AQUAPHONIC 4CHUS WASTEWATER TREATMENT

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ABSTRACT

The increasing pollution of water resources in Malaysia over the past few years is being concern. If water is not properly maintained from now, the country would lose our water resources by 2020. As example, the water crisis in Selangor began to occur as a result of the quantity of water that reaches the standard class 1, 2 and 2b, which currently only less than 25 percent of the total 142.38 miles. This shows that only 49 miles of river in Selangor are suitable to be treated due to the total water quality that meets the highest standards of clean drinking water. The purpose of this study was to determine the wastewater characteristics such as pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS) and Ammonium Nitrogen (NH_3–N), to determine the effect of 0, 2, 4 and 6 hours of hydraulic retention time (HRT) treatment on wastewater quality and to determine the growth of adopted vegetable during treatment. Aquaphonics system is used to treat wastewater from catfish (*Clarias Batrachus*). This aquaphonics system provides many benefits to our environment and society. Among the advantages of this aquaphonics system are it can preserve and protecting our environment from pollution, contribute to the society in preventing the community from any harm and danger of chemicals and can reduce cost life since this aquaphonics system can producing fish and vegetable that are free from chemical. Aquaphonics system allows us to replace traditional agriculture where a used fertilizer which is contains many chemicals. Water resources pollution which is particularly rivers and lakes in Malaysia can be reduced. The results showed that the pH value is at a safe level of 6.5 - 7.5 throughout the study. It can be concluded that the pH can be controlled depending on the rate of the wastewater temperature in the aquarium and the reaction between the unclean fish and vegetables. The value of BOD, COD and NH_3 -N also increase in first three weeks of study. The value o all parameter was decrease where the BOD value from 41.7 mg/L to 33.5 mg/L, the COD value also from 203 mg/L to 102 mg/L, the TSS value from 148 mg/L to 29 mg/L and the NH_3-N value from 2.53 mg/L to 1.29 mg/L. The value of this all parameters decreases and become better start at the fourth week of the study. The growth mustard (*brasica fuller var chinensis*) showed a decline in the early stages but got better start in week four. This is because some mustard dies due to the un-ability to hold water when conducting the testing of effect of hydraulic retention time (HRT). The collected data can be applied and restored to make the better results and outcome in future. This data can be used in our agricultural sector.

ABSTRAK

Peningkatan pencemaran sumber air di Malaysia sejak beberapa tahun kebelakangan ini amat membimbangkan. Jika sumber air tidak dijaga dengan baik, negara mungkin akan kehilangan sumber air bersih menjelang 2020. Sebagai contoh,krisis air di Selangor mula berlaku akibat kuantiti air bersih iaitu yang mencapai standard kelas 1,2 dan 2b yang ketika ini hanya tinggal kurang daripada 25 peratus daripada jumlah keseluruhan 142.38 kilometer. Ini menunjukkan bahawa hanya 49 kilometer dari jumlah keseluruhan sungai ynag mempunyai kualiti air menepati piawaian air minuman bersih iaitu sesuai untuk dirawat. Tujuan kajian ini adalah untuk menentukan ciri air sisa seperti pH, BOD, COD, TSS dan NH_3-N, menentukan kesan 0, 2, 4 dan 6 jam masa tahanan hidrolik (HRT) rawatan terhadap kualiti air sisa dan menentukan pertumbuhan sayur yang diguna pakai semasa rawatan. Sistem akuaponik digunakan untuk merawat air sisa daripada ikan keli (*Clarias Batrachus*). Sistem akuaponik ini memberi banyak manfaat kepada alam sekitar dan masyarakat. Antara kelebihan sistem akuaponik ini ialah ia dapat memelihara dan melindungi alam sekitar daripada pencemaran, memelihara komuniti alam daripada bahaya bahan kimia dan dapat mengurangkan kos kehidupan kerana sistem akuaponik ini dapat menghasilkan sayur dan ikan yang bebas dari bahan kimia. Sistem akuaponik ini membolehkan kita menggantikan pertanian secara tradisional dimana banyak bahan kimia digunakan seperti baja yang kaya dengan ammonia dan racun rumpai. Dengan cara ini pencemaran sumber air di Malaysia terutamanya sungai dan juga tasik dapat dikurangkan. Keputusan menunjukkan nilai pH berada pada tahap selamat iaitu 6.5 – 7.5 sepanjang kajian dijalankan. Ini dapat disimpulkan bahawa nilai pH dapat dikawal bergantung kepada kadar suhu air sisa di dalam akuarium dan tindakbalas antara najis ikan dan juga sayur yang digunakan. Nilai BOD, COD dan NH_3-N juga dilihat meningkat pada tiga minggu awal kajian dan beransur baik bermula pada minggu keempat kajian. Ini menunjukkan sayur yang digunakan mula memberi kesan yang baik apabila mempunyai akar yang banyak untuk melakukan proses rawatan air sisa dengan baik. Nilai TSS juga menurun memandangkan banyak air sisa rawatan melepasi penapis semasa proses penapisan berbanding di awal minggu kajian. Nilai semua bacaan menurun dimana nilai BOD daripada 41.7 mg/L kepada 33.5 mg/L, nilai COD daripada 203 mg/L kepada 102 mg/L, nilai TSS daripada 148 mg/L kepada 29 mg/L dan nilai NH_3-N daripada 2.53 mg/L kepada 1.29 mg/L. Pertumbuhan sawi pak choy (*brasica rapa var chinensis*) menunjukkan penurunan pada peringkat awal tetapi beransur baik bermula pada minggu ke empat. Hal ini disebabkan oleh sesetengah anak sawi pak choy mati kerana tidak dapat bertahan dengan air apabila ujian kesan masa tahanan hidrolik (HRT) dijalankan. Data yang dikumpul boleh diguna pakai dan dibaik pulih di masa akan datang dan boleh digunakan di dalam industri pertanian negara.

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LIST OF SYMBOLS

° C	Degrees Celsius
%	Percentages
mg/L	Milligram per liter
mL	Milliliter
mm	Millimeter
cm	Centimeter
L	Liter
NH_3-N	Ammonium Nitrogen
N_2SO_4	Sulfuric Acid
NaOH	Sodium Hydroxide
X	Vertical Axis
Y	Horizontal Axis

LIST OF ABBREVIATIONS

COD	Chemical Oxygen Demand
BOD_5	Biological Oxygen Demand at 5 days
TSS	Total Suspended Solid
AN	Ammonia Nitrogen
DO	Dissolved Oxygen
HRT	Hydraulic Retention Time
WQI	Water Quality Index
DOE	Department of Environment
MEQR	Malaysia Environmental Quality Report

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Aquaphonics system is a combination of aquaculture (fish) and hydrophonics (plants) in a closed recirculation system (Nelson, 2008). The system waste nutrient provided by the fish to support plant growth where the plant growth helps to maintain water quality and provides food for the fish. Process of nitrification was needed to reduce ammonia that causes the toxicity of the water release the fish. The toxicity of water can lead mortality of fish. The plant will act as the filter for the water and return clean water back into the tank. Fish and plant need each other to survive. Fish get benefit from plant and the plants get benefit from waste nutrient produce by fish. This converting nutrient into biomass and treating wastewater could become a profit-able business (Graber and Junge, 2008). This system can provide food during rain and dry season where plant and fish can be produce without any problem. This aquaphonics system also can be applied at a small spaced area. Water and soil resources may be act as the key to self-sustenance for community living and depending on world food markets.

1.2 PROBLEM STATEMENT

Wastewater pollution has always been a major problem throughout the world. One of the main sources of the pollution is from agricultural wastewater. Wastewater from agricultural always makes our natural resource especially rivers get polluted. Basically, municipal wastewater contains high level of Chemical Oxygen Demand (COD). High level of Chemical Oxygen Demand (COD) can lead to mortality of aquatic live because it result low Dissolve Oxygen (DO) in water. Besides that, municipal wastewater also contains high level of Total Suspended Solid (TSS) such as organic and inorganic material that can cause dirt and odor to the water. This waste is sometime very toxic to the certain aquatic life. To solve this problem, waste need to be treated before it is can be release to the rivers. Waste needs to be treated in order to keep our environment clean and safe to be used.

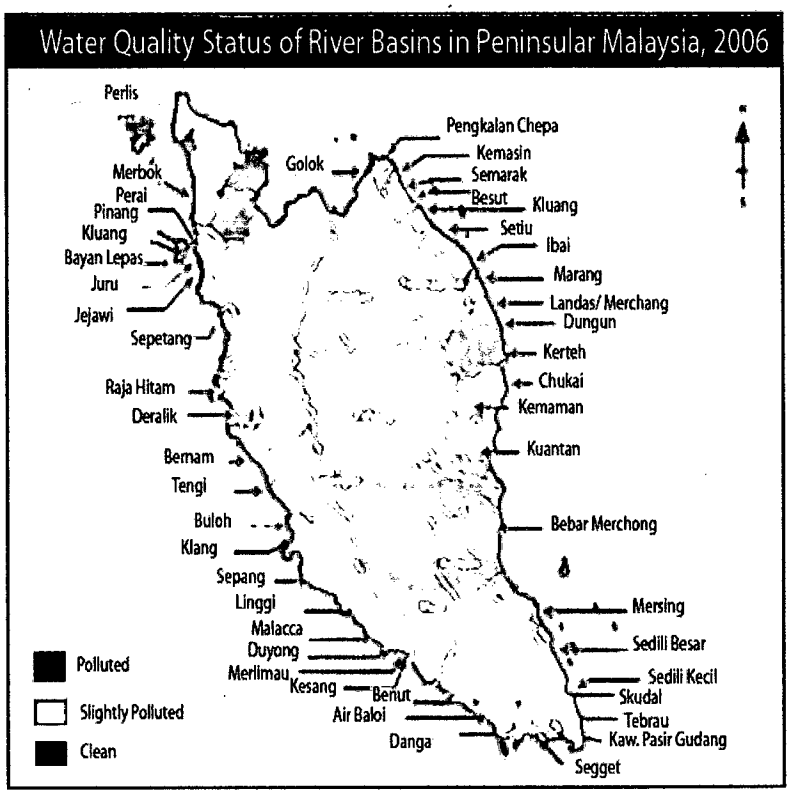

Figure 1.1: Water Quality Status of River Basins in Peninsular Malaysia, 2000

The pollution of the river is seemingly obvious because it could be easily judged by the look, color and smell of the river. The decreases in the number of clean river in Malaysia were attributed to many factors. Obviously, the increasing of river pollution is made from human being. The pollution sources such as sewage treatment plants, agro-based factories, manufacturing factories and pig farms which contributed to an increasing in the pollution load. No proper in their managing of waste before release into the river contributed a load of pollution especially chemicals, oils and grease. Human behaviors also contributed for this pollution problem. Certain people with no awareness in their life through their rubbish into the river also contributed to this pollution problem. Therefore, it is important to study the quality of wastewater currently and determine the recommend suitable solutions to the problem.

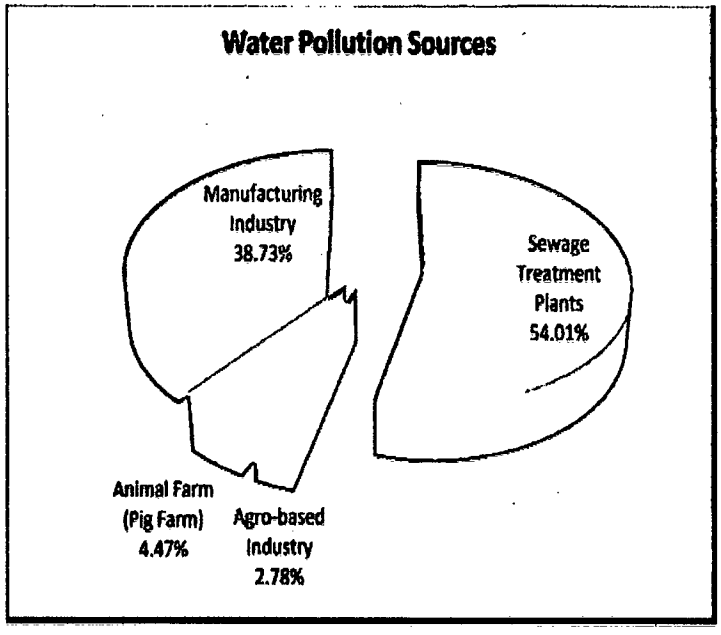

Figure 1.2: Composition of Water Pollution Source by Sector in Malaysia (MEQR, 2008)

1.3 OBJECTIVES

The objectives of this study are:

1) To determine the wastewater characteristic such as pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Ammonium Nitrogen (NH_3-N) and Total Suspended Solid (TSS).
2) To determine the effect of hydraulic retention time (HRT) treatment on wastewater quality.
3) To determine the growth of adopted vegetable during treatment.

1.4 SCOPE OF STUDY

In order to achieve the objectives, there are some of the scope has been identified. The objectives of this study are to determine the wastewater characteristics, to determine the effect of hydraulic retention time (HRT) treatment on wastewater quality and to determine the growth of adopted vegetable during treatment. The scope of this study is to treat water from aquaphonics system by using water quality parameter. Catfish (*Clarias Batrachus*) is taken from a pond at Agro Bazar, Pekan Pahang. Catfish is taken from there because the place provides the fish that are fresh from Sg. Pahang. The water inside the pond also has been pump from river.

The vegetable used in this study is Chinese mustard or pak choy (*brasica fuller var chinensis*). This vegetable is one of the mustard family. Gravel size from 4.75 mm and above is use in this aquaphonics system. Gravel is a wonderful and ideal replacement of conventional soil for garden plant growth. The wastewater quality is determined by done the test according to the parameter of pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Ammonium Nitrogen (NH_3-N) and Total Suspended Solid (TSS). The parameters used are based on the Water Quality Index (WQI) from the Department of Environment (DOE).

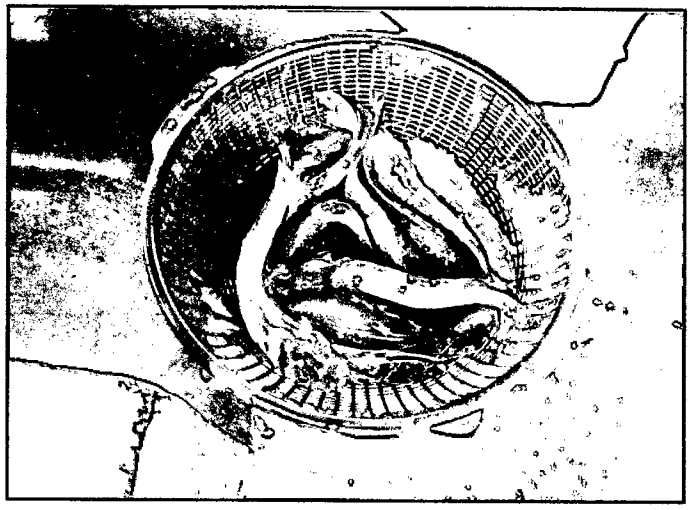

Figure 1.3: Catfish (*Clarias Batrachus*)

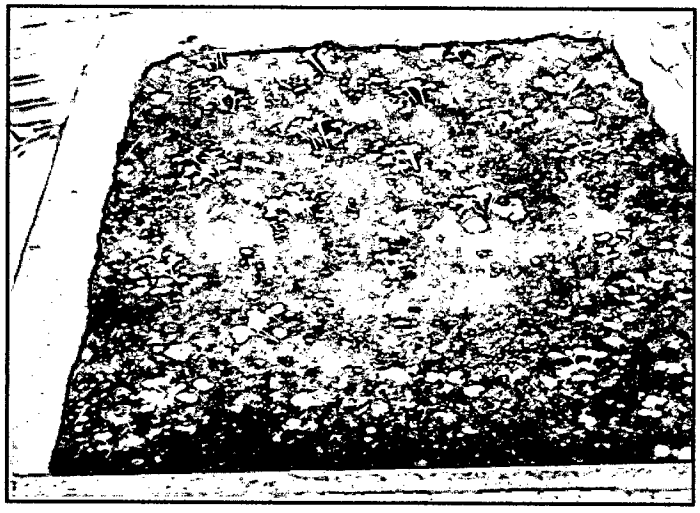

Figure 1.4: Pak Choy (*brasica fuller var chinensis*) at age of 10 days after seeding

This study will consist of in-situ measurement testing and laboratory testing after wastewater sampling. A sample of wastewater is taking from a basin where the vegetable located. The wastewater sampling is taken before hydraulic retention time where is at zero retention time, then for 2, 4 and 6 hours of hydraulic retention time (HRT). To find the effectiveness of this aquaphonics system, the experimental need to be done. pH will be

tested for in-situ measurement, where the rest is done for laboratory measurement which is Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), and Ammonium Nitrogen (NH_3-N). The test of BOD and TSS must be done within 24 hour sample has been taken. For COD and NH_3-N, the testing can be made within 48 hour sample has been taken but the sample must been preserve and store at the refrigeration. After the experiment done, the data collect is use for classification the standard quality for this aquaphonics system wastewater treatment.

Figure 1.5: Sample is stored at the refrigeration

1.5 SIGNIFICANT OF STUDY

By knowing the different value of wastewater quality before and after wastewater treatment, according to the standard, the effectiveness of using this aquaphonics system can be determined. If the result obtained shown the improving value of the wastewater quality, the use of aquaphonics system can be use in our society, industry and environment. Aquaphonics system can be use as a one of the solution to preserving and protecting our environment from pollution. This system also can be use for all people either with the small space area especially at home or for the business purpose. The improving of wastewater quality value can be proved if the result obtained shown the improvement.

The used of aquaphonics system instead of using vegetable to filter wastewater, fish also provided waste nutrient to support plant growth. With this application, the toxicity of wastewater that produced by fish waste which is contain ammonia can be reduced. This ammonia can be finding in conventional industry throughout the fertilizers and chemicals added instead that. These thing effected to the river water quality which is the wastewater from farm is discharge through to the river. These substance may harmful the aquatic life in the river. The pollution of our water sources especially river can lead mortality of fish. Ammonia is toxic to fish and aquatic organisms, even in very small amounts and can polluted our river. This ammonia will effect the fish and aquatic organisms. Fish and plant need each other to survive. Fish get benefit from plant and the plants get benefit from waste nutrient produce by fish.

Aquaphonics system are more useful, save and beneficial to the environment and society. There are several benefits of aquaphonics system besides preserving and protecting our environment from pollution, this aquaphonis system also can contribute to the society in preventing the community from any harm and danger chemical for our instance water. As we known, we get our instance water or can be called freshwater from sources especially rivers and lakes. If our sources is classified polluted by our Department of Environment (DOE), there are more cost needed in order to treat the water. It will be

different if our sources clean. More polluted our sources, more danger we must face since more chemicals must to be added before we can use water for our daily life purpose. In additional, this system can reduce life cost since the aquaphonics system can producing fish and vegetable without using any chemical substance in their production. To simply it, the application of this system in our life gives us three in one of benefit. Where the benefit are reduce and protect our environment from pollution, organic vegetable that free from any chemicals and protein sources from fish production.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is about literature review about this study. This chapter will explain about aquaphonics and water quality parameter in this study. Water quality parameters are based on the Water Quality Index (WQI) from the Department of Environment (DOE).

2.2 AQUAPHONICS

Aquaphonics is a modern farming system and it very suitable at small spaced area. The nutrient will be recycling from the aquaphonics process. A wastewater from fish will recycle by production of vegetable. It is reported that aquaponics systems that rely solely on fish waste to supply nutrients for plants (Graber and Junge, 2009). Rakocy and Hargreaves (1993) stated that aquaponics systems have the only bio-filter that generates income, which is obtained from the sale of hydroponic produce such as vegetables, herbs and flowers.

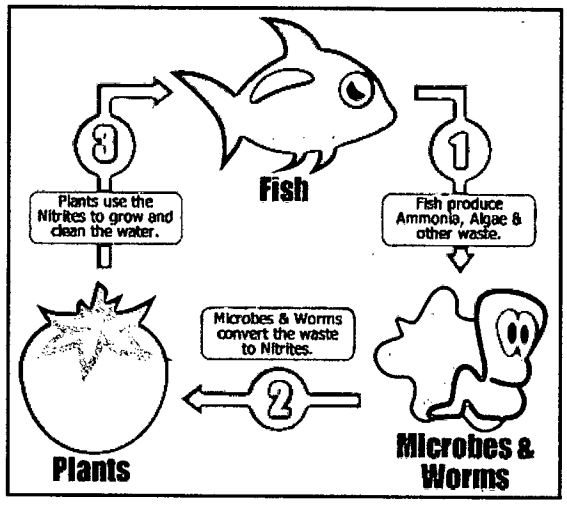

Figure 2.1: Aquaphonics Cycle

2.3 WATER QUALITY PARAMETER

The physical–chemical and biological characteristics of water in fish ponds were investigated with a view to optimise the conditions for fish productivity using small ponds. The successful productivity of fish using ponds depends on the physical–chemical and biological characteristics of water used for fish cropping and the nutrition management of the aquaculture species (Ntengwe and Edema, 2008). Although the management of fish can be improved using increased protein component of fish diets by sources of protein derived from non-aquatic sources such as soybean meal (Ntengwe and Edema, 2008), the poor conditions in the water such as the potential damage to ocean and coastal resources through habitat destruction, waste disposal, exotic species and pathogen invasions can affect fish productivity (Naylor *et al.*, 2000). Good fish management begins with an understanding of the physical, chemical and biological characteristics of the ponds. These characteristics determine the quality of fish the ponds can produce and the problems that may be encountered.

2.3.1 pH

pH is a measure of the activity of the hydrogen ion. The pH conditions that were conducive for fish cropping in the ponds are ranging from 6.9 - 7.5 (Ntengwe and Edema, 2008). Studies elsewhere have shown that the fish die at pH values of 2 and 11 (Ntengwe, 2005). It was supported by Serfay and Harrell (1993) where one laboratory study found that three species of fish avoided pH levels greater than pH 9.5, except when combined with supersaturated oxygen levels. The fish production in waters with pH $\leqslant$ 6 has been found to be poor (Lazur *et al.*, 2002). Alkaline water also causes immediate, dramatic inhibition of ammonia excretion and subsequent increase in plasma ammonia, which can be potentially lethal (Dawn *et al.*, 2005).

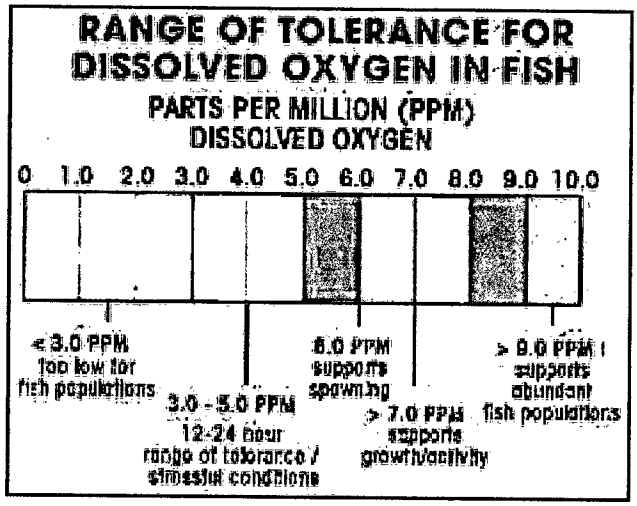

Figure 2.2: Range of tolerance for Dissolved Oxygen in fish

2.3.2 Dissolved Oxygen

Oxygen saturation or dissolved oxygen (DO) is a relative measure of the amount of oxygen that is dissolved or carried in a given medium. Oxygen saturation in the environment generally refers to the amount of oxygen dissolved in the soil or bodies of water. Environmental oxygenation can be important to the sustainability of a

particular ecosystem. The addition of more water increased the oxygen level and fish activity and the gasping for air by fish was also reduced when more water was added to the pond (Ntengwe and Edema, 2008). Only oxygen-rich waters can support a broad variety of aquatic organisms while the waters with low amounts of DO can support limited amounts and types of aquatic organisms (Ntengwe and Edema, 2008). If the oxygen levels drop to less than 4 mg/L, the fish become stressed. Stress can then trigger secondary problems, such as poor growth, poor reproduction and diseases.

2.3.3 Temperature

The temperature has a great influence in determining what type of organisms can survive in a water body. The temperature directly affects the amount of oxygen that can be dissolved in water (Peavy *et al.*, 1985). Besides that, the activity of the fish increased as the temperature increased during the day and dropped as the temperature reduced during the sun set (Ntengwe and Edema, 2008). The activity of the fish is related to the stress level of the fish.

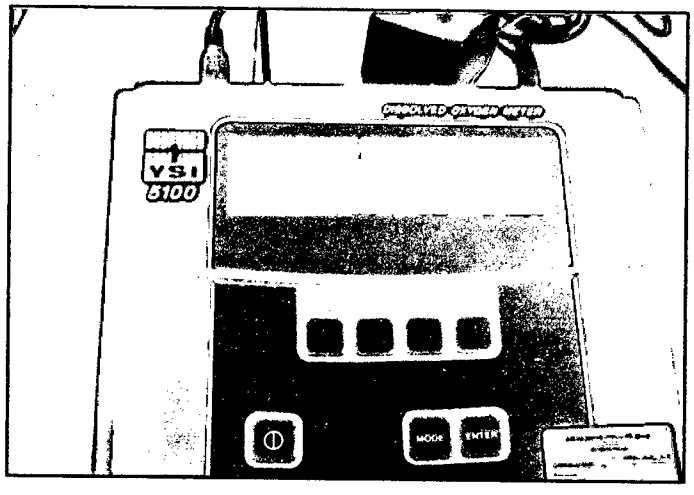

Figure 2.3: Dissolved Oxygen Meter which can be used to measure DO and temperature

Table 2.1: Relationship between Dissolved Oxygen and temperature

Suhu (°C)	Kadar Oksigen terlarut (mg/l)	Suhu (°C)	Kadar Oksigen terlarut (mg/l)	Suhu (°C)	Kadar Oksigen terlarut (mg/l)
0	14,62	14	10,31	28	7,83
1	14,22	15	10,08	29	7,69
2	13,83	16	9,87	30	7,56
3	13,46	17	9,66	31	7,43
4	13,11	18	9,47	32	7,30
5	12,77	19	9,28	33	7,18
6	12,45	20	9,09	34	7,06
7	12,14	21	8,91	35	6,95
8	11,84	22	8,74	36	6,84
9	11,56	23	8,58	37	6,73
10	11,29	24	8,42	38	6,62
11	11,03	25	8,26	39	6,51
12	10,78	26	8,11	40	6,41
13	10,54	27	7,97		

2.3.4 Total Suspended Solid

Total suspended solids is a water quality measurement usually abbreviated TSS. As levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen. TSS can also destroy fish habitat because suspended solids settle to the bottom and can eventually blanket the river bed. Suspended solids can smother the eggs of fish and aquatic insects, and can suffocate newly-hatched insect larvae. Increased turbidity levels limit photosynthesis by algae and rooted aquatic plants by reducing sunlight penetration into the water which limits production of food for aquatic life (Lloyd *et al.*,1987). Besides that, suspended sediment can harm incubating fish eggs and fry (Cedarholm *et al.*, 1982), and reduce the abundance of insect larvae, a food source for fish, by filling up the larvae's guts or nets with indigestible material (Hynes 1973).