



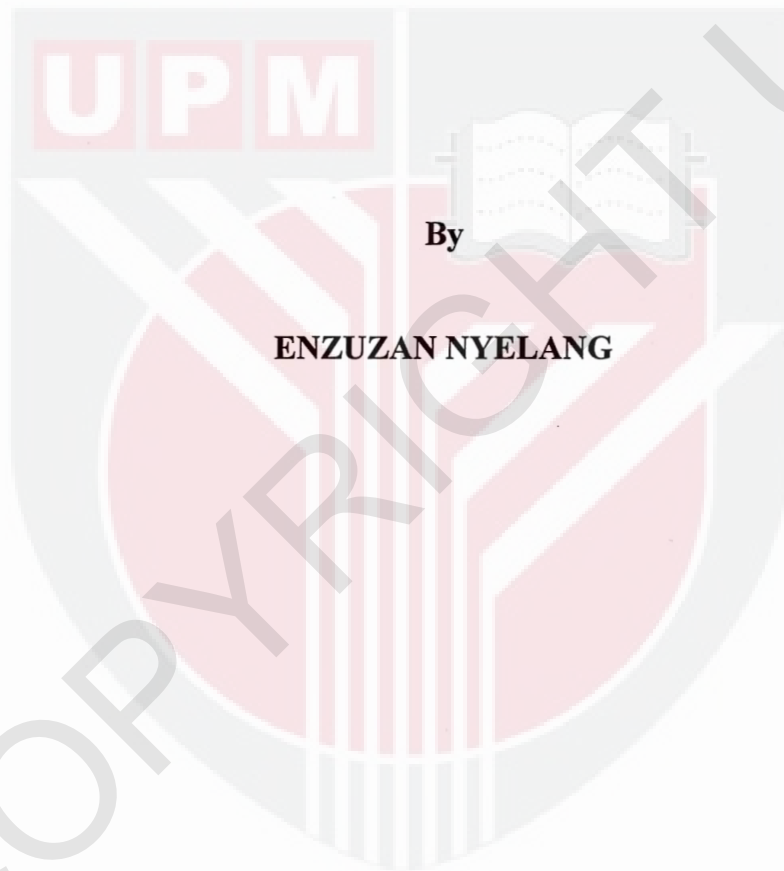
UNIVERSITI PUTRA MALAYSIA

***PHYSICOCHEMICAL PROPERTIES AT DRINKING
WATER IN UNIVERSITY PUTRA MALAYSIA,
BINTULU CAMPUS, BINTULU SARAWAK***

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FSPM 2007 13**

**PHYSICOCHEMICAL PROPERTIES AT DRINKING WATER IN
UNIVERSITY PUTRA MALAYSIA, BINTULU CAMPUS,
BINTULU SARAWAK**



**A Project Report Submitted in Partial Fulfillment of the Requirement
For the Degree of Bioindustry Science in the
Faculty of Agriculture and Food Sciences
University Putra Malaysia Bintulu Campus**

2007

ABSTRACT

The study at Physicochemical Properties at drinking water in UPMKB has been carried out on 13th and 20th October 2006. There are nine (9) parameters such as pH, Turbidity, Dissolved Oxygen, Ammonia, Nitrate, Total Dissolved Solid, Temperature, Conductivity and Chloride. All the parameters were monitored at six (6) sampling stations which were Laku Pipe (S1), Reservoir water tank UPMKB (S2), Kolej Kediaman 2 Tank (S3), Kolej Kediaman 2 Sink (S4), Kolej Kediaman 1 Tank (S5) and Kolej Kediaman 1 Sink (S6). Each parameter has been analyzed using field measurement method which is Multi-parameter Troll 9500. The result shows the range for DO (8.23 ± 0.10 mg/L to 24.94 ± 0.63 mg/L on 13th October 2006 and 8.91 ± 0.10 mg/L to 15.12 ± 0.63 mg/L on 20th October 2006) with the standard limit 10 mg/L, TDS (1.36 ± 0.01 ppm to 1.59 ± 0.01 ppm on 13th October 2006 and 1.35 ± 0.01 ppm to 1.51 ± 0.01 ppm on 20th October 2006) with the standard limit 1000 ppm, Turbidity (5.29 ± 0.48 NTU to 10.98 ± 2.75 NTU on 13th October 2006 and 0.00 ± 0.00 NTU to 0.98 ± 0.19 NTU on 20th October 2006) with the standard limit 5NTU and Chloride (0.93 ± 0.01 ppm to 0.99 ± 0.02 ppm on 13th October 2006 and 0.99 ± 0.01 ppm to 1.00 ± 0.01 ppm on 20th October 2006.) with standard limit 250ppm. The range for pH is 6.89 ± 0.03 to 8.73 ± 0.01 at 13th October 2006 and 6.10 ± 0.03 to 8.29 ± 0.12 at 20th October 2006, for Conductivity is 2.16 ± 0.01 μ S/cm to 2.64 ± 0.01 μ S/cm at 13th October 2006 and 2.20 ± 0.02 μ S/cm to 2.52 ± 0.01 μ S/cm at 20th October 2006 and for Temperature is 28.60 ± 0.01 to 29.39 ± 0.01 at 13th October 2006 and 28.08 ± 0.01 to 29.52 ± 0.03 at 20th October 2006. There is no Ammonia and Nitrate been detected in the water. All parameters showing the positive result which were below the standard limit approved by WHO.

ABSTRAK

Kajian Fizikokimia dalam air minuman yang terdapat di UPMKB telah dijalankan pada 13 dan 20 Oktober 2006. Terdapat sembilan (9) parameter iaitu pH, Kekeruhan, Keterlarutan Oksigen, Amonia, Nitrat, Jumlah Keterlarutan Pepejal, Konduktiviti dan Klorida yang diambil pada enam (6) stesen persampelan iaitu Paip Laku (S1), Tangki air simpanan UPMKB (S2), Tangki Kolej Kediaman 2 (S3), Sinki KK2 (S4), Tangki Kolej Kediaman 1 (S5) and Sinki Kolej Kediaman 1 (S6). Setiap parameter di analisis dengan menggunakan kaedah pengukuran di lapangan iaitu Multi-parameter Troll 9500. Keputusan menunjukkan julat bagi DO (8.23 ± 0.10 mg/L hingga 24.94 ± 0.63 mg/L pada 13 Oktober 2006 dan 8.91 ± 0.10 mg/L hingga 15.12 ± 0.63 mg/L pada 20 Oktober 2006) dengan had piawai 10mg/L, TDS (1.36 ± 0.01 ppm hingga 1.59 ± 0.01 ppm pada 13 Oktober 2006 dan 1.35 ± 0.01 ppm hingga 1.51 ± 0.01 ppm pada 20 Oktober 2006) dengan had piawai 1000ppm, kekeruhan (5.29 ± 0.48 NTU hingga 10.98 ± 2.75 NTU pada 13 Oktober 2006 dan 0.00 ± 0.00 NTU hingga 0.98 ± 0.19 NTU pada 20 Oktober 2006) dengan had piawai 5NTU and Klorida (0.93 ± 0.01 ppm hingga 0.99 ± 0.02 ppm pada 13 Oktober 2006 and 0.99 ± 0.01 ppm hingga 1.00 ± 0.01 ppm pada 20 Oktober 2006.) dengan had piawai 250ppm. Julat bagi pH ialah 6.89 ± 0.03 hingga 8.73 ± 0.01 pada 13 Oktober 2006 dan 6.10 ± 0.03 hingga 8.29 ± 0.12 pada 20 Oktober 2006, bagi konduktiviti, julat ialah 2.16 ± 0.01 μ S/cm hingga 2.64 ± 0.01 μ S/cm pada 13 pada 2006 dan 2.20 ± 0.02 μ S/cm hingga 2.52 ± 0.01 μ S/cm pada 20 Oktober 2006 dan bagi suhu, julat ialah 28.60 ± 0.01 hingga 29.39 ± 0.01 pada 13 Oktober 2006 dan 28.08 ± 0.01 hingga 29.52 ± 0.03 pada 20 Oktober 2006. Dalam kajian ini, tiada Ammonia dan Nitrat yang di kesan dalam air minuman. Sebagai kesimpulannya, kesemua parameter menunjukkan keputusan yang positif iaitu berada di bawah had piawai yang telah di tetapkan oleh WHO.

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I certify that this research project report entitled “Physicochemical Properties at Drinking Water in University Putra Malaysia, Bintulu Campus, Bintulu Sarawak” 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, University Putra Malaysia Bintulu Campus.

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LIST OF ABBREVIATIONS

Abbreviation

Definition

° C

Degree Celsius

et al.

And all

g

Gram

mg/L

Miligram per liter

NTU

Nephelometric units

pH

Power of Hydrogen

ppm

Part per million

TDS

Total Dissolved Solid

WHO

World Health

Organization

μS/cm

MicroSiemens per
centimeter



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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, mankind in the 21st century is faced with unprecedented challenges imposed by water scarcity, pollution and water quality degradation. Everyone knows water where human can let it flow out of a tap and drink it. Water of sufficient quality to serve as drinking water is termed potable water whether it is used as such or not. Drinking water means water used or intended to be used for domestic purpose. It is also part of a global water cycle, which is a function of many abiotic and biotic processes (Skipton *et al.*, 2005). However, drinking water quality is very difficult to control. This may due to the water contains that has many trace elements and minerals which may be benign, beneficial or toxic. Clean water contributes to good health where contaminated water can cause disease and even death. Due to this, clean drinking water will be needed to supply for human consumption. Typically water supply networks deliver a single quality of water, whether it is to be used for drinking, washing or landscape irrigation, where drinking water can be optionally delivered by a separate tap. In Malaysia, public drinking water is governed by a different of water companies due to their country. For Sarawak including Bintulu areas, public drinking water is governed by Lembaga Air Kawasan Utara (LAKU) Management Sdn. Bhd. In here, drinking water supply has to be treated in some way such as physical, chemical and biological processes before being supplied for human consumption. This is to ensure the water is clean and safe for human to consume after distributed. However, the cleanliness qualities of the drinking water which is at UPMKB were doubted because it is too cloudy. This may due to the condition of piping system or other relevant reasons. Until today, no

research had been carried out around UPMKB to ensure the quality of drinking water. Therefore, this study should be carried out to determine the Physicochemical properties at drinking water quality in UPMKB.

1.2 Objectives:

In general, this study is conducted according to the following objectives:

- i. To determine the pH, Turbidity, Dissolved Oxygen, Ammonia, Nitrate, Total Dissolved Solid, Temperature, Conductivity and Chloride in drinking water of UPMKB.
- ii. To compare the quality of drinking water from UPMKB with WHO guidelines for drinking water quality standard.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter summarizes based on four main parts which are Drinking Water, Water Treatment Process, and Drinking Water Quality that are being studied. This chapter also explains about side effects towards human health when the concentration of each parameter exceeds the Standard Limit that has fixed by WHO.

2.2 Drinking Water

According to WHO (2004); Drinking water means water that is intended to be used for domestic purpose. People can survive days, weeks or even longer without food but only about four days without water (Skipton *et al.*, 2005). Other than that, drinking water has an important role for keeping the skin moist, energy levels up and alleviates some headache. Besides, it's also keeping well hydrated often helps to regulate appetite, flushes out wastes, transports nutrients, regulates body temperature, maintain acid-alkaline balance and support chemical process.

However, drinking water is never pure. According to Skipton *et al.* (2005); some dissolved mineral in water can be beneficial to health. For example, the National Research Council (National Academy of Sciences) states that drinking water containing dissolved acceptable drinking water levels for a chemical substance over a given period of time based on health effect information. Therefore, it is important to understand that standards for drinking water contaminants do not guarantee that water with a contaminant level below the standard is risk-free.

Besides that, according to the WHO (1984); Drinking water may cause health hazard whereas its depend on a condition or thing in relation to drinking water that does on is likely to endanger the public health. For example; the piping system which has responsibility to supply the drinking water into the house or for domestic purpose may gives influences to the cleanliness and quality of drinking water where the cement mortar used for coated the inside of water pipes may release considerable amounts of ammonia, nitrate and metal such as cadmium and lead which are potential toxic to the human health (Alley, 1976).

Due to this, clean drinking water will be needed to supply for human needs where before distributed to human consumption, the water supply need to treat in some way such as physical, chemical and biological processes before being supplied for human consumption. Typically water supply can be optionally delivered by a separate tap. In Malaysia, public drinking water is governed by a different of water companies due to their country. For Sarawak including Bintulu areas, public drinking water is governed by LAKU Management Sdn. Bhd.

Table 2.1: Water Supply Organizations.

STATE AND FEDERAL TERRITORY	WATER SUPPLY ORGANIZATIONS
PUTRAJAYA (FEDERAL TERRITORY)	SAJ Holdings Sdn. Bhd.
PERLIS	Perlis Public Works Department
KEDAH	Kedah Public Works Department
LABUAN (FEDERAL TERRITORY)	Labuan Water Supply Department
SARAWAK	Sarawak Public Works Department
PAHANG	Pahang Water Supply Department
NEGERI SEMBILAN	Negeri Sembilan Water Supply Department
SABAH	Sabah Water Department
PERAK	Perak Water Board
KUCHING	Kuching Water Board
SIBU	Sibu Water Board
MELAKA	Melaka Water Corporation

Source: DOE (2006)

Table 2.2: Water supply regulatory bodies

STATE	WATER SUPPLY REGULATORY BODIES
JOHOR	Johor State Regulatory Body
KELANTAN	Kelantan water Department
PENANG	Pulau Pinang Water Department
TERENGGANU	Terengganu Water Department
SELANGOR	Selangor State Regulatory Body

Source: DOE (2006)

Table 2.3: Privatized water companies

STATE	PRIVATIZED WATER COMPANY
JOHOR	SAJ Holdings Sdn. Bhd.
KELANTAN	Air Kelantan Sdn.Bhd.
SARAWAK	LAKU Management Sdn. Bhd.
PENANG	Perbadanan Bekalan Air Pulau Pinang Sdn. Bhd
TERENGGANU	Syarikat Air Terengganu Sdn. Bhd. (SATU)
SELANGOR	Perbadanan Urus Air Selangor Sdn. Bhd. (PUAS)

Source: DOE (2006)

2.3 Water Treatment Process

Drinking water source means a stream, reservoir well or aquifer from which drinking water is taken (WHO, 2003). For drinking water source of UPMKB, it is comes from Sibu River which is handled by Lembaga Air Kawasan Utara (LAKU) Management Sdn. Bhd. which a wholly owned of state government of Sarawak. There are 2 parts for water treatment process at Nyabau Water treatment plant, Bintulu which are Pulsator Clarifier Water Treatment Plant Water Treatment Process and Dissolved Air Flotation (DAF) Water Treatment Plant.

2.3.1 Pulsator Clarifier Water Treatment Plant Water Treatment Process

According to the LAKU (2004), raw water is pumped from Sibu River and stored in the Sika raw water reservoir which is formed by five earth dams. Raw water from Sika reservoir is then pumped to the raw water tank. From the raw water tank, water is gravitated to the inlet works where the following water treatment chemicals are added:

- i. Hydrated Lime for adjusting the pH of the raw water
- ii. Aluminum Sulphate for coagulation process. (Small particles are combined to form larger particles called flocs)

The water then flows into vacuum chamber. When the water in the vacuum chamber reaches a preset level the water is pushed through perforated pipes into the clarifiers.

The flocs settled at the bottom of the clarifier and form a sludge blanket.

The clarified water flows into the filters which remove suspended particles and flocs that are not settled in the clarifiers to produce clean water.

The following chemicals are added to the filtered water before it is stored in the clear water well:

- i. Liquid chlorine for disinfection,
- ii. Hydrated Lime to adjust the pH to 7-7.5
- iii. Sodium silicofluoride (for prevention of dental caries among children)

The treated water is then pumped to the water tower and distributed to the consumers (LAKU, 2004).

2.3.2 Dissolved Air Flotation (DAF) Water Treatment Plant

According to the LAKU (2004), the DAF water treatment plant draws water from the same source as the other water treatment plant, i.e. the Sika Reservoir. The water treatment chemicals hydrated lime and aluminum sulphate are added to the raw water in the flash mixing tank and the flocculation and coagulation process take place in the flocculator.

Before the water enters the flotation / filtration tank, water saturated with dissolved air is injected into the water. The millions of tiny air bubbles from the saturated water are released and attach to the particles / flocs in the water causing them to float to the surface for collection and removal, leaving the clarified water behind. The

clarified water then passes through the sand filters to filter off the remaining flocs and particles. The following chemicals are added to the filtered water:

- i. Mixed oxidant for disinfection
- ii. Hydrated Lime to adjust the pH to 7-7.5
- iii. Sodium silicofluoride (for prevention of dental caries among children)

The treated water is stored in the clear water reservoir before it is pumped to the balancing reservoir. From the balancing reservoir the water is distributed to the consumers.

The disinfectant used at the DAF plant is mixed oxidant which is formed from common salt using electrolysis process. The mixed oxidant is known to last longer in the distribution system and reduce the total trihalomethane (TTHM) in the treated water.

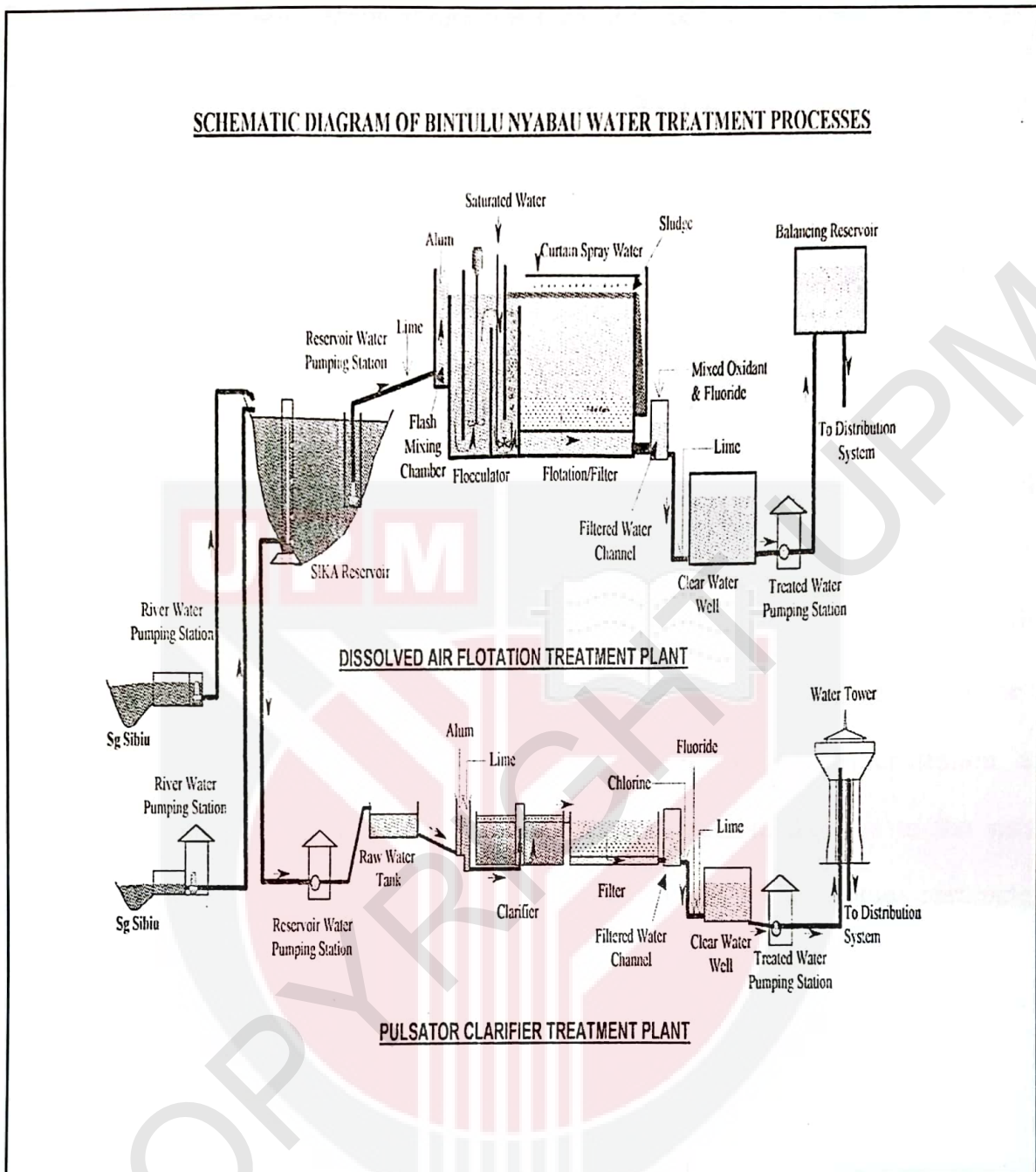


Figure 2.1: Schematic Diagram of Bintulu Nyabau Water Treatment Process

Source : LAKU (2004)

2.4 Drinking Water Quality of UPMKB

There are 9 parameter will be reviewed which are pH, Temperature, Dissolved Oxygen, Total Dissolved Solid, Turbidity, Chloride, Nitrate, Ammonia and Conductivity. Each parameter has their own effect and influence to human health and

to the parameter it self. Besides that, conductivity has being found has no effect to human health.

2.4.1 pH

pH stands for "potential hydrogen" whereas common pH definition is: "a logarithmic scale, from 1 to 14, used to describe the acidity or alkalinity of a solution" (Feldman, 1956). The degree of acidity or alkalinity of a solution is measured in terms of a value known as pH. Represents a terminology used by chemists to indicate the concentration, in a solution, of hydrogen ions (H^+) (Alley, 1976). A pH level of less than 7 indicates an acidic solution while a pH greater than 7 indicates an alkaline solution. 7 is the pH level of distilled water (Hudson, 1976). The main purpose in controlling pH is to produce water in which corrosion and incrustation are minimized. These processes, which can cause considerable damage to the water supply system, result from complex interactions between pH and other parameters such as dissolved solids, dissolved gases, hardness, alkalinity and temperature (Dye and Tuepker, 1971). Besides that, because of pH is related to a variety of other parameters, it is not possible to determine whether pH has a direct relationship with human health. In so far, as pH affects the unit processes in water treatment that contribute to the removal of viruses, bacteria and other harmful organisms, it could be argued that pH has an indirect effect on health (Taylor *et al.*, 1966). There are no specific health effects on which to base limits for the pH of drinking water. Obviously low pH of strong acidity in water causes some health problems and too high pH of strong Alkalinity is not always helpful for our health. The normal range according to the WHO Guidelines for Drinking Water Quality Standard was 6.6-8.5.

Meanwhile, drinking water with a pH level above 8.5 could indicate that the water is hard. This situation can cause aesthetic problems to humans (USEPA, 2004).

