6.5	11	6	6	10
	E (mg/L)	3.3	6	5	5	6
Point 2	M (mg/L)	5.9	5	6	15	8
	A (mg/L)	3.1	11	6	3	8
	E (mg/L)	3.5	5	10	6	2
Point 3	M (mg/L)	4.8	9	4	11	7
	A (mg/L)	6.8	10	7	6	4
	E (mg/L)	4.2	5	9	6	5

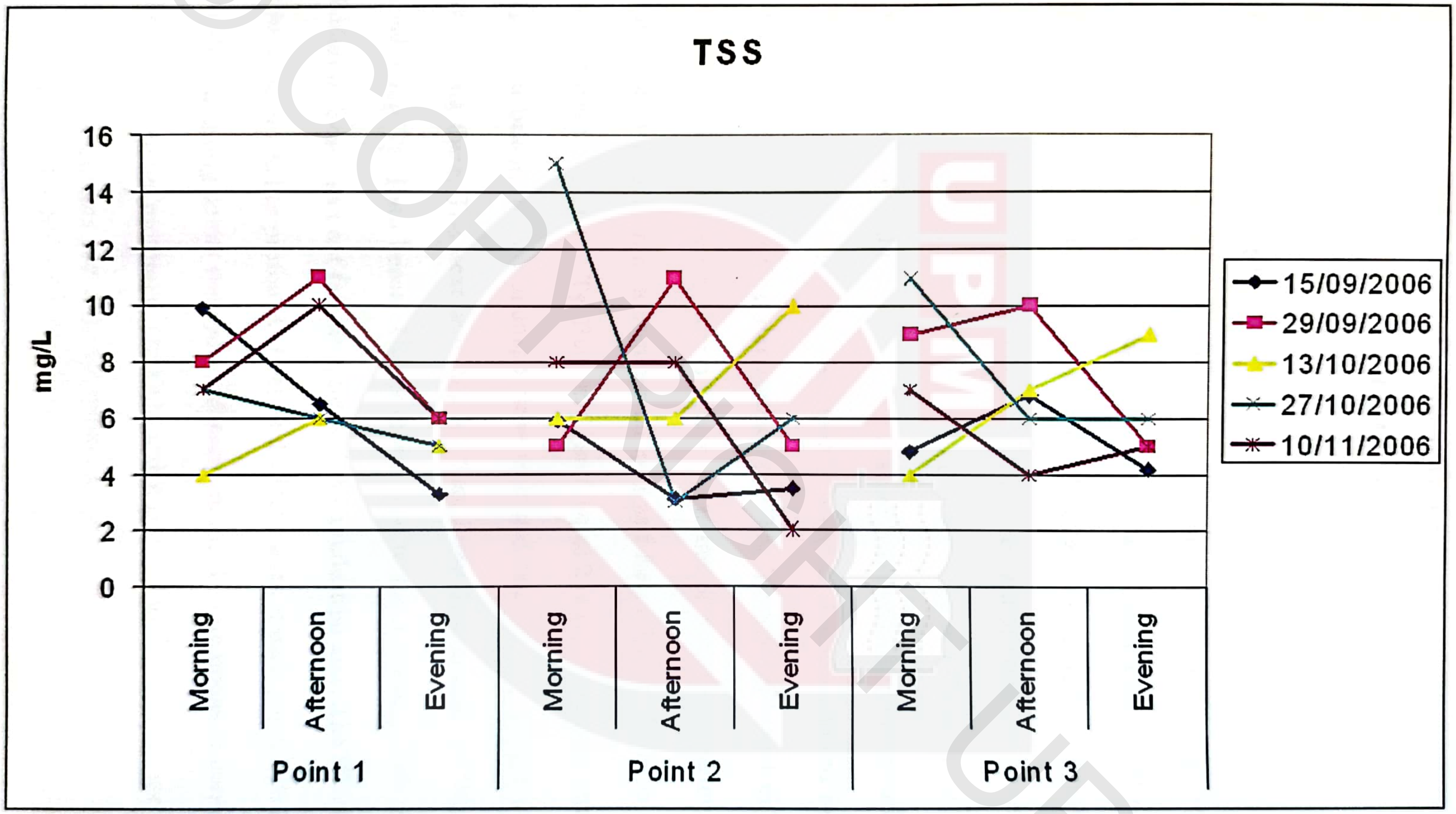

Figure 8: Changes in Total Suspended Solids during the Study Period.

