# The effects of fish meal substitution with Black Soldier Fly Larvae (BSFL) and earthworm on growth performance and water quality of Betta fish (*Betta Splendens*)

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**DECLARATION**

I hereby declare that the work embodied in here is the result of my own research except for the excerpt as cited in the references.

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# ABSTRACT

This study aims to identify The Effect of Different Fish Feed On the water quality Of Ornamental Fish (*Betta Splendens*). The feed cost can rise by more than 70% of production because the soybean and fish meal are costly. The replacement of Black Soldier Fly Larvae (BSFL) and earthworm in feed ingredients can cut off the feed cost. Both BSFL and earthworm contain the nutrient composition that meets the requirement of fish feed. This experiment was done to find an alternative for fish meals. The feed that contains more protein is better for the fish. Unfortunately, there are a lot of factors that can affect the development of the *Betta Splendens*, such as water quality. The water quality that will be observed is that pH level, water temperature, Dissolved oxygen level and ammonia level. Three types of feeding trial, fish meal (control), BSFL, and earthworm used to determine the better water quality for the fish.

Keywords: BSFL, earthworm, feed, water quality.

# ABSTRAK

Kajian ini bertujuan untuk mengenal pasti kesan suapan ikan yang berbeza terhadap kualiti air ikan hiasan (*Betta Splendens*). Kos makanan boleh meningkat lebih daripada 70% pengeluaran kerana makanan kacang soya dan ikan mahal. Penggantian larva terbang askar hitam (BSFL) dan cacing tanah dalam ramuan makanan boleh memotong kos suapan. Kedua-dua BSFL dan cacing tanah mengandungi komposisi nutrien yang memenuhi keperluan makanan ikan. Percubaan ini dilakukan untuk mencari alternatif untuk makanan ikan. Makanan yang mengandungi lebih banyak protein adalah lebih baik untuk ikan. Malangnya, terdapat banyak faktor yang boleh menjejaskan pembangunan *Betta Splendens*, seperti kualiti air. Kualiti air yang akan diperhatikan ialah paras pH, suhu air, paras oksigen terlarut dan paras ammonia. Tiga jenis ujian pemakanan, tepung ikan (kawalan), BSFL, dan cacing tanah digunakan untuk menentukan kualiti air yang lebih baik untuk ikan.


Kata kunci: BSFL, cacing tanah, kualiti air

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|---|---|
| **BSFL** | **Black Soldier Fly Larvae** |
| **BSF** | **Black Soldier Fly** |
| **CM** | **Centimeter** |

# CHAPTER 1

# INTRODUCTION

## 1.1 Research background

The demand market of ornamental fish is increasing over time due to their market prospect. In this chapter, the background of the study is about the effect of Black Soldier Fly Larvae (BSFL) and earthworm feeding on the water quality of betta fish. This study also includes the research questions, research objectives, problems statements, scope of study, and significance of study.

This study was done in order to get access about the effect of different fish feeding practices towards the water quality of the fish that was place in the aquarium. In order to investigate about the water quality, the temperature, PH level and dissolved oxygen need to be checked in order to know which feed is better.

Black Soldier Fly or known as *Hermetia illucens* and earthworm that is usually used as a substitute for fish meal. BSFL is known as a juvenile grub of the BSF whereby the fish and chicken find it delicious. There is a type of premium protein that will be extracted from the BSFL which is Hi.protein. Hi.protein is said to contain a high crude protein content with a well-balanced amino acid profile. BSFL is natural, sustainable, and environmentally friendly. For the nutrient content, it is said to contain about 40 to 50% crude protein that will make it a high protein source for animal feed. Next, it is also stated that the BSFL are high in calcium content but low in phosphorus than fish meal whereby fish meal contains 8 to 10 % of dry matter and 0.6 to 1.5 % of dry matter respectively. However, it contains an unsuitable amount of calcium: phosphorus ratio for fish feed but it can be improved by adding phosphorus.

It is stated that different species of earthworm contain about 50–60% of crude protein (CP) in dry matter (DM) and have low ash content which is a favourable characteristic for an ingredient of fish feed. There was a research that stated that earthworm (*Perionyx Excavates*) was found to be an excellent source of protein. It is also an important high protein component that is used as a dietary supplement for fish species. This tropical earthworm species' high reproductive rate and biomass production make it suitable for worm meal production. The nutritional value of this earthworm is a major prerequisite in serving as fish meal substitution in feed production. Both Black

Soldier Fly Larvae (BSFL) and earthworm can be used as a substitute for a fish meal due to the protein contents. It is said that on a dry basis matter it can contain about 60-70% protein, 5-21% carbohydrates, 6-11% fat, and 2-3% minerals, and a couple of vitamins, including niacin.

Fish meal is known as a commercial product which has a high demand in the market. It is primarily composed of fish that are not intended for human consumption and is used as animal feed in agricultural settings. Fish meal is produced by frying, pressing, drying, and milling fresh raw fish or fish trimmings in a series of steps. Fish meals has a high protein content, with 65 percent of it being protein.

## 1.2 Problem Statement

The demand for aquaculture feed had increased for the past few years whereby it had exceeded the supply of certain feed that is used in the aquaculture feed. This study was conducted in order to substitute the ingredient in the feed which is the fish meal. The problem that was faced is that the limited source of fish meal. limited amount of fish meal available and the increasing price of this product has been research about a decade in order to reduce the dependency of the fish meal.

Next, the water quality among the breeder of ornamental fish breeders had become a problem when they wanted to breed the fishes. Ornamental fish is said to be very sensitive towards the temperature as well as the PH level whereby it can affect the health of the fish. If the feed that is high in protein and high-intensity production, it can cause water quality problem which can deplete the level of dissolved oxygen in the water.

Since the year 2000, the price of fish meal continues to increase over the month whereby the price is about two or three times the price of soybean meal. Due to the high cost of fish meal, the price of fish feed that consists of the fish meal also increases which made it harder for the smallholder farmer to buy it.

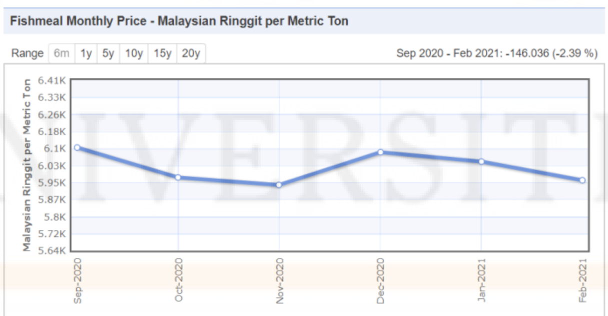


Figure 1.1: Fish meal monthly price (source:World Bank)

### 1.3 Research objective

The specific objective is to:

1) To investigate the water quality on growth performance feed with earthworm nd Black Soldier Larvae (BSFL)

## 1.4 Hypothesis

Ho: There is no difference in the water quality such as temperature, dissolved water oxygen, PH level, and ammonia level when comparing with black soldier fly larvae meal and earthworm meal in the betta fish.

Ha: There is a difference in the water quality such as temperature, dissolved water oxygen, PH level, and ammonia level when comparing with black soldier fly larvae meal and earthworm meal in the betta fish.

## 1.5 Research question

1) Will the fish consume the feed that was formulated using earthworm powder and Black Soldier Fly Larvae (BSFL) meal?

2) Which feed will have better water quality which is suitable for the betta fish?

3) Can earthworm meal or Black Soldier Fly Larvae (BSFL) meal compete with the fish meal regarding the nutrition content?

### 1.6 Scope of study

This study is about the water quality that was effect by the different protein sources in the feed. In this study, the water quality of the different feeding trials will be observed to know which ingredient is more suitable as an alternative for fish meals. The most significant factor that needs to control the dissolved oxygen level and ammonia level. The comparison based on the observation can be obtained when the water quality is measured by using several equipment such as dissolved oxygen meter and sensor, PH meter, thermometer, and Fluorometers for 2 months.

### 1.7 Significance of study

In this study, the effect of different feeding trials on the water quality of betta fish was highlighted. There are a lot of ssign of this study. One of them is to know which feeding has the better water quality that is suitable for the fish production in terms of PH level, dissolved oxygen level, water temperature, ammonia level, and organoleptic test.

This study will provide a lot of knowledge to people especially the breeder of betta fish about the perfect ingredient that can be exchanged with the fish meal. For the buyer, they can obtain enough feed for the fishes without worrying about the feed suppl

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Ornamental fish



Ornamental fish are fishes that are inside a home aquarium, or it was used for aesthetic purpose. There is a wide variety of ornamental fishes that varies in shapes, sizes, and colors. In ornamental fish management, the water quality is very important in aquaculture because water quality will ensure the health of the fish. There are more than 30,000 fish species that was reported all over the world whereby about 800 are ornamental fishes. It includes eight closely associated families such as Anabantidae, Characidae, Callichthyidae, Cobitidae, Cichlidae, Cyprinidae, Cyprinodontidae, and Poeciliidae. There are two groups of aquarium fishes which are egg.

Layers (oviparous) and livebearers. In addition, the aquarium species are the egg layers and usually the external fertilization occurs. For the egg layers, it will be categories into 6 groups which are egg carriers, nest-builders, mouth incubator, egg buriers, egg scatter laying adhesive eggs and egg scatter laying non-adhesive eggs.

### 2.1.1 Beta fish (*Betta splendens*)

*Betta splendens* is known as the Siamese fighting fish or it is said as a betta. This fish can be found in Malaysia, Cambodia, Thailand, Indonesia, and Vietnam. There are more than 73 species that comprise the genus of Betta but only *Betta splendens* is referred to betta due to the large popularity though out the world as pets. This fish is widely available due to the vibrant color, low maintenance, and diverse morphology. This species usually grows about 6-8 cm in length. It is usually green, grey, and brown in color while the fins are short. These Siamese fighting fish have. The suitable condition for this fish is that the PH needs to be 6 to 7.5 while the temperature is about 75°F - 80°F. the life span of betta fish is about 3 to 5 5 years but it depends on the tank condition that the fish are kept. The water change, nitrogen level, and a proper tank setup are very important in order to prevent any disease and at the same time extend the lifespans of fish.

i. **Feed nutrition for Betta fish**

Betta fish need a well-balanced diet which is high in protein content because it is known as carnivores. When feeding the betta fish, the protein, fat, phosphorus, fiber, carbohydrates, vitamins (A, D3, E, B1, K, B2, B3, B6, B12, H, C, M) and calcium. The betta fish cannot process fillers such as wheat and corn well due to its very short digestive tracts. It was found that the filler can affect the fish by causing the fish to bloat and suffer digestive issues such as constipation. The filler will not give any nutritional benefits to the fish because it will flow as waste. The wheat meal contains a high content of fibre which made it limited to be used to herbivorous and omnivorous fish. The recommended amount of wheat meal to be used is between 2 and 5% and it is preferably extruded (Hertrampf et al., 2000).

### ii. Betta fish industry

The production of high-quality ornamental fish is made possible by Thailand's abundant natural resources and long tradition in the ornamental fish business. Thailand is one of the world's leading suppliers of ornamental fish (Dey, 2016). The betta fish has long been the most popular and most valuable aquatic animal exported. Betta fish exports totaled roughly 22.82 million last year, with a monetary worth of $5.55 million. As betta fish's global market value and popularity rise, the local betta fish farmers may thank DOF's capacity development trainings, which taught them how to use effective online marketing tactics, particularly social media advertising.

## 2.2 Fish meal

In the past, fish meal (FM) was the primary source of animal protein for aquaculture production. Overfishing, on the other hand, has increased, endangering many wild fish species. This, combined with rising demand, has resulted in an increase in the price of FM, as well as a decrease in the availability and desirability of aquafeeds. Fish meal is known as an excellent source of highly digestible protein, essential vitamins and minerals, long-chain omega-3 fatty acids (EPA and DHA) (*IFOMA, 2001*). it was used as a component of animal feeds for a couple of centuries, but the fish meal production has become a global enterprise for the past 50 years. The fish meals usually produce from the species of fish that was not used directly for human consumption or from the production of by-products of seafood processing. More than a decade ago, the annual global production in the fish meal had continued to increase from the range of 5.5 and 7.5 tons (Mt). More than 65% of the fish meal that was produced had been traded internationally whereby it had affected the global supplies and prices. Poultry feed was the largest single use of fish meal. Less than 10% of the annual fish meal production was utilized for the aquaculture feeds until 1990 but over the year, it had increased by about more than 10% for the past decades. It is said that sooner or later the demand for the fish meal will exceed the annual production due to the current use pattern of the fish meal.

For the past 15 years or more, there was a lot of research center that had conducted a few tests in order to find an alternative protein source that can replace the fish meal in the diet of farmed fish. The others that were not a part of the research to find an alternative for the fish meal had embraced the issue for a couple of reason int he aquaculture industry and the awareness had been expended over the segment of the scientific community that needs to face the issues every day (Naylor et al.,2000).

The expansion of fish meal had led to the demand for high-quality of protein source. The fish meal had become the primary protein sources in the feed diets of poultry, fish and swine that needed a higher quality of protein than the other farm stock such as sheep and cattle (FAO,1975). The overall production of aquaculture production had increased from 10 Mt to over 30 Mt between the years 1964 and 1997 (FAO,1999). In 1998, the production of fish was nearly 19 Mt which is more than 70 % that was attributed to the production of cyprinids such as the various species of carp (FAO,2000).

### 2.2.2 Nutrient composition of fish meal

The addition of fish meals in fish diets can help to increase the feed efficiency and growth for better feed palatability and at the same time enhance nutrient uptake, absorption, and digestion. In fish meal, it consists of a balanced amino acid composition that can provide a synergistic effect with the other animal and the vegetable protein that contain in the diet that can promote fast growth. With the addition of fish meal into the aquatic animal's diet, it can help to reduce the pollution due to the wastewater effluent by providing a better nutrient digestibility. A high-quality fish meal usually consists more than 66% of crude protein, about 8 to 11% of fat, and usually less than 12% of ash. Other fishery by-products will consist of fish protein concentrate with a high level of protein which is more than 70% (Kaushik, 2010). The fish meal also high in other nutrients like essential fatty acid, cholesterol, phospholipids minerals, and certain vitamins (Tacon et al.,2009)

## 2.3 Black Soldier Fly Larvae (BSFL)

Black Soldier Fly or it is known as *Hermetia illucens Linnaeus* 1758 which is a fly type (Diptera) and it is from the *Stratiomyidae* family. For the black soldier fly larvae (BSF larvae), the cycle of the BSF will run parallel with the flow of the organic waste transformation (Dortmans et al, 2017). The adult fly is black in color, wasp-like, and 15-20 mm long (Hardouin et al., 2003). The length will be 27 mm, 6mm wide and up to 220 mg during the last stage of their larval can be achieved by the larvae. The larvae are dull and whitish in color (Diclaro et al., 2009). The larva will empty the digestive tract and at the same time, it will stop its breeding and movement at the last of the larval stage which is prepupa (Hardouin et al., 2011). For the duration of the pupal stage, it will take 14 days, but it can be extremely variable whereby it can last for 5 months (Hardouin et al., 2003). Two days after the emergence, the female will mate and oviposit into the dry cracks and crevices adjacent to a feed source (Diener et al., 2011). In addition, the adults will not feed on the fat that had been stored from the larval stage (Diclaro et al., 2009).since the 1990s it had been proposed that rearing the *Hermetia illucens* is an efficient way to get rid of the organic waste by transforming it into a protein-rich and fat-rich biomass that is very suitable for various purposes such as animal feeding for all livestock species, chitin production and biodiesel (Van Huis et al., 2013; Diener et al., 2011). The black soldier fly is known as a very resistant species whereby it can deal with demanding environmental conditions such as feed shortage, drought, or oxygen deficiency (Diener et al., 2011). By using the feed based on black soldier fly larvae in aquaculture, an additional marketing opportunity was able to open for the farmers whereby some of the customers were supposed to use fish meal in the feeds (Tiu,2012).

### 2.3.1 Process of black soldier fly larvae

In order to rear the black soldier flies, several methods can be done such as rearing it on a substance such as pig manure (Newton et al., 2005), food waste (Barry, 2004) and poultry manure (Sheppard et al., 1994) had been designed. The optimum condition inclusing a narrow range of temperature and humidity and including the suitable levels of texture, moisture content of the diet and the viscosity. For the temperature, it need to be maintained between 29 and 31ºC which is through a wider ranges that may be feasible. Between 50 and 70% that the humidity is suitable. Higher humidity will make the diet too sticky, and the diet should usually have enough structure for the larvae to crawl on it, get enough oxygen, and consume it (Barry,2004). The ideal temperature for mating and ovipositing has been stated to be about 24-40°C or

27.5-37.5°C (Sheppard et al., 2002). Adult flies aren't drawn to human environments or food, so they aren't considered a nuisance (Van Huis et al., 2013).

### 2.3.2 Life cycle of black soldier fly

The fly's life cycle will last approximately 5 to 6 weeks. After the female dies, the oviposition process will begin, producing 400 to 800 eggs. The first larva stadium will hatch after 4 days, and they will be just a few mm long and voracious. The first larvae will continue to develop for another 12 to 14 days if they are given appropriate environmental conditions and a good organic substrate. Finally, at the end of the cycle, the larva will reach the pupa stadium, which will end in 2 or 3 weeks with the emergence of a fly (Dormans et al., 2017). The female will find a husband, mate, lay eggs, and die when she reaches the single week of her adult life. Around 69 percent of the mating will take place two days after the eclosion, with the light intensity having a major effect (Tomberlin and Sheppard, 2002).

After four days of eclosion, about 70% of the adult females had laid their eggs (Tomberlin and Sheppard,2002). The control of light intensity will aid in synchronizing mating behavior, causing females to lay eggs at roughly the same time (Dortmans et al., 2017). The larvae were inoculated into the organic matter and after five days had hatched, the biotransformation process began. Just around 2% to 5% of the of the larvae will be allowed to mature into adults (Dortmans et al., 2017). It will be harvested on day 12 post-inoculation, when their nutritional properties are at their peak and before they turn into prepupae (Dortmans et al,. al., 2017; Liuetal.,2017).

The final weight will be determined by the quality and quantity of substrate, as well as the environmental conditions and light level. If the conditions are suboptimal, the weight achieved will be lower, and the time to reach the final stage will be longer (Dortmans et al., 2017). The transformed organic matter and the larvae will be processed separately after harvesting. The larvae are normally dried or frozen before being commercialized as an animal feed ingredient. The organic product can be dried for use as a compost or fermented for biogas production, among other things (Dortmans et al., 2017).

### 2.3.3 Nutrient composition of black soldier fly larvae

BSFL are wealthy in a extend of supplements such as protein, fat, calcium, and phosphorus. For the 100g of dried BSFL, it comprises of up to 50% protein, 6% calcium, 35% of fat, 1% Magnesium, 1.2% phosphorus, and 0.3% of sodium. The fat that was found in BSFL contains an amino corrosive composition that is comparative to the angle supper. BSFL is additionally known and utilized as an elective protein source for the pigs, poultry, angle, and shrimp species. In the event that the BSFL is encouraged with diverse sources, it can impact the supplement composition of the BSFL hatchlings. In the event that the BSFL is bolstered with fertilizer, the sum of protein will be higher whereby the protein substance within the fly hatchlings can be diverse from 31.2% to 45.7%. BSFL contains around 80 times more sum of calcium compared to other commonly eaten insects. The BSFL is additionally wealthy in fat whereby the fat is more qualitative than the other conventional nourish fats. This is often due to the 53% of fat contained within the BSFL is known as lauric acid which may be a great substance that offers assistance to the pets to absorb the nutrients easier.

Table 2.1: nutrient composition of 100g of dried BSFL

| Nutrient | Amount (%) |
|---|---|
| Protein | 50 |
| Magnesium | 1 |
| phosphorus | 1.2 |
| Calcium | 6 |
| sodium | 0.3 |
| Fat | 35 |

## 2.4 Earthworm

The earthworm is known to be very efficient in converting plant and animal waste into biomass whereby it can be used as a feeding ingredient in animal production. 100 kg of worms can be produced from a ton of animal wastes (Edwards,1985). The earthworm is known as a good quality of protein that is used in animal feeds whereby the practical use of the earthworm meal can be influence by economics. The protein-rich earthworms are the byproduct of vermicomposting. It is said that in order to grow the earthworms, it is easier than raising the insects and through the economic and the energy point of view as the many earthworm species are adapted to the broader temperature ranges than insects (Tedesco et al., 2019). An extensive research programme was initiated by the Agricultural Research Council at Rothamsted Experimental Station, Harpenden, Herts, to develop economically viable methods of using earthworms to break down animal and vegetable wastes into useful vermicomposts, as well as to produce earthworm protein that could be used in fish farming and for domestic animal feeds (Edwards et al. 1985; Edwards 1988). African night crawler is characterised as a giant earthworm that grows exceptionally rapidly, is moderately prolific, and under optimum conditions might be considered as ideal for production of animal feed protein.

### 2.4.1 Morphology and life cycle of earthworm

The earthworm is segmented, displaying indeterminate growth after sexual maturity, bilaterally symmetrical invertebrates, and the length can reach up to 30 cm. The earthworms have a digestive tract that consists of a mouth, a crop and gizzard, an intestine, and an anus. The earthworm circulatory system, it is consisting of a blood vessel and several pairs of hearts (5 Lombricids). it does not have any lungs and the respiratory exchange will happen through the skin. It is also known as hermaphrodites which is the earthworm has both female and male sexual organ.

Both sexual organs must mature and mate in order for mating to occur. They must move close to each other and transfer their sperm through the clitellum (whitish part of the earthworm). After that, the sperm will be kept in a sac and will begin to form cocoons to house the fertilized eggs. The eggs will then be transferred to the cocoons, where they will be fertilized with sperm obtained from another earthworm. If it runs out of sperm, the earthworm will continue to produce eggs and sperm. After that, the cocoons would be dropped to the ground. The cocoons will hatch in two to three weeks, and each cocoon will release one to five young earthworms. The cocoons will be inactive for a long time, waiting for the right conditions. The young worms are only an inch to a half-inch long when they are born. The young worms are translucent and white. It is also said that the embryos grow inside the cocoon, and the incubation period can last anywhere from 5 to 20 weeks, depending on the species and the temperature where they live (Edwards and Lofty 1972).

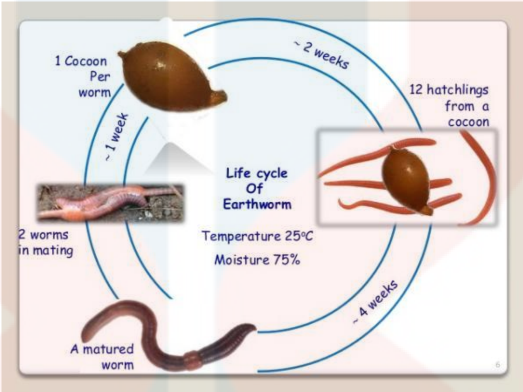


Figure 2.1: Life cycle of an earthworm (source: AOL.)

### 2.4.2 Nutrient composition of earthworm

The protein content and amino acid composition of earthworm are better than the fish meal and soybean milk. For dry matter, earthworm contains 60-70% protein, 2-3% minerals, 6-11% fat, 5-21% carbohydrates, and a range of vitamins including niacin. An earthworm is known to be higher in essential amino acids such as methionine, lysine, and either meat or fish meat. The earthworm is also high in the essential long chain of fatty acids.

Table 2.2 nutrient composition of dry matter earthworm

| Nutrient | Amount (%) |
|---|---|
| Protein | 60-70 |
| Minerals | 2-3 |
| carbohydrates | 5-21 |
| Fat | 6-11 |

## 2.5 Water quality

Water is the cultural environment for fish and other aquatic organisms. It is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion, and excretion (Bronmark and Hansson, 2005). There are a lot of different physical, chemical, and biological characteristics that make water suitable for a certain purpose. Water quality in the broadest sense refers to all of these characteristics (Boyd, 1979). Water quality management in fish health means controlling these parameters in order to help fish grow and in some cases to control reproduction, which is mostly to keep the fish healthy and show off their healthy looks and behaviour. Poor water quality is thought by most experts to be the main reason fish die and the main stressor that makes them more likely to get sick. Routine water quality monitoring is important for fish health, and fish keepers will benefit a lot if they check water quality at regular intervals.

Fish, unlike other animals, feed and defecate inside the same water where they live and the quality of the water inside which they live directly affects feed efficiency, rate of growth, survival, and the state of health of the fish. When water quality depreciates, consumed feed is not properly converted into body flesh. Poor growth is recorded, fish survival is affected, and ultimately massive fish kills may occur (Towers, 2014). In fish production, key water quality parameters which need to be continually monitored are temperature, dissolved oxygen, and pH value. Water parameters play a major role in the overall business of profitable fish farming. Making profit from fish farming really goes beyond just giving food to the fishes. Water quality parameters such temperature, pH, and dissolved oxygen (DO) level must be monitored, and acceptable ranges must be maintained (Towers, 2014).

The biological activity and metabolic rates of aquatic species are affected by water temperature (Wetzel, 2001). Fish are cold-blooded, unlike humans, which are warm-blooded. The temperature of the water has a significant impact on the metabolism that occurs in their bodies. The hydrogen ion concentration in water is measured by pH. Water can be alkaline, neutral, or acidic. Highly low or high pH would have a significant impact on fish production. pH levels that are too high can also destroy the fish.

### 2.5.1 Dissolved oxygen

The amount of free, non-compound oxygen contained in water or other liquids is referred to as dissolved oxygen. Because of its impact on the creatures that live in bodies of water, it is an essential metric in determining water quality. Too much or too little dissolved oxygen can damage aquatic life and degrade water quality. Non-compound oxygen (O2), also known as free oxygen (O2), is oxygen that has not been bound to any other element. The existence of these unbound O2 molecules within water is referred to as dissolved oxygen. The bound oxygen molecule in water (H2O) is a chemical that does not contribute to dissolved oxygen levels. Based on the IFAS Extension from University of Florida, it was stated that the dissolved oxygen level for Betta can range from 0.0 until 7.4 mg/L. Dissolved oxygen (DO) refers to the oxygen gas that is in water and is called oxygen gas that is in water. Fish use their gills to get the DO out of the water and into their bloodstream. Even though some fish, like bettas and gouramis, can breathe air, enough oxygen should always be in the water for all fish. When water is hot, salty, and at a certain pressure, it can hold a certain amount of oxygen. This is called saturation. It gets warmer, and the amount of oxygen that water can hold gets smaller.

If there is not enough oxygen in the water for the fish to have healthy gills. Their gills will start to look dark red and swollen. It happens when blood vessels near the affected area widen, allowing white blood cells to get closer to the injured tissue and start the body's own healing process. Inflamed gills are caused by this. Gill inflammation makes it hard for the body to get the oxygen it needs. In order to get more oxygen into its body, the fish breathes faster when it thinks there isn't enough in its body.

### 2.5.2 PH

PH stands for the negative logarithm (log 10) of the hydrogen ion (H +) concentration, which is called the pH value. People who live in the water need a pH level that is between 5.5 and 8.5. Fish species have different ideal pH ranges. It's best for marine fish to have a pH of 8.0 to 8.5 (basic), but some tropical species prefer a slightly acidic pH (7.0). In fish farming systems, a number of chemical and biological processes keep the pH level stable. The buffering capacity of water determines how much acid-forming biochemical reactions change the pH of the water they happen in. An acid or base and one of its salts can make up a buffer. It can also be made up of a weak acid and one of its salts (Boyd, 1979).

When it comes to the pH of a Betta Fish, it should be between 6.5 and 7. The neutral pH, which is 7, is covered by this. It doesn't have to be acidic or alkaline to be a good thing. It is said that both acidic and basic pH levels can be bad for fish which can kill the fish. pH can chemically burn the outside and inside of betta fish and other invertebrates at both ends of the scale. In addition, betta fish could die due to excessive amount of ammonia, which can be very painful for them to die. Different type of fish that comes from different parts of the world have different body systems that can handle different water conditions and parameters. There are many things that betta fish, as well as other animals, and plants, need to work properly if the pH in their water is correct.

### 2.5.3 Temperature

Fishes are mostly ectotherms, which means that their metabolisms are well-suited to a wide temperature range (Moyle and Cech, 2004; Crockett and Londraville, 2006). The optimal temperature range for a species of interest must be determined. Temperate species can withstand water temperatures ranging from 0 degrees Fahrenheit to 30 degrees Fahrenheit. To maintain optimal health, most freshwater tropical fish prefer between 24 and 27 degrees Celsius (75 and 80 degrees Fahrenheit), while most tropical marine species prefer between 25 and 29 degrees Celsius (78 and 84 degrees Fahrenheit).

Most of Southeast Asia's coastlines have water temperatures ranging from 25 to 32 degrees Celsius on a regular basis. Temperatures might fall as low as 10 degrees Celsius during the rainy or cold season. In contrast, the warm or dry season lasts for a shorter period. As a result, Bettas do better in warm water than in cold water. It's a tropical fish, hence it behaves in this manner. Betta Fish require a temperature of between 21 and 27 degrees Celsius to thrive in an aquarium. The aquarium needs to be placed in a safe and secure location where it won't be harmed by any outside influences on the water's temperature. Fish are thought to be particularly sensitive to the dangers of very hot or very cold water.

It can kill the betta if the water is too cold. Their immune system will slow down, and it will be prone to disease. It may also be uncomfortable for older fish who have a faster metabolism than fish that live in cooler water for a long time. Cool water can make the fish sick or die due to lack of oxygen or stress in fish.

2.5.4 Ammonia

Ammonia is the main nitrogenous waste product of fish. It is mostly removed through the fish's gills, but also a little through the kidneys (Schwedler et al., 1985). Ammonia is also made when organic matter in water, like faeces, food that hasn't been eaten, or dead plants, breaks down. In water, unionised ammonia (NH 3) and ionised ammonium (NH4+) are in balance with each other at different pH and temperatures. This is important because NH 3 is more harmful to aquatic life than NH4+, so when the pH and temperature of the water in a culture system are higher, more ammonia is harmful.

When the levels of ammonia in your fish's water get too high, the water isn't safe for them. Burns the fish's eyes and gills, fins and skin. A fish that is exposed to even small amounts of ammonia can make more skin mucus, giving him a pale look. The mucus can also get on the fish's gills and make it hard for him to breathe. The fish's skin is burned by ammonia, and bacteria can spread both inside and outside the fish. Below 0.5-1 mg/l, the fish will be fine, but keeping the ammonia level at 0.01-0.2 mg/l is better for the fish and still gives the bacteria some food to eat.

# CHAPTER 3

# METHODOLOGY

## 3.1 Materials

### 3.1.1 Equipment



All the equipment that had been used in this study are beaker 250 ml, plastic dropper, distilled water bottle, Hanna multiparameter and ammonia checker set

### 3.1.2 Raw materials

Raw materials that had been used in this study are earthworm and black soldier fly larvae (BSFL) which is the main ingredient of the fish feed that was made.

## 3.3 Methods

### 3.3.1 Water preparation

For the water preparation, the water that was used for the betta fish was put into a big container to prepare an amount of water that is needed for all the aquariums. There are approximately 33 aquarium which each of the aquarium have 2 pairs of fish. In the big container 3000ml of tap water was added and about 4ml of anti-chlorine was mixed. The water was then left for about half an hour for the anti-chlorine to be mixed thoroughly with the tap water. Next, the water was filled in each of the aquarium for about half of the aquarium and the fish was added.

### 3.3.1 Feed preparation

There are two types of feed that was formulate which is the earthworm based feed and Black soldier fly larvae (BSFL) based feed. For the feed preparation of earthworm-based feed, the earthworm was obtain from Masjid UMK Jeli that was then breed using an aquarium with the soil origin of the earthworm. The feed was mixed manually by hand and the binder that was used is molasses. The control feed that was used in this experiment is 100% based fish meal or it is known as 0% BSFL and 0% earthworm. The experimental feed that was prepared for each main ingredient have different level of main ingredient (BSFL and earthworm) which are 25%, 50%, 75% and 100%.

### 3.3.2 Proximate analysis

Proximate composition analyses of the experimental diets were performed according to AOAC (1997). The composition of the diets ingredients and proximate composition that are given. proximate composition of the feed is based on the table 3.2.2.1 and table 3.2.2.2. Table shows the proximate composition for feed using Black Soldier Fly Larvae (BSFL) while table is for All experimental diets were analyzed for amino acids composition using HPLC (High Performance Liquid Chromatography) system (Breeze, Water Corporation, Milford, MA, USA) according to the manufacturer instructions. The feed that was made using earthworm. The feed was formulated into 5 compositions for each type of feed which is 0%, 25%, 50%, 75% and 100%. For the formulation, the ingredient that was used is soybean meal, wheat flour, vitamin mineral premix, rice bran and molasses. Molasses was used as a binder for the feed so that all the ingredients can bind together.

Table 3.2.2.1 proximate analysis for earthworm feed

| Ingredients (g/kg) | Feeds | | | | |
|---|---|---|---|---|---|
| | 0% earthworm (EW 1) | 25% earthworm (EW 2) | 50% earthworm (EW 3) | 75% earthworm (EW 4) | 100% earthworm (EW 5) |
| Fish meal | 26 | 19.5 | 13 | 6.5 | 0 |
| Earthworm | 0 | 6.5 | 13 | 19.5 | 26 |
| Soybean meal | 30 | 30 | 30 | 30 | 30 |
| Wheat flour | 10 | 10 | 10 | 10 | 10 |
| Vitamin mineral premix | 2 | 2 | 2 | 2 | 2 |
| Molasses (binder) | 4 | 4 | 4 | 4 | 4 |
| Rice bran | 28 | 28 | 28 | 28 | 28 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Proximate analysis (%) | | | | | |
| Crude fibre | 1.59 | 1.78 | 2.03 | 1.82 | 2.1 |
| Crude fat | 2.67 | 2.87 | 3.57 | 3.00 | 2.63 |
| