EFFECTS OF DIFFERENT CONCENTRATIONS OF TOTAL SUSPENDED SOLIDS AND DISSOLVED OXYGEN ON SURVIVAL AND GROWTH OF JUVENILE *BARBONYMUS SCHWANENFELDII* AND *OREOCHROMIS NILOTICUS*

Nona Nabilah Binti Ahmad Tarmizi (31625)

Bachelor of Science with Honours
Aquatic Resource Science and Management Programme
2014
Effects of Different Concentrations of Total Suspended Solids and Dissolved Oxygen on Survival and Growth of Juvenile *Barbonymus schwanenfeldii* and *Oreochromis niloticus*

Nona Nabilah Binti Ahmad Tarmizi (31625)

This dissertation is submitted in partial fulfillment of the requirements for the degree of Bachelor of Science with Honors

Aquatic Resource Science and Management
Department of Aquatic Science
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak
ACKNOWLEDGEMENT

Highest gratitude and appreciation to my main supervisor, Prof Dr Lee Nyanti for his guidance, support, provisions for the project, provide help for our main transportation to the external lab, and effort in editing my thesis. Thanks also to Dr Ling Teck Yee, my lovely co-supervisor for advice and assistance especially regarding statistics.

I am also thankful for the support of the Faculty of Resource Science and Technology and the help provided by the laboratory assistants of the Department of Aquatic Science, FSTS especially Mr Mustafa Kamal, Mr Zaidi Ibrahim and Mr Mohd Nor Azlan. The financial support provided by Sarawak Energy Berhad through research grant no. GL(F07)/SEB/6/2013(32) is gratefully acknowledged.

I would also like to express my deep appreciation for the endless support and pray for my success to my parents, Ahmad Tarmizi bin Ariffin and Lely Murni binti Abul Ain, my family members and my friends. My special thanks also go to my lab mate, Nik Nurul Kamila binti Abu Rashid, who always bears with me in all conditions and face the hard time together with me to finish up the project. To all of you and those I have not mentioned, thank you and God bless you all.
DECLARATION

I, Nona Nabilah binti Ahmad Tarmizi, final year student of Aquatic Resource Science and Management hereby declare that this thesis is my own work and effort with the guidance of my supervisor, Professor Dr Lee Nyanti. No part of the thesis has previously been submitted for any other degree, university or institution of higher learner.

(NONA NABILAH BINTI AHMAD TARMIZI)                       Dated:
Aquatic Resource Science and Management
Faculty of Resource Science and Technology
University Malaysia Sarawak
# TABLE OF CONTENTS

Acknowledgement i  
Declaration ii  
Table of Contents iii  
List of Abbreviations v  
List of Tables vi  
List of Figures viii  
Abstract 1  

## 1.0 Introduction  
1.1 Introduction 2  
1.2 Objectives 3  

## 2.0 Literature Review  
2.1 Effect TSS and DO on habitat changes in natural water bodies 4  
2.2 Effect of TSS and DO on fish  
2.2.1 Effect of TSS on fish 5  
2.2.2 Effect of DO on fish 5  
2.3 Effect of TSS and DO concentrations on growth, mortality and FCR of fish  
2.3.1 Effect of TSS concentrations on growth, mortality and FCR of fish 6  
2.3.2 Effect of DO concentration on growth, mortality and FCR of fish 8  

## 3.0 Materials and Methods  
3.1 Tank preparation 9  
3.2 Tank water preparation and volume 10  
3.3 Acclimation of juvenile 10  
3.4 Fish stocking 10  
3.5 Total suspended solids 11  
3.6 Dissolved oxygen 14
3.7 Water quality monitoring 14
3.8 Data collection 15
3.9 Statistical Analysis 16

4.0 Results
4.1 Total Suspended Solids
  4.1.1 Physiochemical parameters of water 17
  4.1.2 Survival rate 18
  4.1.3 Growth performance
    4.1.3.1 Total length gain 22
    4.1.3.2 Standard length gain 24
    4.1.3.3 Body weight gain 26
  4.1.4 Feed conversion ratio 28
  4.1.5 Specific growth rate 30
  4.1.6 Behavioral characteristics
    4.1.6.1 Feeding impairment 32
4.2 Dissolved Oxygen
  4.2.1 Physicochemical parameters of water 33
  4.2.2 Survival rate 34
  4.2.3 Growth performance
    4.2.3.1 Total length gain 38
    4.2.3.2 Standard length gain 40
    4.2.3.3 Body weight gain 42
  4.2.4 Feed conversion ratio 44
  4.2.5 Specific growth rate 46
  4.2.6 Behavioral characteristics
    4.2.6.1 Movement 48
    4.2.6.2 Avoidance 49
    4.2.6.3 Feeding Impairment 50

5.0 Discussion
  5.1 Total suspended solids 51
  5.2 Dissolved oxygen 54

6.0 Conclusion 57

7.0 References 58
LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>Total suspended solids</td>
</tr>
<tr>
<td>DO</td>
<td>Dissolved oxygen</td>
</tr>
<tr>
<td>FCR</td>
<td>Feed conversion ratio</td>
</tr>
<tr>
<td>mg/L</td>
<td>Milligram per litre</td>
</tr>
<tr>
<td>kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl chloride</td>
</tr>
<tr>
<td>RF</td>
<td>Reserved fish</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>m</td>
<td>Meter</td>
</tr>
<tr>
<td>µm</td>
<td>Micrometer</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1 : Ranking on effects of suspended sediments on fish and aquatic life 7

Table 2 : Mass of sediment grain size content in the soil sample from dry sieve analysis 12

Table 3 : Mass of silt and clay content in the soil sample from pipette method 12

Table 4 : Mean values of temperature, dissolved oxygen, pH, concentration of ammonia-nitrogen and concentration of nitrite at different total suspended solids concentrations 17

Table 5 : Survival rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 20

Table 6 : Total length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 23

Table 7 : Standard length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 25

Table 8 : Body weight gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 27

Table 9 : Feed conversion ratio of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 29

Table 10 : Specific growth rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 31

Table 11 : Feeding impairment between *Barbonymus schwanenfeldii* and *Oreochromis niloticus* until Day 30 at different TSS concentrations 32
Table 12: Mean values of temperature, pH, concentration of ammonia-nitrogen and concentration of nitrite at different DO concentrations

Table 13: Survival rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Table 14: Total length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Table 15: Standard length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Table 16: Body weight gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Table 17: Feed conversion ratio of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Table 18: Specific growth rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Table 19: Movement between *Barbonymus schwanenfeldii* and *Oreochromis niloticus* until Day 30 at different DO concentrations

Table 20: Avoidance between *Barbonymus schwanenfeldii* and *Oreochromis niloticus* until Day 30 at different DO concentrations

Table 21: Feeding impairment between *Barbonymus schwanenfeldii* and *Oreochromis niloticus* until Day 30 at different DO concentrations
LIST OF FIGURES

Figure 1  : The dimension of fiberglass tank and set up of experimental design 9

Figure 2  : Survival rate (percentage) of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* from Day 1 to 30 for different TSS concentrations 19

Figure 3  : The survival rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 20

Figure 4  : The total length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 22

Figure 5  : The standard length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 24

Figure 6  : The body weight gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* on different TSS concentrations 26

Figure 7  : The feed conversion ratio of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 28

Figure 8  : The specific growth rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different TSS concentrations 30

Figure 9  : Survival rate (percentage) of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* from Day 1 to 30 for different DO concentrations 35

Figure 10 : The survival rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations 36

Figure 11 : The total length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations 38
Figure 12 : The standard length gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Figure 13 : The body weight gain of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Figure 14 : The feed conversion ratio of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations

Figure 15 : The specific growth rate of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at Day 30 for different DO concentrations
Effects of Different Concentrations of Total Suspended Solids and Dissolved Oxygen on Survival and Growth of Juvenile Barbonymus schwanenfeldii and Oreochromis niloticus

Nona Nabilah Binti Ahmad Tarmizi
Aquatic Resource Science and Management Programme
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak

ABSTRACT

The purpose of this study is to determine the effects of different concentrations of total suspended solids (TSS) and dissolved oxygen (DO) on the survival rate and growth of a native species (Barbonymus schwanenfeldii) and an exotic species (Oreochromis niloticus). The two species of fish were placed in a tank with different concentrations of TSS; 0 mg/L, 500 mg/L, 1,000 mg/L, 5,000 mg/L, and 10,000 mg/L and different concentrations of DO; 7 mg/L, 4 mg/L, 2 mg/L, 1 mg/L, and 0 mg/L. When both species were placed in different TSS concentrations, Barbonymus schwanenfeldii showed lower survival rate compared to Oreochromis niloticus at 10,000 mg/L of TSS. The FCR of Barbonymus schwanenfeldii was significantly higher than Oreochromis niloticus in all of the treatments. When both species were tested at the five DO concentrations, Barbonymus schwanenfeldii showed lower survival rate compared to Oreochromis niloticus. Both fish recorded the highest survival rate at 7 mg/L of DO. There is no survival for both species at 2 mg/L, 1 mg/L, and 0 mg/L. The FCR of Barbonymus schwanenfeldii was significantly higher than Oreochromis niloticus at 7 mg/L and 4 mg/L. These conclude that Oreochromis niloticus (exotic species) is harder than Barbonymus schwanenfeldii (native species). The outcome of this study could be used to determine the effects of changes in habitat on the overall population of Barbonymus schwanenfeldii and Oreochromis niloticus.

Key words: survival, growth, FCR, exotic species, native species.

Kata kunci: kadar kemandirian, pertumbuhan, FCR, eksotik spesies, spesies asli.
1.0 INTRODUCTION

1.1 Introduction

Land use is the greatest factor that influences the changes in total suspended solids (TSS) and turbidity in rivers. Excessive sediment goes into the river from erosion of unstable riverbank, construction site, agricultural activities and urban runoff. These activities will reduce the ability of the vegetation to filter runoff before it reaches the river affects the aquatic life in the river. Many watersheds have been affected by land use that alters sediment input and transport, and thus do not provide a stable riverbank. Over space and time, erosion becomes worst as the sediment will be loaded in the river. This will result in more sediment entering into the river and causes high TSS and the water becomes more turbid.

Effects on fish will differ based on their developmental stage. Suspended sediments may affect fish by altering their physiology, behavior, and habitat, all of which may lead to physiological stress and reduced survival rates. A sizable body of data has been gathered in North America focusing on the relationship between turbidity, total suspended sediments, and fish health (Bash et al., 2001).

Dissolved oxygen is a vital for all the organisms in the water. Very high dissolved oxygen (DO) concentrations can also be harmful to aquatic life. Fish in waters containing excessive dissolved gases may suffer a condition in which bubbles of oxygen block the flow of blood through blood vessels, causing death. Abrupt changes in dissolved oxygen induce stress and subsequently make the fish more susceptible to disease (Murphy, 2007).
Among the most important water quality parameters, total suspended solids and dissolved oxygen plays a vital role in affecting growth and mortality of fish. The effects of the two water quality parameters (TSS and DO) have not yet been compared between *Barbonymus schwanenfeldii* and *Oreochromis niloticus*. Therefore, the purpose of this study is to provide an analysis on the effects of different concentrations of total suspended solids and dissolved oxygen levels on the mortality and growth of a native species (*Barbonymus schwanenfeldii*) and an exotic species (*Oreochromis niloticus*).

1.2 Objectives

The objectives of this study were:

i. To determine the survival rate, growth performance and feed conversion ratio (FCR) of juvenile *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at different concentrations of total suspended solids and dissolved oxygen,

ii. To record the behavioral characteristics (movement, avoidance and feeding impairment) of the two species when exposed to different concentrations of total suspended solids and dissolved oxygen, and

iii. To determine the optimum condition for the water clarity due to total suspended solids and the concentration of dissolved oxygen for the two species.
2.0 LITERATURE REVIEW

2.1 Effect TSS and DO on habitat changes in natural water bodies

Sediment delivery rates and composition are controlled by topography, climate, geology, hydrology, and vegetation (Spencer et al., 1996). The alteration of upslope hydrological and erosional processes with changes in instream hydrological, erosion, and depositional processes can result in a reduction in channel depth and increases fine and course sediment load. Clearing the land for urban development have played major role in altering upslope and instream physical and biological process (Berman, 1998). The main effects of TSS in the streams are increases in the turbidity of the streams water and increases siltation of stream beds (Rowe et al., 2003). Increases in sediment load can also limit photosynthesis by reduces the amount of light penetration entering the water, which can affect primary production. For examples, the algal growth will decrease and low algal productivity can reduces the productivity of aquatic life which are the main food sources of many fish and also can lead to reduce amount of DO available in the water for plants and animals to breathe (Lloyd et al., 1987). Besides, increase in sediment load give an impact on the area of a river that is used for spawning as the spawning habitat is eliminated, leading to a reduction in the number of juvenile species. Loaded sediments can harm incubating fish eggs and fry (Cedarholm et al., 1982). Turbidity can also cause changes in fish feeding behavior since prey is less visible to find and capture food.
2.2 Effect of TSS and DO on fish

2.2.1 Effect of TSS on fish

According to Alabaster and Lloyd (1982), for inland fisheries, there is no evidence that concentrations of suspended solids up to 25 mg/L have any harmful effect on fish. The FIFAC (1980) suggests that TSS concentrations be maintained below 15 mg/L as a safe value in recirculating systems, while Muir (1982) recommends a limit of 20 to 40 mg/L for these same systems. Based on the experiment carried out by James et al. (n.d.), tilapia grown in systems with TSS in excess of 100 mg/L still maintained good fish productivity, but this was in an absence of virtually all other stressors. However, different fish species may have significantly different tolerance levels to solids concentrations and that other water quality parameters may impair a fish's ability to withstand high TSS concentrations. Most researchers report the evidence from high concentrations of TSS caused the mortality rate to increase and younger fish has greater sensitivity towards TSS (Anderson et al., 1996; Newcombe & MacDonald, 1991).

2.2.2 Effect of DO on fish

Oxygen is essential to the survival of fish and also to sustain healthy environment for fish. The first indicator that there may be a DO problem in the water is when the fish become lethargic and stop feeding. As oxygen levels in the water decreases, the fish do not have energy to swim and to feed (Mallya, 2007). The ideal dissolved oxygen concentration for many fish is between 7 and 9 mg/L and the optimal DO for adult brown trout is 9-12 mg/L. Most fish cannot survive at concentrations below 3 mg/l of dissolved oxygen (Murphy, 2007). The recommended minimum dissolved oxygen requirements for cold water fish is 6 mg/L (70% saturation), tropical freshwater fish is 5 mg/L (80% saturation) and tropical marine fish is 5 mg/L (75% saturation) which are the minimum requirements
for healthy growth, tissue repair and reproduction (Svobodova et al., 1993). However, the period of time during the oxygen level drops below the required minimum level will cause the fish to become stressed and causes fish death (Mallya, 2007).

2.3 Effect of TSS and DO concentrations on growth, mortality and FCR of fish

2.3.1 Effect of TSS concentrations on growth, mortality and FCR of fish

Sediment is a natural component of river but excessive sediment would give effect to fish health. When the TSS concentration is low at all times, it will increase growth rates, reduce the food conversion ratio and increase overall fish production. As the suspended solids concentration decreases, respiration and feeding activities (FCR) will also decrease. As a result, the growth rate is reduced and the possibility of a disease attack is increased and therefore increase mortality rate. Newcombe and MacDonald (1991) have group the effects of sediment on salmonids into three categories which are lethal, sublethal and behavioral effects. Lethal effects kill individual fish and cause immediate death (mortality), sublethal effects relate to tissue injury or the physiology alteration may lead to mortality over time and behavioral effects are the results in a change of activity and may also lead to mortality (Table 1). High turbidity is one of the environmental conditions which negatively influencing the trout survival and explain the poor populations of wild salmonid (Susfalk et al., 2008).
Table 1: Ranking on effects of suspended sediments on fish and aquatic life (Source: Newcombe et al., 1991).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Description of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increased coughing rate</td>
</tr>
<tr>
<td>2</td>
<td>Alarm reaction, avoidance reaction</td>
</tr>
<tr>
<td>3</td>
<td>Avoidance response, abandonment of cover</td>
</tr>
<tr>
<td>4</td>
<td>Reduction in feeding rates</td>
</tr>
<tr>
<td>5</td>
<td>Impaired homing</td>
</tr>
<tr>
<td>6</td>
<td>Poor condition of organism</td>
</tr>
<tr>
<td>7</td>
<td>Moderate habitat degradation</td>
</tr>
<tr>
<td>8</td>
<td>Physiological stress and histological changes</td>
</tr>
<tr>
<td>9</td>
<td>Reduction in growth rates</td>
</tr>
<tr>
<td>10</td>
<td>0 to 20% mortality</td>
</tr>
<tr>
<td>11</td>
<td>&gt;20 to 40% mortality</td>
</tr>
<tr>
<td>12</td>
<td>&gt;40 to 60% mortality</td>
</tr>
<tr>
<td>13</td>
<td>&gt;60 to 80% mortality</td>
</tr>
<tr>
<td>14</td>
<td>&gt;80 to 100% mortality</td>
</tr>
</tbody>
</table>
2.3.2 Effect of DO concentration on growth, mortality and FCR of fish

Previous studies have shown that fish survival and growth are affected by the level of DO in the water. When the oxygen level is maintained at its optimum concentrations at all times, it will increase growth rates, reduce the food conversion ratio and increase overall fish production. As the dissolved oxygen concentration decreases, respiration and feeding activities (FCR) will also decrease. As a result, the growth rate is reduced and the possibility of a disease attack is increased and therefore increase mortality rate. Fish is also not able to assimilate the food consumed when DO is low (Tom 1998). According to Mallya (2007), halibut of 20-50 g in weight were reared in replicate at 60%, 80%, 100%, 120% and 140% oxygen saturation levels in a tank recirculation system. Within two weeks, results shows that at 80% - 120% oxygen saturation, the growth and FCR had a positive effect but at 140%, the growth was slightly lower. At 60% and 140%, FCR was higher compared to the others.
3.0 MATERIALS AND METHODS

3.1 Tank preparation

Five fiberglass rectangular tanks of equal dimensions were used in this study. The dimension of each tank is 2.10 m long x 1.30 m wide x 0.61 m deep. Thus, the total volume of each tank is 1.67 m$^3$ (Figure 1). In each tank, three rows of smaller compartments were placed perpendicular to the length of the tank. They were placed at equal distance from the edge of the tank and among each row. Each row were subdivided into three equal compartments made from polyvinyl chloride (PVC) and net with length of 0.49 m, width of 0.39 m x depth of 0.67 m. Therefore, the total volume of each compartment is 0.13 m$^3$ (Figure 1).

![Figure 1: The dimension of fiberglass tank and set up of experimental design.](image-url)
3.2 Tank water preparation and volume

Every tank were filled with tap water to a depth of 0.42 m. Anti-chlorine solution (NIKA) was added to each tank at a volume of 0.2 ml per liter of water. The water were aerated and left for a period of 7 days before the start of experiment. The volume of the water in the tank is 1.15 m$^3$ and the volume of the water in each compartment is 0.07 m$^3$.

3.3 Acclimation of juvenile

The juveniles of *Barbonymus schwanenfeldii* were obtained from the Department of Agriculture in Tarat, Serian while the juveniles of *Oreochromis niloticus* were bought from PM Aquaculture, Kota Sentosa. Before placing these juveniles into the tank in the laboratory, 25% of water volume from the tank was added to the plastic bag holding the juveniles and left for 30 minutes. The fish was stocked into acclimatization tank a week before experiment start until the fish become active and no mortality due to stress during transportation and handling.

3.4 Fish stocking

Twenty juveniles of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* were weight using weighing balance (Adventurer, Dhaus) while the standard length and the total length were measured using measuring board (Wildco, 118) to obtain the initial average mean weight and average mean standard length and total length of the fish. The fish were fed twice daily at 5% body weight (Iyaji, 2008) with floating pelleted fish feed throughout the experimental period. Aeration was facilitated using aerator to obtain concentration of dissolved oxygen at 6 mg/L. For each total suspended solids and dissolved oxygen concentrations, twenty individuals of juveniles *Barbonymus schwanenfeldii* and
*Oreochromis niloticus* were exposed for a period of 30 days in triplicate for each treatment.

### 3.5 Total suspended solids

Sediment composed of silt and clay was collected from the banks of Sarawak River to represent the natural silt and clay in natural system. All sediment samples were transported back to laboratory for particle size analysis. Silt and clay is a very small particle and therefore, wet and dry sieve analysis is necessary to separate them from the sediment sample. Following Dunnivant and Anders (2006) sediment analysis method, the sediment was weighed and was left to air-dry overnight at 105 °C. After dried, the dry sample was weighed again to give the dry weight of the whole sample. The sand sample was dispersed in a sodium hexametaphosphate to helps separation the fine and clay particles. The sediment sample was soaked overnight with tap water and sodium hexametaphosphate. Using 62 µm mesh sieve, the sediment sample was puddled in the sieve immersed in water and sodium hexametaphosphate in the basin. The sand fraction remained on the surface of the sieve and silt and clay fraction passed through. For silt and clay fraction, pipette was performed. From the dry sieve analysis, the mass of sediment grain size content in the soil sample used in this experiment is shown in Table 2. Table 3 shows the mass of silt and clay content in the soil sample used in this experiment from the pipette method.
Table 2: Mass of sediment grain size content in the soil sample from dry sieve analysis.

<table>
<thead>
<tr>
<th>Sieve size (µm)</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>0.067</td>
</tr>
<tr>
<td>500</td>
<td>0.149</td>
</tr>
<tr>
<td>250</td>
<td>1.654</td>
</tr>
<tr>
<td>125</td>
<td>3.932</td>
</tr>
<tr>
<td>63</td>
<td>5.829</td>
</tr>
<tr>
<td>&lt;63 (pan)</td>
<td>0.934</td>
</tr>
</tbody>
</table>

Table 3: Mass of silt and clay content in the soil sample from pipette method.

<table>
<thead>
<tr>
<th>Pipette samples</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
<td>0.124</td>
</tr>
<tr>
<td>After 7 minutes 44 seconds</td>
<td>0.073</td>
</tr>
<tr>
<td>After 2 hours 3 minutes</td>
<td>0.003</td>
</tr>
</tbody>
</table>
The sediment sample was sterile by heating the samples in the oven (ESCO Isotherm, Isocide) at 125 °C before added into the treatment tank to ensure there is no contamination to the water in the tank. Five concentrations of TSS were tested in this studies which are 0, 500, 1,000, 5,000, and 10,000 mg/L. There was no soil added into 0 mg/L TSS treatment tank and 0.575 kg of dried soil was added to the 500 mg/L of treatment tank. In 1,000 mg/L treatment tank 2.15 kg of soil was added, in 5,000 mg/L treatment tank 7.25 kg of soil was added into the tank whereas in 10,000 mg/L treatment 14.5 kg of soil was added into the tank. The sterile silt and clay sediment added was stirred in the water of the tank and total suspended solids were measured to ensure the targeted concentrations were met.

The TSS was measured using the standard method 2540D (APHA, 1998). Filtration is needed to determine the total suspended solids. Before filtration, the glass fibre filter paper (GF/C, 47 mm diameter) were soak in distilled water and placed on a piece of labeled aluminium foil before dried in the oven (ESCO Isotherm, Isocide) overnight at 104 °C. The initial weight of the wrapped filter paper was determined. The water samples from each tank were filtered by using the prepared filter paper in triplicate. The final weight of the wrapped filter paper was determined after overnight dried in the oven at 104 °C. The TSS values were calculated using the formula as follows:

\[
\text{TSS (mg/L)} = \frac{F_F - F_S}{V}
\]

Where,

\[
F_F = \text{final weight of filter paper (g)}
\]

\[
F_S = \text{initial weight of filter paper (g)}
\]

\[
V = \text{Volume of water sample used (L)}
\]