CHAPTER 5

DISCUSSION

5.1 Dissolved Oxygen

The dissolved oxygen content for all the 3 sampling points during the sampling period shows concentration values well above the minimum stipulated value in the ASEAN Marine Quality Criteria of 4 mg/L. The DO content at Point 1 is in the range of 6.81 mg/L to 7.41 mg/L, followed by the DO content of Point 2 in the range of 6.8 mg/L to 7.23 mg/L and Point 3 has a DO content range of 6.76 mg/L to 7.35 mg/L. During the course of the sampling period, Point 1 showed the obvious variation in its DO content in a day, followed by Point 2 where as Point 3 showed rather stable variation in the DO readings throughout a day. The location of Point 1 in Tg. Batu is situated about 400 meters from a construction site of a seaside apartment project, municipal drainage from a commercial area and has a drainage that is channeling water close to Point 1 at Tg. Batu area itself. Point 2 is situated at the central area of Tg. Batu beach, has no drainage close to it and occasionally people can be seen swimming there. The next sampling location, Point 3, is situated at the end of the road along Tg. Batu beach. This point is close to the Kidurong Club golf course, Kidurong beach and not far away, the Kidurong industrial area. The location of these sampling points has profound effect on the DO values at each point. The DO content at all 3 sampling points showed a reduction during the afternoons as compared to the DO content in the mornings. The DO content is found to rise again in the evenings at all 3 sampling points due to the temperature.

5.2 Temperature

The temperature reading at all the sampling points throughout the sampling period is in the range of 28 °C to 33 °C, which showed only slight fluctuations. The ASEAN Marine Water Quality Criteria states the range of increase is not more than 2°C above the maximum ambient temperature. This is a common properties of seawater in the tropical areas which is about 28 to 32 °C (Gouda *et.al.*, 1995). The stability of temperature is one of the major characteristics of the tropical oceans (Wickstead, 1976). Temperature influences the solubility of oxygen as reported by Rajendran *et. al.* (1975) from their study in the Vellar Estuary. The sampling done at Tg. Batu showed a connection between the temperatures of seawater with the dissolved oxygen level recorded. The DO level dropped for all the sampling points throughout the study during the afternoons as compared to mornings because the temperature rises during the afternoon period. Then the DO showed increase in the evenings when the temperature drops. This shows that when the temperature rises, the DO concentration in the seawater drops and vice versa.

5.3 pH

As for the pH value during the sampling period, there was not much variation of the values and it is quite consistent. The range was between pH 7.9 – 8.0, which is a narrow range. This show that the waters of Tg. Batu is resistant to drastic changes in pH due to the natural properties of seawater that has buffering capacity to resist these changes from effluents and river water. The pH range is normal for seawater near coastal areas (Din *et. al.*, 1997).

5.4 Turbidity

The turbidity values obtained during the whole sampling period at the 3 sampling points show visible fluctuations between each sampling, the sampling points and different times of the day. The turbidity range during the first sampling day (15/9/2006) was in the range of 24.8 NTU to 53.2 NTU. Turbidity values in the morning of the first sampling day were below 30 NTU and showed slight increase in the afternoon at all 3 sampling points. On the evening period, the turbidity value increased at all 3 point to a range of 44 NTU to 54 NTU. During the second sampling day (29/9/2006), turbidity readings in the morning period ranged from 29 NTU to 42 NTU and increased to a range of 45 NTU to 57 NTU. Later in the evening, the range dropped to 17 NTU to 20 NTU. This pattern of turbidity levels of the first sampling and second sampling are the opposite of each other. The NTU value on the first day of sampling showed a low value in the morning compared to the rest of the day because of the early morning rain. For the second day of sampling, the weather was rainy in the evening, which reflects the low NTU reading compared to the morning and afternoon readings. The third sampling day (13/10/2006) turbidity values for 3 sampling points in the morning were quite consistent in the range of 18 NTU to 37 NTU which dropped slightly to 13 NTU to 23 NTU range in the afternoon, then raised back slightly to 17 NTU to 25 NTU range in the evening. During the fourth sampling day (27/10/2006) the turbidity for the morning period was in the range of 43 NTU to 68 NTU for all 3 sampling points, which then showed a reduction to a range of 29 NTU to 54 NTU in the afternoon. This is followed by a stable range of 32 NTU to 47 NTU in the evening compared to noon time. The last sampling day (10/11/2006) gave a turbidity range of 13 NTU to 55 NTU in the morning, then a narrower range of 17 NTU to 44 NTU in the afternoon. The evening turbidity range for the 3 sampling points showed slight increase to a range of 22 NTU to 46 NTU. The pattern that is seen on the first sampling was an increase of turbidity through the course of the day. The second sampling day showed the turbidity range to increase from morning till midday and then dropping back in the evening. The third sampling day showed an opposite pattern to the previous week, whereby the turbidity dropped during midday and rose back in the evening. The last two sampling days showed rather stable readings and not much change in turbidity during the course of the day. These fluctuations may be associated with the influx of murky water from the Batang Kemena River, turbulence (wave action), low and high tide conditions and also unseen particles in the seawater. Rainy days also have affected the turbidity levels as seen on the first and second samplings, which showed obvious reduction. For this parameter, the Interim National Water Quality Standards for Malaysia is used to compare the results as there is no specific turbidity standard for marine waters stated by the DOE. The results for the turbidity of the Tg. Batu seawater can be classified into Class IIB of the Interim National Water Quality Standards for Malaysia for surface water.