2.4.2 Temperature

Temperature is not used to evaluate directly either potable water or wastewater. It is however one of the most important parameters in natural surface-water systems. The temperature of surface waters governs to a large extent the biological species present and their rates of activity. Temperature has an effect on most chemical reactions that occur in natural systems. Temperature also has a pronounced effect on the solubility's of gases in water (Peavy *et al.*, 1985). A rise in temperature of the water accelerates chemical reactions, reduces solubility of gases, amplifies taste and odor and elevates metabolic activity of organism (Gupta, 2000). Other than that, temperature of source water can fluctuate seasonally and depends upon the type of source. In consumer's homes, water is typically used from below ambient temperatures to as high as 65 °C. Drinking water industry researches indicated that sample serving temperature influenced how much consumers liked their drinking water (Pangborn & Bertolero, 1972). Pangborn and Bertolero (1972) found that temperature affected taste intensities, and also concluded that chilling it increased consumer palatability and acceptance of drinking water. Pangborn and Bertolero (1972) also concluded that elevating the presentation temperature affected the perceived odor intensity, and odor intensities at 45 °C were higher than at 25 °C. This indirectly may produce aesthetically displeasing tastes, and odors which consider can cause harmful to human health.

2.4.3 Dissolved Oxygen

Dissolved oxygen analysis measures the amount of gaseous oxygen dissolved in an aqueous solution. Besides that, dissolved oxygen also has found as measure of water quality indicating free oxygen dissolved in water (Alley, 1976). Dissolved Oxygen inversely proportional to temperature and the maximum oxygen that can dissolve in water at most ambient Temperature is about 10 ppm (Peirce *et al.*, 2000). Beyond that, Dissolved oxygen can be a source of serious trouble in a household water supply. The fact is that oxygen causes corrosion. In cold water, oxygen normally has little corrosive effect. In contrast, when the water is heated, the oxygen can cause serious corrosion problems (Follet *et al.*, 1989). Besides, when the content of Dissolved Oxygen being decrease, this can affect the taste and odor of water. This situation indirect can cause asthmatics to human (Fundingsland *et al.*, 1988).

2.4.4 Total Dissolved Solids

Total Dissolved Solids is a portion that passes through the filter from the Total Suspended Solid. The portions are various minerals and salts as calcium, bicarbonate, nitrogen, phosphorus, iron, sulphur, and other ions (Alley, 1976). This material is left as a solid residue upon evaporation of the water and constitutes a part of total solids. Determining the electrical conductivity of the water often makes an approximate analysis for TDS. The ability of water to conduct electricity, known as the *specific conductance*, is a function of its ionic strength (Peavy *et al.*, 1985). Many dissolved substances are undesirable in water. High concentrations of TDS may cause adverse taste effects. Dissolved minerals, gases, and organic constituents may produce aesthetically displeasing color, tastes, and odors. Some chemicals may

be toxic, and some of the dissolved organic constituents have been shown to be carcinogenic to human health (Peavy *et al.*, 1985). High TDS water is less thirst quenching. Some of the individual mineral salts that make up TDS pose a variety of health hazards. The most problematic are Nitrates, Sodium, Sulfates, Barium, Cadmium, Copper, and Fluoride (Dalton *et al.*, 1997).

2.4.5 Turbidity

Turbidity is determined by the optical property that causes light to be scattered, adsorbed or reflected rather than transmitted in a straight line through or into a liquid. Turbidity in water caused by suspended matter like clay, silt, organic matter, phytoplankton and other microscopic organisms (Gupta, 2000). Simply stated, turbidity is the measure of relative clarity of a liquid. Clarity is important when producing drinking water for human consumption and in many manufacturing uses. Normal range for turbidity was 5 NTU. Besides that, turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches which has found can cause acute gastrointestinal illness, or gastroenteritis which is waterborne disease (Peavy *et al.*, 1985).

2.4.6 Chloride

Chloride is major ion surface water and wastewaters and its concentration in natural water varies widely. Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium (CaCl₂). Levels of chloride in water supplies are limited to 250 ppm as at higher concentrations chloride imparts a salty taste, which makes the water unpalatable, and the WHO guideline for drinking water is set at this value (Radojević & Bashkin, 1999). Other than that, high chloride content may harm metallic pipes. Chloride toxicity is harmful to humans such as congestive heart failure, eyes/nose irritation; stomach discomfort (WHO, 2003). Beside that, health concerns of chloride exposure include, but are not limited to: possible increased risk of miscarriage, birth defects, rectal and bladder cancer, respiratory complaints, corrosion of the teeth, inflammation of the mucous membranes of the nose, and increased susceptibility to tuberculosis. There is an alarming lack of comprehensive test data (ZWA, 1999).

2.5.7 Nitrates, NO₃

Nitrate has been used as an indicator for the presence of organics. The normal range according to the WHO guidelines for drinking water quality standards was 50 ppm (Alley, 1976). The concentration of nitrates is commonly expressed as NO₃⁻. The term "nitrate nitrogen" is used to refer to the nitrogen present which is combined in the nitrate ion. Nitrate as nitrogen concentrations average below any accepted value indicating human impacts. The concentrations are usually expressed in milligrams per liter of nitrogen. The maximum acceptable concentration of nitrate in drinking water is 45 mg/L as NO₃. In excessive amounts it poses a health risk (NAP, 1981). Besides that, exposure to nitrate *per se* is not of particular interest with respect to

human health. However, nitrate can be reduced endogenously (within the human body) to nitrite through bacterial and other reactions; nitrite can be further reduced to N-nitroso compounds (NOCs) whereas; NOCs are some of the strongest known carcinogens, which can act systemically, and have been found to induce cancer (WHO, 2003). Besides that, Nitrate (NO_3) levels should not be higher than 10 mg/l if reported as nitrogen (N) or nitrate-nitrogen (N-NO_3) or higher than 45 mg/l if reported as nitrate (NO_3). High nitrate may cause methemoglobinemia (infant cyanosis or "blue baby disease") in infants who drink water or formula made from water containing nitrate levels higher than recommended (Alley, 1976).

2.4.9 Ammonia

Ammonia may be present in drinking-water as a result of disinfection with chloramines. The presence of ammonia at higher than geogenic levels is an important indicator of faecal pollution (ISO, 1986). Taste and odor problems as well as decreased disinfection efficiency are to be expected if drinking-water containing more than 0.2 mg of ammonia per litre is chlorinated (Weil *et al.*, 1975), as up to 68% of the chlorine may react with the ammonia and become unavailable for disinfection cement mortar used for coating the insides of water pipes may release considerable amounts of ammonia into drinking-water and compromise disinfection with chlorine (Wendlandt *et al.*, 1988). The presence of elevated ammonia levels in raw water may interfere with the operation of manganese-removal filters because too much oxygen is consumed by nitrification, resulting in mouldy, earthy-tasting water (WHO, 1986). The presence of the ammonium cation in raw water may result in drinking-water containing nitrite as the result of catalytic action (Reichert *et al.*,

1984) or the accidental colonization of filters by ammonium-oxidizing bacteria. The normal range according to the Water Quality Index was 0.1-0.3 ppm. Ammonia has a toxic effect on healthy humans only if the intake becomes higher than the capacity to detoxify. If ammonia is administered in the form of its ammonium salts, the effects of the anion must also be taken into account. With ammonium chloride, the acidotic effects of the chloride ion seem to be of greater importance than those of the ammonium ion (WHO, 1986). At a dose of more than 100 mg/kg of body weight per day (33.7 mg of ammonium ion per kg of body weight per day), ammonium chloride influences metabolism by shifting the acid-base equilibrium, disturbing the glucose tolerance, and reducing the tissue sensitivity to insulin.

2.5.10 Conductivity

Conductivity is a quantification of the ability of water to carry an electric current. It can be used as an approximate measure of the total concentration of inorganic substances in water. Ions that have a major influence on the conductivity of water are H^+ , Na^+ , K^+ , Mg^{2+} , Ca^{2+} and certain metals (Alley, 1976). Significant changes in conductivity can indicate that pollution has entered a watershed. The unit's microsiemens/cm ($\mu S/cm$) and millisiemens/cm (mS/cm) are most commonly used to describe the conductivity of aqueous solutions (Peavy *et al.*, 1985)

CHAPTER 3

METHODOLOGY

3.1 Study Area

The study area is located at University Putra Malaysia Bintulu Campus, Bintulu Sarawak whereas it is middle of Northern Nyabau Mountain, East of Nyabau Road, South of Bintulu Road and West of Kidurong Road. The major activities will be carried out at Laku Pipe (Station 1), Reservoir water tank UPMKB (Station 2), Kolej Kediaman 2 Tank (Station 3), Kolej Kediaman 2 Sink (Station 4), Kolej Kediaman 1 Tank (Station 5) and Kolej Kediaman 1 Sink (Station 6). (Appendix B)

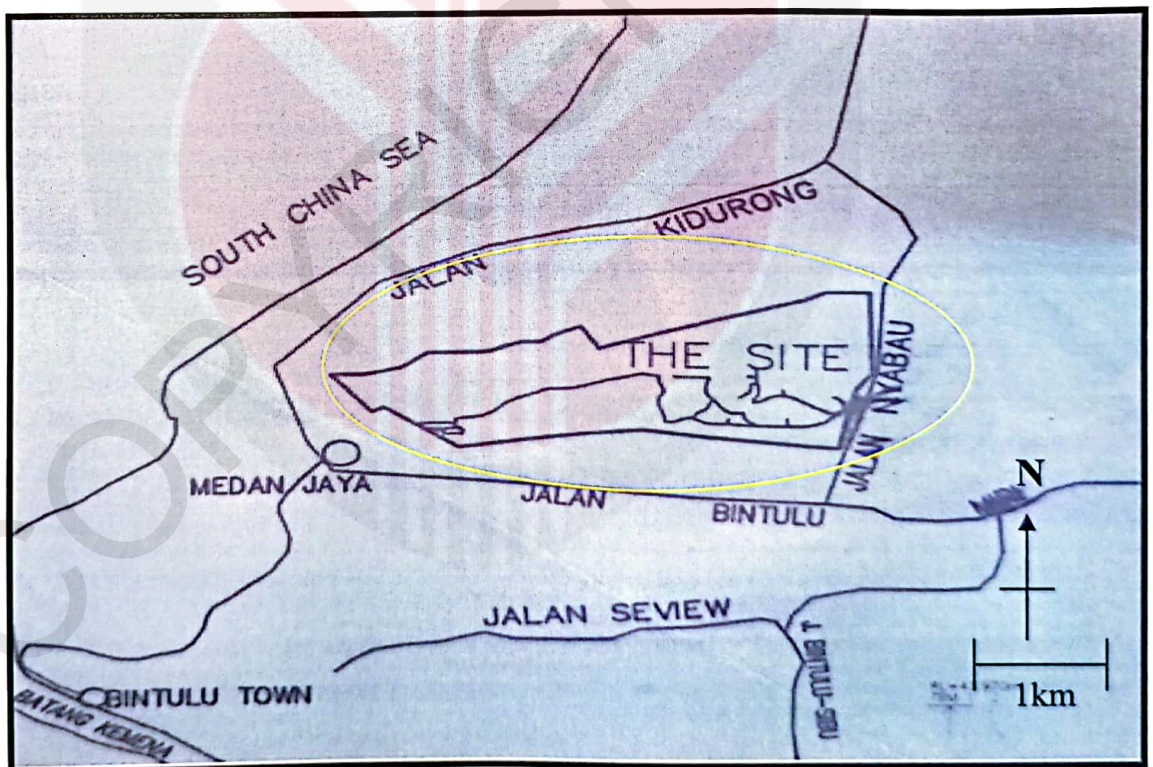


Figure 3.1: Map of study the area

3.2 Sample collection and analysis

Sample collection has been carried out weekly for two week in a month. The sources of drinking water used by UPMKB communities which were comes from Borneo Best Project, KK1 (Storage Tank and Sink) and KK2 (Storage Tank and Sink) was analyzed using portable equipment according to the standard methods to the examination of water and waste water (APHA, 1989). According to this, the parameter that is in total, 9 parameter as shown in table 3.1 has been analyzed by using field measurement method by using Multi-parameter Troll 9500. The concentration of all parameter compared with WHO guidelines for drinking water Quality standards as shown in table 3.2.

Table 3.1: Method of measurement for each parameter

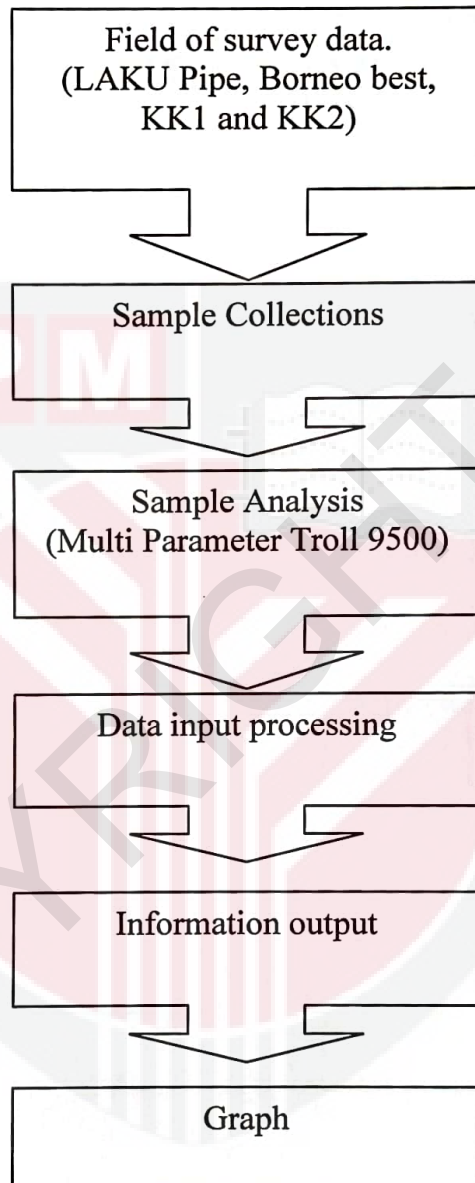
Instrument	Parameter
Multi Parameter Troll 9500	pH
	Temperature
	Dissolved Oxygen
	Oxidation Reduction Potential
	Total Dissolved Solid
	Turbidity
	Chloride
	Nitrate
	Ammonia
Conductivity	

Table 3.2: Drinking Water Quality Standards

Parameters	Concentration	Units
Total Solid	500	(mg/L)
Total Dissolved Solid	1000	(mg/L)
Turbidity	5	(NTU)
PH	6.5-9.0	-
Nitrates as N	10	(ppm)
Ammonia as N	1.5	(ppm)
Chloride as Cl ⁻	250	(ppm)
Dissolved Oxygen	10	(mg/L)

Source: WHO, (2003)

3.3 Process of the study



3.4 Apparatus

Apparatus

- Multi-Parameter Troll 9500
- Quick-cal 4 X 250 ml (for calibrating basic sensor)
- pH 4,7,10 (buffer)
- Nitrate, 14, 140 and 1400 ppm as N (for calibrating basic sensor)
- Ammonium, 14, 140 and 1400 ppm as N (for calibrating basic sensor)
- Chloride 35.5,355 and 3545 ppm (for calibrating basic sensor)
- Turbidity 10,100 and 1000 NTU polymer suspension 500 ml (for calibrating basic sensor)

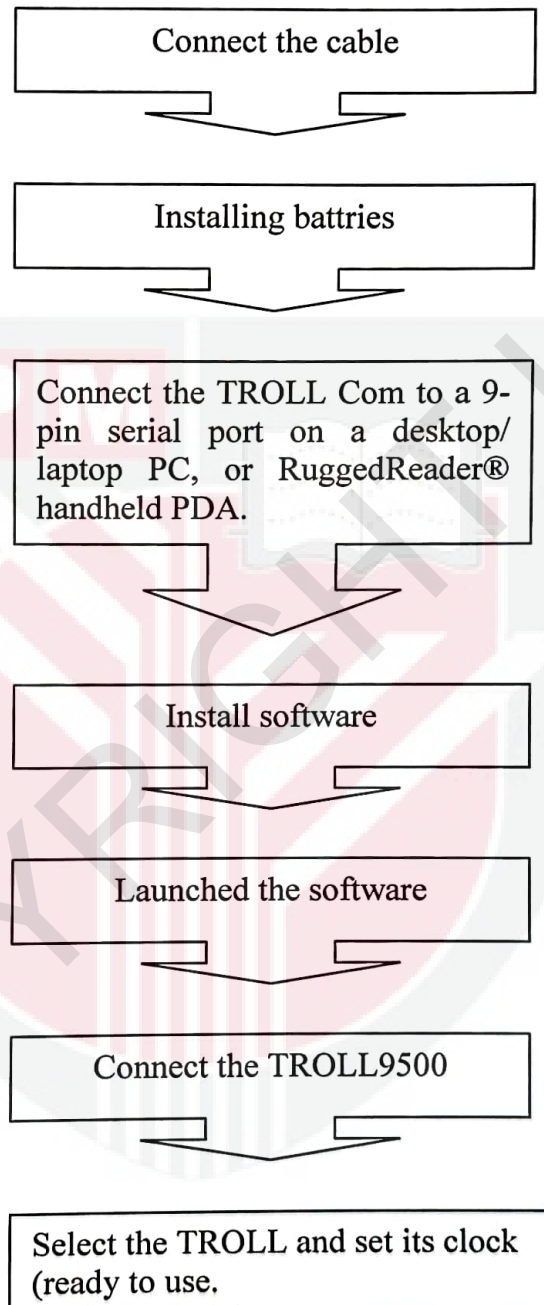
3.5 Getting Started The Multi-Parameter Troll 9500

Firstly, the cable was connected and the red dustcaps was removed. Then the TROLL 9500 was inserted into the cable connector. After that, push, twist, and click to lock. The “click” insures the cable is securely attached. Then the TROLL Com™ was connected to the other end of the cable.

The second part was installing batteries. Battery was removed from its compartment cover. Then, a battery was inserted with replace cover and tightens. After that, the TROLL Com was connected to a 9-pin serial port on a desktop/ laptop PC, or RuggedReader® handheld PDA. Then, Rugged Reader Pocket-Situ™ 4 is pre-installed. After installed the software, there would be launched the software followed by the Connect to the TROLL9500.

Finally, the device appears in the Navigation tree below the COM port. The TROLL was selected and set its Clock. After that, MULTI - PARAMETER TROLL 9500 can be use.

3.5.1 Process of getting started THE MULTI – PARAMETER TROLL 9500



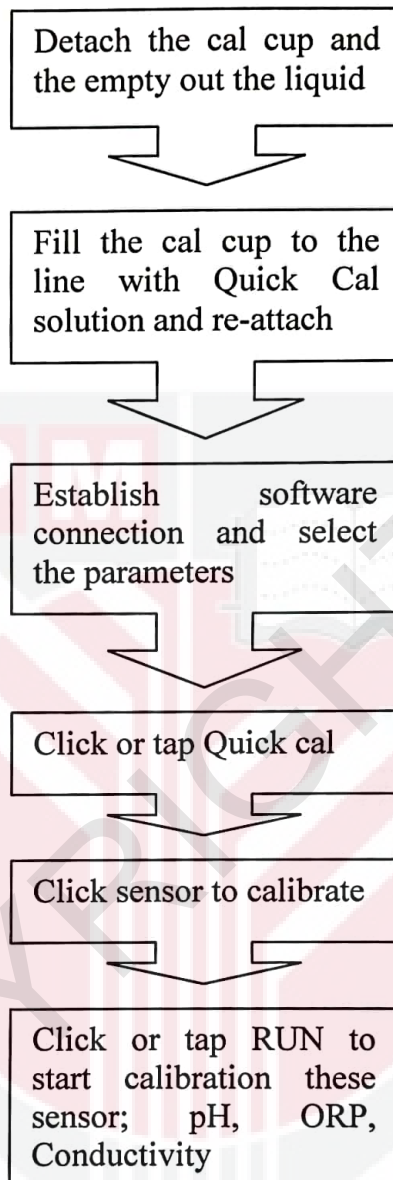
3.6 Calibration Technique

The calibration technique divided into two parts. The first part is about using the Quick-cal which is the fastest way to calibrate pH, Conductivity, Polagraph D.O and ORP. Quick Cal is not available for these sensors; Nitrate, Ammonium, Chloride, Turbidity, Optical D.O. Traditional Calibrations should be performed for best results from these sensors. The second part is about using the calibration solutions which is traditional calibrations to calibrate the water quality sensors.

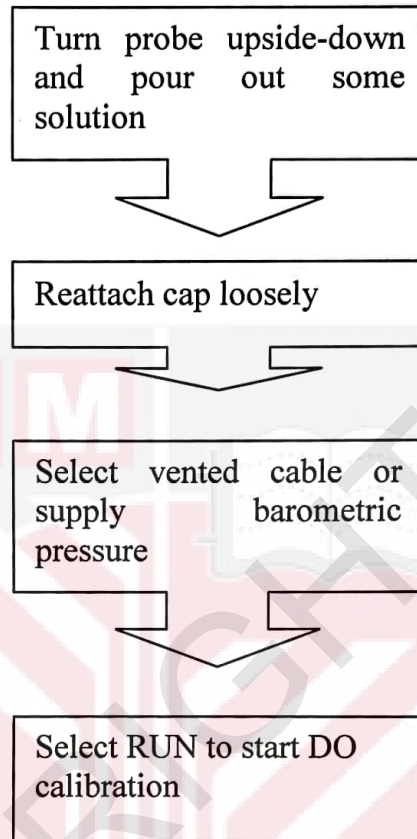
3.6.1 Quick-cal the Basic Water Quality Sensors

MP TROLL 9500 with basic sensors was installed (pH, ORP, polarographic D.O, Conductivity). Plugs in any unused ports. The Quick Cal solution was shaking before used. There are two steps for doing the calibration process which has been showed in the flow chart below.

3.6.1.1 Process of Quick-cal The Basic Water Quality Sensors:



3.6.1.2 Process of Quick-cal the Basic Water Quality Sensors for Polagraphic DO;



3.6.2 Calibration Solution

For some sensor, the Quick cal is not available. A traditional is recommended. To calibrate, the sensor in the Parameters list were selected and the **Calibration** button was selected to launch a Calibration Wizard. Ammonium chloride (NH_4CL), Sodium nitrate (NaNO_3), and Ammonium chloride (NH_4CL) solutions certificated to N.I.S.T. standards are supplied in the In-Situ Calibration Kits. For turbidity calibration, a range of polymer suspensions was available individually from In- Situ Inc. for calibrating any expected turbidity range. They has been diluted with turbidity-free water achieved other NTU values. It is definitely different with chloride, ammonium and nitrate calibration. It is because the turbidity polymer suspension must undergo to be diluted before they can run the calibration process. The turbidity polymer suspension consists of;

- 10 NTU
- 100 NTU
- 1000 NTU

Calibration procedure (Chloride, Ammonium, Nitrate):

The Cal Cup and front end of the MP TROLL 9500 was rinsed with clean water. Then, the Cal Cup was filled with the selected calibration solution until the fill line. (Begin with the lowest concentration when performing a multi-point calibration.). After that, the front end of the MP TROLL 9500 was inserted into the open end of the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening. After that, the MP TROLL 9500 was connected to a PC and established a connection in Pocket-Situ then the MP TROLL 9500 in the Navigation tree was selected. The number of calibration points for this calibration, and the

concentration (ppm) of the calibration solution for each point was selected. After that, **NEXT** button was selected to continue.

In the next screen, to begin the stabilization, **RUN** button was selected. The displayed will continuously update as readings are taken and compared against the stabilization criteria. (Wait until **STABLE** is displayed. The calibration proceeds automatically to the next screen.). After that, the cal cup was removed and the first solution was discarding. Then the cal cup and the front end of the instrument were rinsed with clean water, followed by a rinse in the next calibration solution, and attach to the instrument.

RUN button was selected to begin the stabilization for cal point 2 (Status indicators and controls are the same as for cal point 1. Again wait for **STABLE** status.). The final screen of the Calibration wizard shows the calculated sensor slope and offset. Then, **FINISH** button was selected to program the sensor with the newly calculated calibration coefficients and ready to use.

Turbidity calibration procedure:

Polymer suspension was diluted to achieve the volume that was needed.

For example, 10 ml;

$$10 \times V_i = 1 \times 250 \text{ ml}$$

$$\begin{aligned} V_i &= (1 \times 250 \text{ ml}) / 10 \\ &= 25 \text{ ml} \end{aligned}$$

After that, the front end of the MP TROLL 9500 was rinsed with the clean water. (Shake well to remove the rinse water; dry external surfaces (not the optical

windows) with the clean tissue.). Then, the selected calibration standards were poured which was already diluted into the beaker and the MP TROLL 9500 was inserted into the solution. After that, the MP TROLL 9500 was connected to a PC and established a connection in Pocket-Situ. The Parameters of turbidity were then selected.

After that, the calibrate solution and type of calibration and the operational range target was selected. The ranges are suggestions only; a 1- to 4-point calibration may be performing any range, using any standards. Then, to continue, the **NEXT** button was selected. In the next screen, the number of calibration points for this calibration, and turbidity value (in NTU) of the calibration solution for each point was selected. One to four points (solutions) may be selected for any operational range target selected in the previous screen.

When performing a multi-point calibration, cal point 1 must be taken in a standard with a value of 0 NTU. Clear water has been use for this. To continue, the **NEXT** button was then selected. After that, when the sensor was situated in the calibration medium, **RUN** button was selected to begin the stabilization. The display will continuously update as readings are taken and compared against the stabilization criteria (Wait until **STABLE** is displayed. The calibration proceeds automatically to the next screen.). Then the first solution was discarding. The beaker and the front end of the instrument were rinsed thoroughly. The beaker was rinsed with the second solution, and the MP TROLL 9500 was inserted as before.

For the second calibration point the **RUN** button was selected to begin the stabilization (Status indicators and controls are the same as first calibration point. Again wait for **STABLE** status.). The final screen of the Calibration wizard shows the calculated sensor slope and offset. **FINISH** button was selected to program the sensor with the newly calculated calibration coefficients and ready to use.

3.7 PROFILING

All models of the MP TROLL 9500 include a software feature called the Profiler that delivers instant real-time readings on all available channels. Readings are continuously updated as long as the Profiler is running. This provides a convenient way to characterize surface waters using a hand-held controller-running Pocket-Situ.

3.7.1 Profiler Features

Auto detects- the software automatically identifies all properly connected sensors and continuously updated readings from all available channels. The optional data logged to the connected PC. Then, the optional started the device in the Profiler mode and optional selectable Profiler interval (2-60 seconds).

3.7.2 Starting the Profiler

MP TROLL 9500 with water quality sensors installed and calibrated. Quick-Connect Submersible, ComIT or comm cables, PDA running Pocket-Situ were needed for getting started the profiler.

Then, the MP TROLL 9500 was connected to a host PC and established communication in Pocket-Situ. The MP TROLL 9500 in the Navigation tree was

then selected. The software automatically detected the installed sensor and the installing process was started. After that, in the Navigation tree the parameter was selected and each active channel was read sequentially (Up to 8 channels can be shown.).

Readings are updated approximately every 2 seconds as the Profiler cycles through the available channels in turn. The currently selected measurement unit is shown below each reading. A window without a reading indicates the channel is not available to read, usually because there is no sensor installed in the port.

3.7.3 Logging Profiler Data

Profiler data were logged to the connected PC while in the 'Meter' view.

- i. **Snapshot:** To log a single set of profiler readings, click or tap the SnapShot button in the 'Meter' view.
- ii. **Continuous:** To log continuous readings, click or tap the continuous button in the 'Meter' view. Readings will be logged until we cancel the operation by clicking **Stop Log**

3.7.4 Transfer Data from the RuggedReader to a PC

The RuggedReader to a PC, Microsoft® ActiveSync™ was installed on the desktop or laptop PC for transferring data. It is on the Pocket PC Companion CD or may be obtained from Microsoft (www.microsoft.com/windowsmobile).

The data transferred from the RuggedReader to a PC, when prompted by ActiveSync, the Rugged Reader was connected to the PC (USB cable) and **Guest**

partnership was installed. After that, Win-Situ 4 on the same PC was installed from the Win-Situ/Pocket-Situ CD and Pocket-Situ from the Win-Situ/Pocket-Situ CD also installed to the same folder. Briefly disconnect the PocketSync utility if there does not start automatically and then reconnect the USB cable. ActiveSync starts and PocketSync begins to synchronize.

PocketSync automatically copy all the data files from the RuggedReader's nonvolatile memory to the Win-Situ \ Data folder on the desktop PC.

- .bin files (logged data)
- .flo files (low-flow data)
- .html files (calibration reports)

After the transfer, Data Folder branch of the Navigation tree (an instrument connection is not needed.) was opened the data files and automatically launched Win-Situ

CHAPTER 4

RESULTS

4.1 Introduction

Generally, this chapter shows the results of this study based on the data collected at UPMKB (S1, S2, S3, S4, S5 and S6) for a month. The figure below shows the data collected around UPMKB from 13th October 2006 to 20th October 2006.

4.2 pH

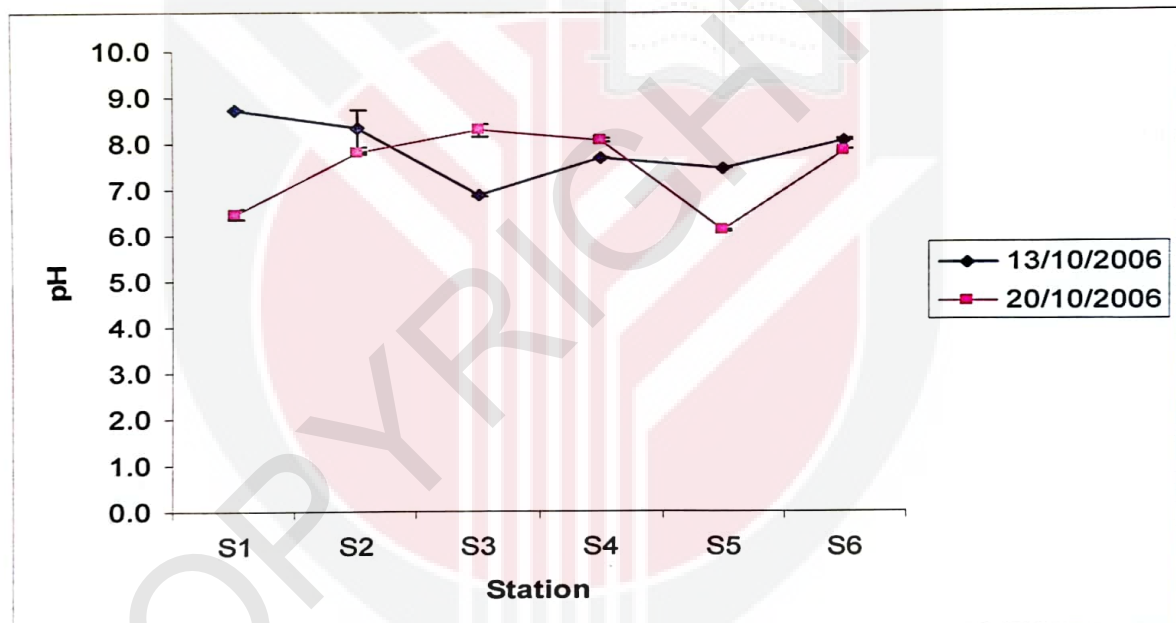


Figure 4.1: pH level in water for S1 to S6

Figure 4.1 shows that the pH level on the 13th October 2006 ranged from 6.89 ± 0.03 to 8.73 ± 0.01 . For sampling carried out on the 20th October 2006, the pH water level ranged from 6.10 ± 0.03 to 8.29 ± 0.12 . The graph shows the pH for each station always keep in changing from one station to the next station.

4.3 Temperature

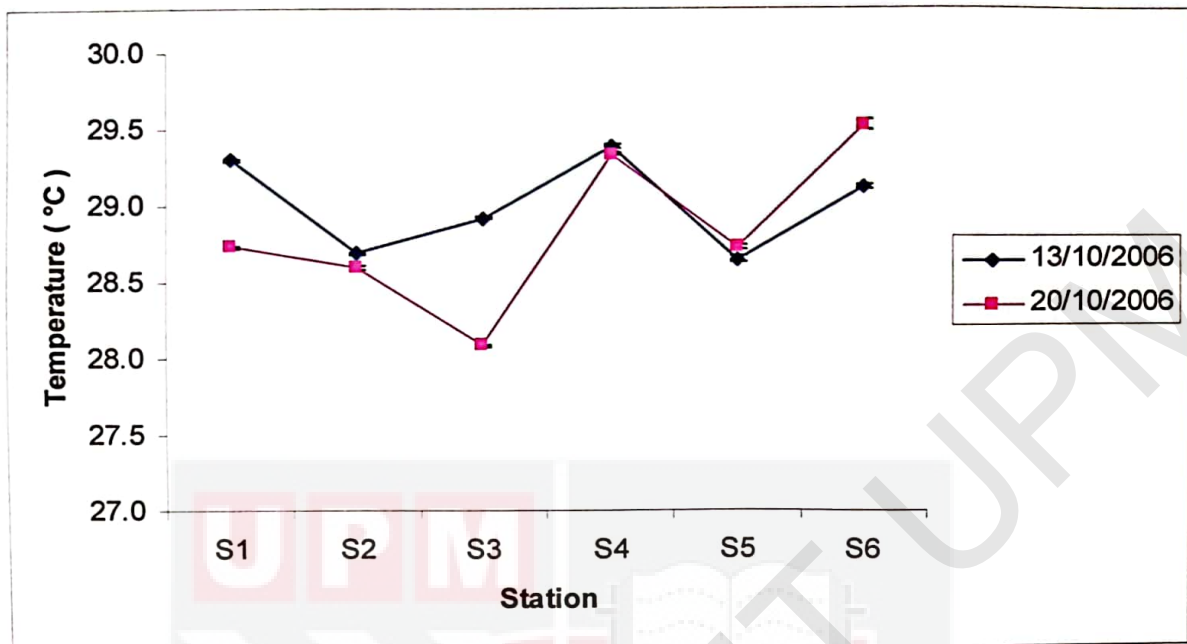


Figure 4.2: Temperature of water for S1 to S6

Figure 4.2 shows that the temperature of the water in the stations on the 13th October 2006 ranged from 28.60 ± 0.01 °C to 29.39 ± 0.01 °C. For the sampling carried out on the 20th October 2006, the temperature ranged from 28.08 ± 0.01 °C to 29.52 ± 0.03 °C.

4.4 Total Dissolved Solid

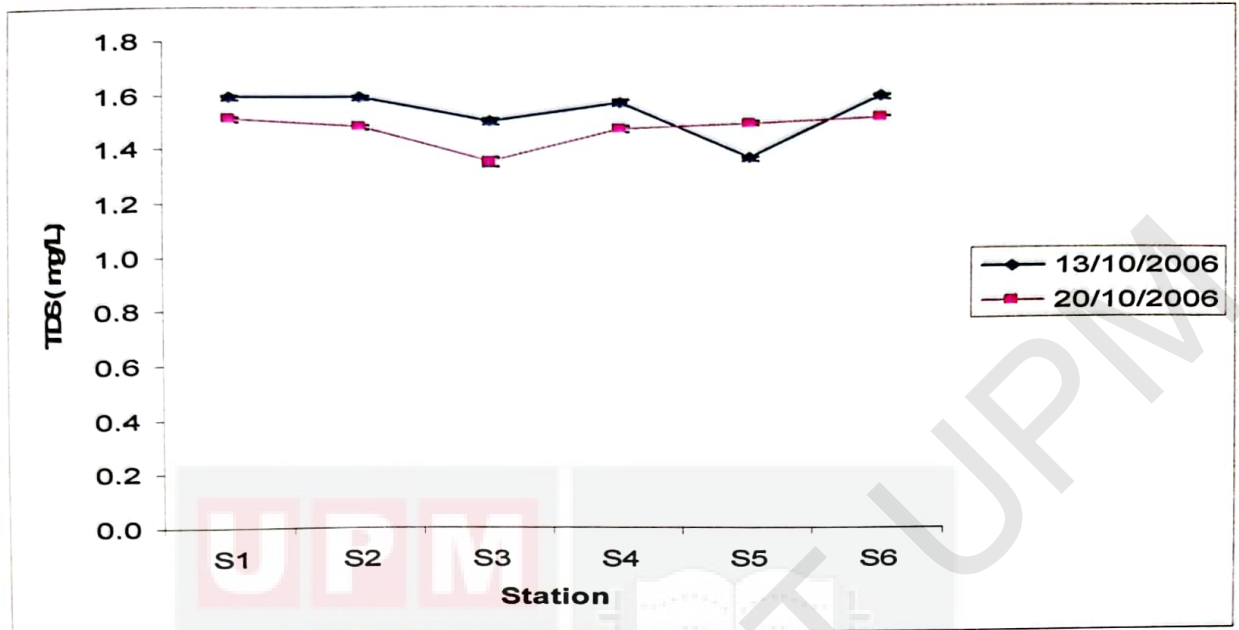


Figure 4.3: Total Dissolved Solid level in water for S1 to S6

Figure 4.3 shows that the Total Dissolved Solid level in the water of the stations on the 13th October 2006 ranged from 1.36 ± 0.01 mg/L to 1.59 ± 0.01 mg/L. While for the sampling carried out on the 20th October 2006 it ranged from 1.35 ± 0.01 mg/L to 1.51 ± 0.01 mg/L.

4.5 Dissolved Oxygen

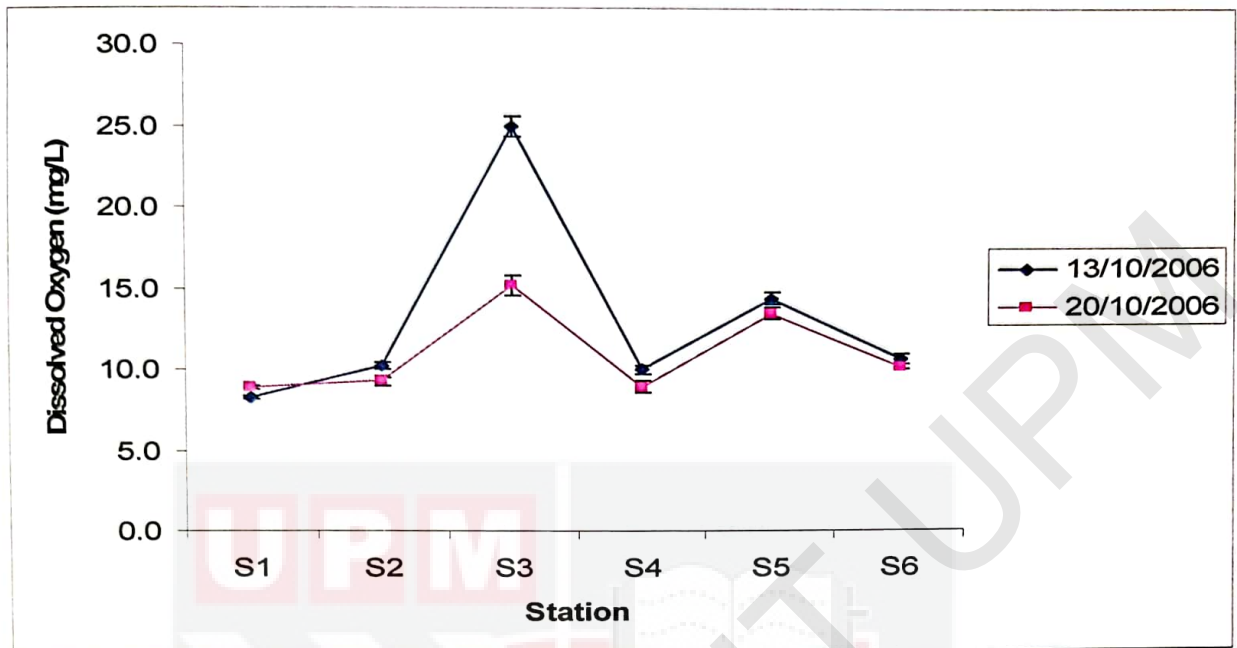


Figure 4.4: Dissolved Oxygen in water for S1 to S6

Figure 4.4 shows that the Dissolved Oxygen level in the water of the stations on the 13th October 2006 ranged from 8.23 ± 0.10 mg/L to 24.94 ± 0.63 mg/L. For the sampling carried out on the 20th of October 2006 it ranged from 8.91 ± 0.10 to 15.12 ± 0.63 mg/L. The graph shows that the concentration of Dissolved Oxygen for both day at S3 increase a bit which is from 10.20 ± 0.23 mg/L to 24.94 ± 0.63 mg/L on the 13th October 2006 and from 9.24 ± 0.23 to 15.12 ± 0.63 mg/L on the 20th October 2006.

4.6 Turbidity

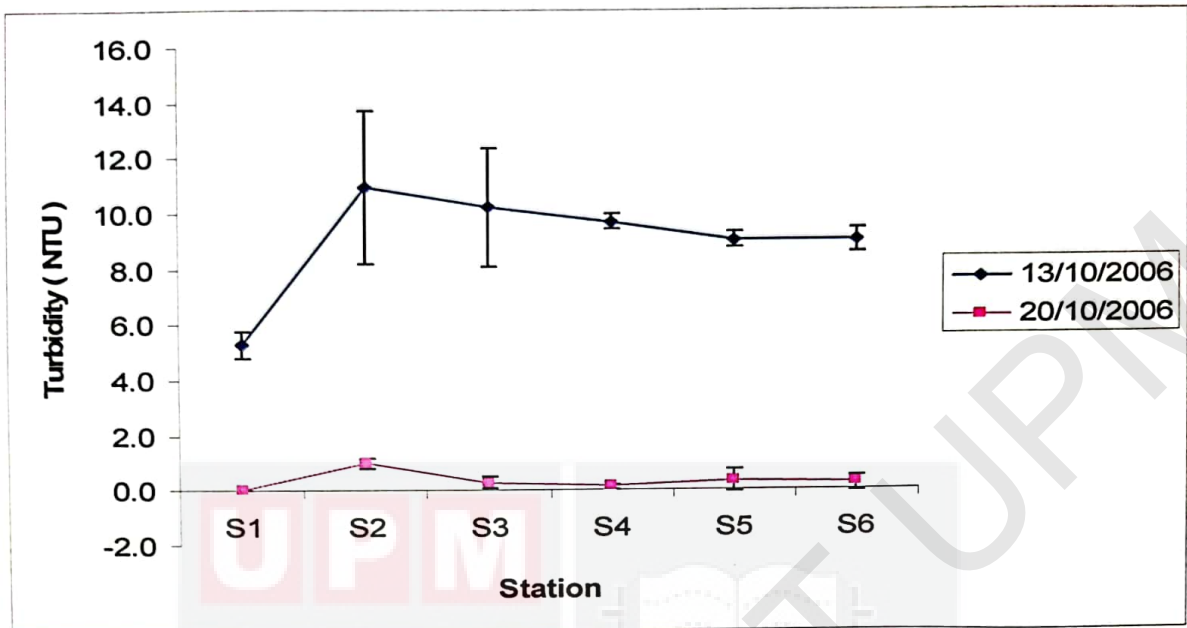


Figure 4.5: Turbidity level in water for S1 to S6

Figure 4.5 shows that the turbidity of the water in the stations on the 13th October 2006 ranged from 5.29 ± 0.48 NTU to 10.98 ± 2.75 NTU. While for the sampling carried out on the 20th October 2006 it ranged from 0.00 ± 0.00 NTU to 0.98 ± 0.19 NTU. Generally the turbidity of the stations on the 13th October 2006 decreased remarkably by 20th October 2006.

4.7 Chloride

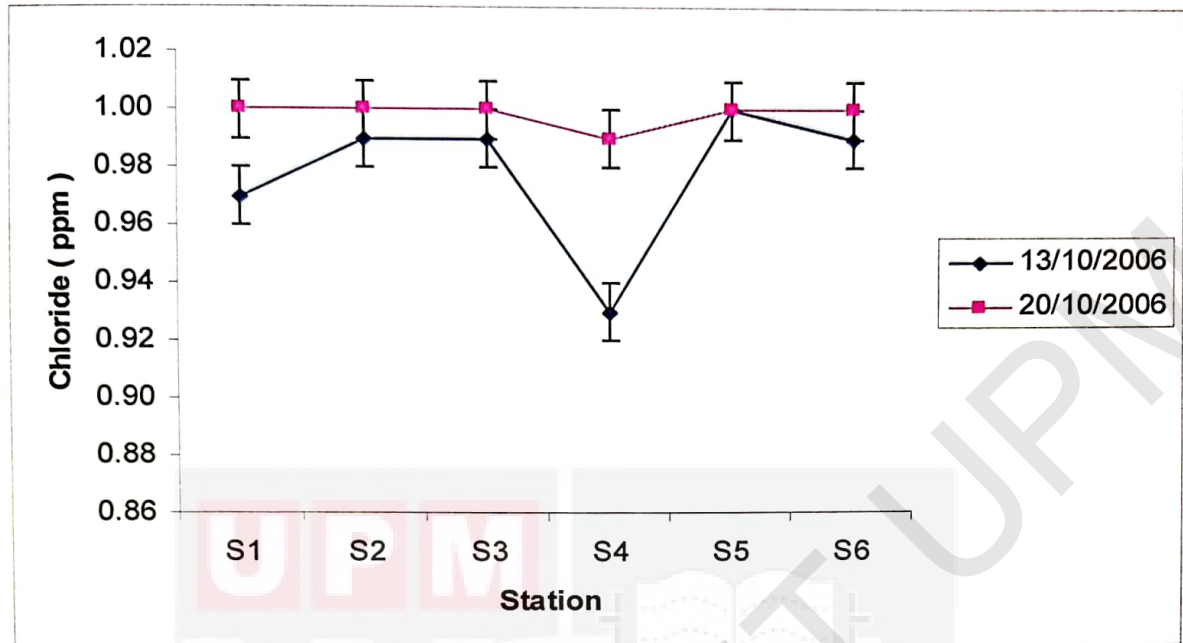


Figure 4.6: Chloride in water for S1 to S6

Figure 4.7 shows that the Chloride of the water in the stations on the 13th October 2006 ranged from 0.93 ± 0.01 ppm to 0.99 ± 0.02 ppm. For the sampling carried out on the 20th October 2006 it ranged from 0.99 ± 0.01 ppm to 1.00 ± 0.01 ppm. The graph shows that the concentration of Chloride at S4 decreased a bit which is from 0.99 ± 0.02 ppm to 0.93 ± 0.08 ppm on the 13th October 2006.

4.8 Nitrate

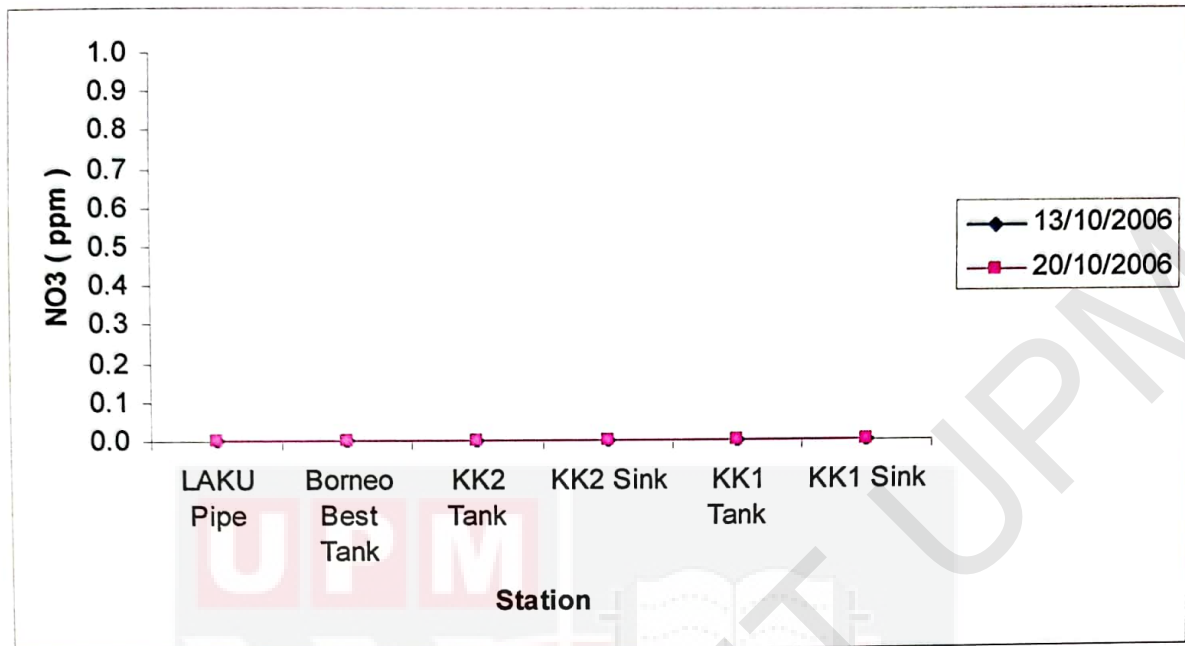


Figure 4.7: Nitrate in water for S1 to S6

Figure 4.7 shows that the Nitrate level on the 13th October 2006 and 20th October 2006. The nitrate contents of the stations regardless of sampling date were negligible.

4.9 Ammonia

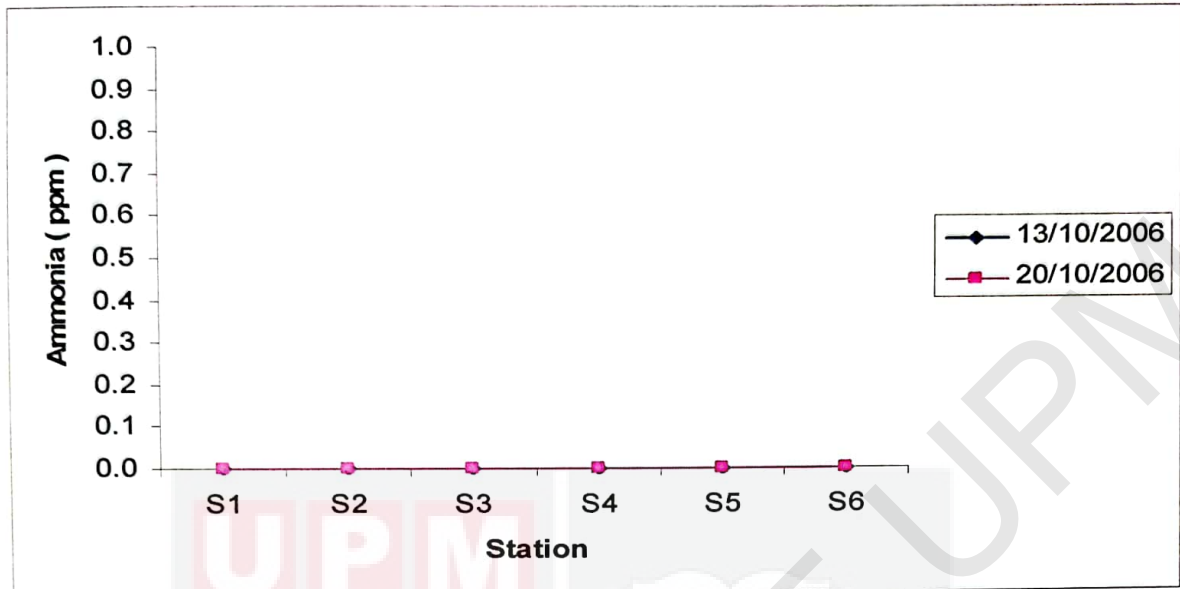


Figure 4.8: Ammonia level at water for S1 to S6

Figure 4.8 shows that the Ammonia level on the 13th October 2006 and 20th October 2006. The Ammonia contents of the stations regardless of sampling date were negligible.

4.10 Conductivity

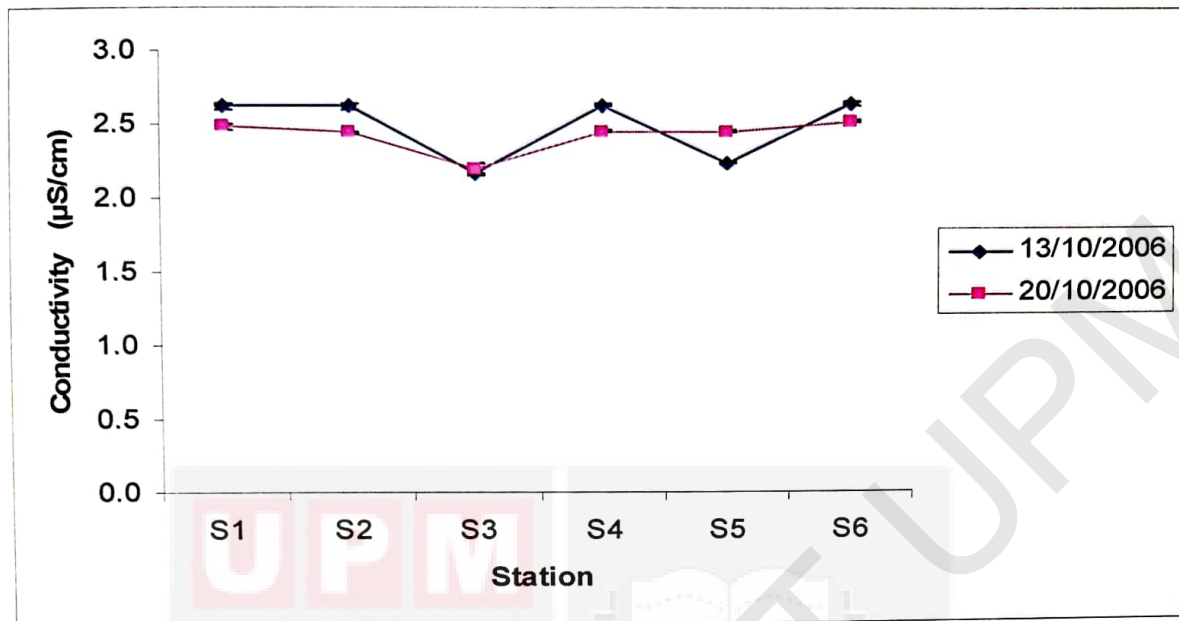


Figure 4.9: Conductivity in water for S1 to S6

Figure 4.9 shows that the Conductivity level in the water of the stations on the 13th October 2006 ranged from $2.16 \pm 0.01 \mu\text{S}/\text{cm}$ to $2.64 \pm 0.01 \mu\text{S}/\text{cm}$. While for the sampling carried out on the 20th October 2006 it ranged from $2.20 \pm 0.02 \mu\text{S}/\text{cm}$ to $2.52 \pm 0.01 \mu\text{S}/\text{cm}$.

CHAPTER 5

DISCUSSION

5.1 Introduction

All samples were collected around UPMKB. The result will be discussed in this chapter. There are altogether 9 parameter value will be discuss.

5.2 pH

pH literally means 'power of hydrogen'. According to the WHO Guidelines for drinking water Quality Standard, the normal pH range for drinking water is between 6.5 and 9.0. In the previous chapter (Figure 4.1), on the 13th October 2006, Station 1 had the highest reading compare to the other stations, while Station 3 tank gave the lowest reading which was 6.89 compared to the other stations. Meanwhile, on the 20th October 2006, Station 3 had showed the highest reading which was 8.29 and the lowest value at Station 5 (6.10 ± 0.03). Except for Station 5 (20th October 2006), all the pH result were below the standard limit. This may be because of the presence of dissolved solids and dissolved gasses in the water. In the previous chapter, DO reading at Station 5 exceeded the standard limit of 13.43 ± 0.34 . This may be because of the pH fluctuation due to the presence of dissolved solid and dissolved gases. However, the water is considered good and safe for human consumption. The situation may be avoided by piping system from corroded and the incrustation can be minimized which according to Dye *et al.* (1971), these processes actually may cause considerable damage to the water supply system, result from complex interactions between pH and other parameters such as total dissolved solids and temperature.

5.3 Temperature

Water temperature plays an important role in water chemistry, which in turn influences the biological activity and growth of aquatic organisms. In the previous chapter (Figure 4.3) the temperature showed uniform readings at all the stations. Besides that, the temperature was slightly high (28.31 – 29.52 °C) for both days of sampling. This may be because the sampling was carried out during the day. According to Peavy *et al.* (1985), temperature also relates to other parameters such as high water temperature which greatly affects the biological activity and the rate of chemical reaction. Warm water holds less oxygen than cold water; the maximum amount of oxygen that can be dissolved in the water decreases as water temperature increases. According to Gupta (2000), a rise in temperature of the water accelerates chemical reactions, reduces the solubility of gases, amplifies taste and odor and elevates the metabolic activity of organisms.

5.4 Total Dissolved Solid

TDS is a measure of the amount of material dissolved in water. Besides, TDS is used to estimate the quality of drinking water, because it represents the amount of ions in the water. The figure 4.4 shows TDS readings were almost uniform at all the stations. This shows the result at every station does not have larger differences between others. According to WHO, the standard limit of TDS is 1000 mg/L. Due to this, the TDS concentration of drinking water in UPMKB is below the permissible limit. But the difference between the stations and sampling date might be due to duration and other related activities. On the whole the TDS in the drinking water of UPMKB has resulted free from any dissolved substances which are undesirable in water.

5.5 Dissolved Oxygen

The figure 4.5 had showed that the Dissolved Oxygen increase due to the decreasing of the temperature. According to Pierce *et al.* (2002), Dissolved Oxygen is highly dependent on temperature and atmospheric pressure. An increase in temperature causes a decrease in the amount of oxygen that can dissolve in water. The figure 4.4 shows, Dissolved Oxygen increased when temperature decreased and Dissolved Oxygen decreased when temperature increased. Beside that, Station 3 gave the highest reading which was 24.94 mg/L and 9.24 mg/L for 13th October 2006 and 20th October 2006 respectively. This may be due to presence of algae which is a waste product of photosynthesis (oxygen). The same reason also trues the Station 5 the 2 dates of samplings. However, all the values of the stations were within the limit WHO which is 10 mg/L (Pierce *et al.*, 2000). In addition, this observation may be because the BOD level in the water was low and free from microscopic organism but if any, the microbes may exist in small amount. On the whole, the water is safe for drinking.

5.6 Turbidity

Turbidity is not a measure of suspended solids; it is a measure of their light-scattering abilities. According to the standard limit of WHO, a turbid water is 5 NTU. The turbidity on 20th October 2006 was below the standard limit while that of 13th October 2006 exceeded WHO's limit. The water was found to be less clean and cloudy. Besides that, the water may contain a small amount of suspended matter like clay, silt, organic matter, phytoplankton and other microscopic organisms. However, on the 20th October 2006, the reading taken has resulted within in this standard limit. Because of this, the water is considered clean but still contain small amount of

organic matter , clay, silt, and other microscopic organisms which even though dangerous, purification is needed.

5.7 Chloride

Chloride is highly soluble ion in water and can potentially be present in high concentrations. According to the drinking water standard (WHO), typical chloride value is 250 ppm. The figure 4.7 in the previous chapter shows that both results were below this limit. This may showed the water considered safe to drink because it is believe that the water is free from chloride toxicity which may cause heart failure, eyes/nose irritation; stomach discomfort.

5.8 Nitrates

Nitrate has been used as an indicator for the presence of organics. The figure 4.8 shows that no reading was taken after two times sampling. This may prove that there was no organics in the treated drinking water. According to the NAP (1981), the maximum acceptable concentration of nitrate in drinking water is 45 mg/L. From this, it can be concluded that, the nitrate values are within the limit of this and as such the water is safe for drinking.

5.9 Ammonia

From the graphs which are in the previous chapter, there was no reading taken after two times sampling. Due to this, no ammonia was detected from any of the stations tested. This may due to the absence of the faecal pollution. According to the ISO (1986), ammonia may be present in drinking water as a result of disinfection with chloramines. Since there no ammonia was detected it suggests that disinfection

process with chloramines did not cause ammonia accumulation. On the whole, this drinking water is free from ammonia and this has made the water safe to consume and no human health effect which is related with ammonia.

5.10 Conductivity

Electric conductivity measures the ability of material to carry an electric current. According to the Alley (1976), ion that have a major influence on the conductivity of water are H^+ , Na^+ , K^+ , Mg^{2+} , Ca^{2+} and certain metals. Due to this, conductivity was known having relation with TDS and indirectly related turbidity. From the discussion above, the TDS and Turbidity in the water were within the acceptable standard limit. Due to this, conductivity in the water is good and makes the water safe and good to drink because it does not have much dissolved solid in the water which may affect the ability of a material to carry an electric current.

CHAPTER 6

CONCLUSION

From the studied that has being conducted, all parameters that have been tested shows Drinking Water quality of University Putra Malaysia, Bintulu Campus is safe because each parameter are still below the standard limit that has fixed by WHO except for turbidity. Drinking Water at UPMKB also believed does not have trace elements and minerals (if any, its may appear in small amount which not harm for human to consume) which may be toxic and free from any dissolved substances which are undesirable in water. Other than that, this study has showed most valuable information and can be references for the next research about Drinking water quality at UPMKB.

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APPENDICES

APPENDIX A

Mean and standard deviation of Drinking Water Quality of UPMKB

Table A1: Mean and standard deviation of pH in the drinking water of UPMKB

Date	13 th October 2006	20th October 2006
Station	pH	pH
Station 1	8.73 ± 0.01	6.45 ± 0.12
Station 2	8.33 ± 0.40	7.79 ± 0.03
Station 3	6.89 ± 0.03	8.29 ± 0.12
Station 4	7.69 ± 0.01	8.07 ± 0.03
Station 5	7.47 ± 0.01	6.10 ± 0.03
Station 6	8.09 ± 0.02	7.85 ± 0.04

Table A2: Mean and standard deviation of Temperature in the drinking water of UPMKB.

Date	13th october 2006	20th october 2006
Station	Temperature (°C)	Temperature (°C)
Station 1	29.31 ± 0.01	28.73 ± 0.01
Station 2	28.70 ± 0.01	28.60 ± 0.01
Station 3	28.92 ± 0.01	28.08 ± 0.01
Station 4	29.39 ± 0.01	29.34 ± 0.01
Station 5	28.60 ± 0.02	28.72 ± 0.01
Station 6	29.11 ± 0.01	29.52 ± 0.03

Table A3: Mean and standard of TDS in the Drinking water of UPMKB

Date	13th October 2006	20th October 2006
Station	TDS (Mg/L)	TDS (Mg/L)
Station 1	1.59 ± 0.01	1.51 ± 0.01
Station 2	1.59 ± 0.01	1.48 ± 0.01
Station 3	1.50 ± 0.01	1.35 ± 0.02
Station 4	1.57 ± 0.01	1.47 ± 0.01
Station 5	1.36 ± 0.01	1.49 ± 0.01
Station 6	1.59 ± 0.01	1.51 ± 0.01

Table A4: Mean and standard deviation of Dissolved Oxygen in the Drinking water of UPMKB.

Date	13th October 2006	20th October 2006
Station	Dissolved Oxygen (mg/L)	Dissolved Oxygen (mg/L)
Station 1	8.23 ± 0.10	8.91 ± 0.10
Station 2	10.20 ± 0.23	9.24 ± 0.23
Station 3	24.94 ± 0.63	15.12 ± 0.63
Station 4	9.98 ± 0.24	8.90 ± 0.37
Station 5	14.38 ± 0.34	13.43 ± 0.34
Station 6	10.62 ± 0.27	10.13 ± 0.17

Table A5: Mean and standard of Turbidity in the Drinking water of UPMKB

Date	13th of October 2006	20th of October 2006
Station	Turbidity (NTU)	Turbidity (NTU)
Station 1	5.29 ± 0.48	0.00 ± 0.00
Station 2	10.98 ± 2.75	0.98 ± 0.19
Station 3	10.27 ± 2.14	0.29 ± 0.21
Station 4	9.70 ± 0.28	0.13 ± 0.08
Station 5	9.05 ± 0.29	0.35 ± 0.40
Station 6	9.02 ± 0.40	0.25 ± 0.29

Table A5: Mean and standard deviation of Chloride in the Drinking water of UPMKB.

Date	13th of October 2006	20th of October 2006
Station	Chloride (ppm)	Chloride (ppm)
Station 1	0.97 ± 0.04	1.00 ± 0.01
Station 2	0.99 ± 0.02	1.00 ± 0.01
Station 3	0.99 ± 0.02	1.00 ± 0.01
Station 4	0.93 ± 0.08	1.00 ± 0.01
Station 5	1.00 ± 0.01	1.00 ± 0.01
Station 6	0.99 ± 0.01	1.00 ± 0.01

Table A6: Mean and standard deviation of Nitrate in the Drinking water of UPMKB.

Date	13th of october 2006	20th of october 2006
Station	Nitrate (ppm)	Nitrate (ppm)
Station 1	ND	ND
Station 2	ND	ND
Station 3	ND	ND
Station 4	ND	ND
Station 5	ND	ND
Station 6	ND	ND

ND= Not detectable

Table A7: Mean and standard deviation of Ammonia in the Drinking water UPMKB.

Date	13th of october 2006	20th of october 2006
Station	Ammonia (ppm)	Ammonia(ppm)
Station 1	ND	ND
Station 2	ND	ND
Station 3	ND	ND
Station 4	ND	ND
Station 5	ND	ND
Station 6	ND	ND

ND= Not detectable

Table A8: Mean and standard deviation of Conductivity in the Drinking water of UPMKB

Date	13th of october 2006	20th of october 2006
Station	Conductivity ($\mu\text{S/cm}$)	Conductivity ($\mu\text{S/cm}$)
Station 1	2.62 \pm 0.02	2.48 \pm 0.02
Station 2	2.62 \pm 0.02	2.44 \pm 0.01
Station 3	2.16 \pm 0.01	2.20 \pm 0.03
Station 4	2.63 \pm 0.01	2.45 \pm 0.01
Station 5	2.24 \pm 0.01	2.46 \pm 0.01
Station 6	2.64 \pm 0.01	2.52 \pm 0.01

APPENDIX B

Sampling stations for Drinking Water Quality of UPMKB



Figure B1: LAKU Pipe (S1)



Figure B2: Reservoir water tank UPMKB (S2)



Figure B3: KK2, KK1 Blue Tank (S3 and S5)

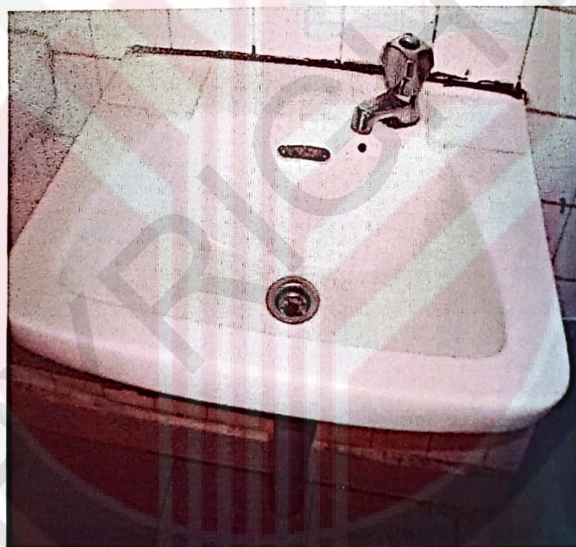


Figure B3: KK2, KK1 Sink (S4 and S6)

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled “Physicochemical Properties at Drinking Water in University Putra Malaysia, Bintulu Campus, Bintulu Sarawak” by the supervisor in joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, University Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.



ENZUZAN NYELANG

Date: 4th May 2007.