5.5 Biological Oxygen Demand (BOD_5)

The minimum level recorded for the biological oxygen demand during the whole study period was 15.61 mg/L and the highest value recorded was 47.12 mg/L. Generally the trend of changes in the biological oxygen demand at the 3 sampling points of Tg. Batu during the course of this study showed an increase from morning till afternoon, and followed by a decrease towards the evenings. This trend may reflect the timing of effluents discharged from the nearby Kidurong industrial area, which can deduced to be released during noontime. The release of effluents will cause an increase of microbiological activity in metabolizing the organic compounds into different compounds. BOD has been widely used as a parameter to assess water pollution where BOD will increase in polluted waters (Kumar, 1996). For this parameter, the Interim National Water Quality Standards for Malaysia is used to compare the results as there is no specific BOD standard for marine waters stated by the DOE. The BOD values from this study of Tg. Batu waters, according to the Interim National Water Quality Standards for Malaysia, by the DOE of Malaysia for surface water, can be classified into Class V (>12 mg/L).

5.6 Total Suspended Solids (TSS)

The total suspended solids of the Tg. Batu waters at the 3 sampling points showed inconsistent results over the period of this study. The maximum value for TSS obtained during this study is 15 mg/L at Point 2 (morning, 27/10/2006) and the lowest value is 2 mg/L at Point 2 (evening, 10/11/2006). This situation exists due to environmental factors such as wind, wave action and the low & high tide periods in a day. The high TSS values may caused by heavy wave action during low tides which churn up the sand and debris in the water, thus reflected in the water sampling done for TSS. The low values are obtained during the high tide period and also during calmer sea conditions due to reduced wave action, thus less sand and debris are churn up into the upper layers of seawater. The general conditions during the course of a day showed that TSS levels increase during noon and reduce towards the evening, with few exceptions whereby there was bad weather condition in the evenings when the TSS level increased due to wind, rain and wave action. There was an increase of overall TSS of the second sampling day compared to the first sampling day. The third sampling day showed a drop in the overall TSS level from the second sampling day, followed by the fourth day with an increase of TSS readings and the widest variation within each point. The last sampling day showed a reducing trend in TSS levels during the course of the day and between Point 1 to Point 3, due to calming of the sea because of less wind effect. The total suspended solids concentrations recorded in Tg. Batu area during this study was well below the stipulated standards of the Malaysian Interim Marine Water Quality Standards of 50 mg/L.

CHAPTER 6

CONCLUSION

6.1 Conclusion

During the course of this study, some of the parameters monitored showed compliance and some has exceeded the stipulated water quality standards by the Malaysian Department Of Environment water quality standards. The DO levels for all 3 sampling points were compliant to the ASEAN Marine Water Quality Criteria recommendation of a minimum of 4 mg/L. The temperature measurements at all 3 sampling points were in the normal range for the tropical seawater conditions of Malaysia. This is a common property of seawater in the tropical areas which is about 28 ^{o}C to 32 ^{o}C (Gouda and Panigrahy, 1995). The pH level of the seawater at all 3 sampling points can be categorized into Class 1 of the Interim National Water Quality Standards for Malaysia, by the DOE of Malaysia.

The turbidity levels that were recorded at Tg. Batu waters revealed that Point 1, Point 2 and Point 3 were in the Class IIB category of the Interim National Water Quality Standards for Malaysia, by the DOE of Malaysia. The parameter of TSS for Point 1, Point 2 and Point 3 were below the maximum stipulated standard of 50 mg/L as stated in the Malaysian Interim Marine Water Quality Standards. As for the BOD_5 levels, all 3 sampling points are categorized into Class V of the Interim National Water Quality Standards for Malaysia.

Thus, it can be concluded from this study that the seawater at the Tanjung Batu beach is polluted according to the turbidity and BOD_5 levels of all 3 sampling points which does not meet the required standards published by the DOE of Malaysia.

6.2 Recommendation

As to ensure that the seawater of the Bintulu coastal area is not to be severely polluted, strict and transparent enforcement of the law is required. This is to create alertness to the industries thriving along the coastline and to ensure sufficient treatment is done to the effluents before it is channeled into the sea.

Constant monitoring by the DOE is also needed as to gather valuable data on the conditions of the coastal waters of Bintulu. This is to provide the initial information on the pollution level before any further actions can be taken to investigate the pollution source.

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APPENDICES

Appendix 1

INTERIM NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA TABLE2.3

		CLASSES					
PARAMETERS	UNIT	I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1	3	3	6	12	>12
COD	mg/l	10	25	25	50	100	>100
DO	mg/l	7	5 - 7	5 - 7	3 - 5	<3	<1
pH		6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Elec. Conductivity *	umhos/cm	1000	1000	-	-	6000	-
Floatables		N	N	N	-	-	-
Odour		N	N	N	-	-	-
Salinity (%)	%	0.5	1	-	-	2	-
Taste		N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature (C)	°C	-	Normal +2°C		Normal +2°C	-	-
Turbidity (NTU)	NTU	5	50	50	-	-	-
Faecal Coliform **	counts/100mL	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	counts/100mL	100	5000	5000	50000	50000	>50000

Notes

N : No visible floatable materials or debris or No objectionable odour, or No objectionable taste

* : Related parameters, only one recommended for use

** : Geometric mean

a : maximum not to be exceeded

<u>Class</u> <u>Uses</u>

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 ll - sensitive aquatic species
CLASS IIB	:	Recreational use with body contact
CLASS III	:	Water Supply lll - extensive treatment required Fishery lll - common, of economic value, and tolerant species livestock drinking
CLASS IV	:	Irrigation
CLASS V	:	Not appropriate for any of the above

Appendix 2

ASEAN Marine Water Quality Criteria

For Aquatic Life Protection

Parameter	Criteria Values	Note
Ammonia (NH_3-N)	70 µg/L	
Cadmium	10 µg/L	
Chromium (VI)	50 µg/L	Criteria value proposed by CPMSII is 48 µg /L. The Meeting recommended to adopt 50 µg /L, following the existing national standards of member countries
Copper	8 µg/L	As the proposed value 2.9 µg/L is too stringent, the Meeting agreed to use round-up value of 7.7 µg /L, the product of the lowest LOEC from a chronic study 77 µg /L for reproduction for Mysidopsis bahiaand a safety factor of 0.1
Temperature	Increase not more than 2°C above the maximum ambient temperature	
Cyanide	7 µg/L	
Dissolved oxygen	4 mg/L	
Lead	8.5 µg/L	
Mercury	0.16 µg/L	
Nitrate (NO_3-N)	60 µg/L	A single criteria value should be derived for nitrate and nitrite combined in future.
Nitrite(NO_2-N)	55 µg/L	
Oil and grease	0.14 mg/L	Other related parameter, e.g. PAH, should be proposed in the future.
Total phenol	0.12 mg/L	
Phosphate	15 µg/L (Coastal 45 µg/L (Estuarine)	
Tributyltin	10 mg/L	
Total suspended solids	Permissible 10% maximum increase over seasonal average concentration	

For Human Health Protection

Parameter	Criteria Values	Note
Bacteria	100 faecal coliform/100 mL 35 enterococci/100 mL	Coastal water quality for recreational activities

Appendix 3

MALAYSIA : INTERIM MARINE WATER QUALITY STANDARDS

Parameter (lab)	Unit	Interim standards
Escherichia coli (*E.coli*)	MPN/100ml	100
Oil & Grease (O&G)	mg/l	0
Total Suspended Solids (TSS)	mg/l	50
Arsenic (As)	mg/l	0.1
Cadmium (Cd)	mg/l	0.1
Chromium (Cr) Total	mg/l	0.5
Cuprum (Cu)	mg/l	0.1
Plumbum (Pb)	mg/l	0.1
Mercury (Hg)	mg/l	0.001

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled Determination of seawater quality at Tanjung Batu, Bintulu by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.

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Sivaneswaran A/L Goval Krishnan

Date : 4/5/2007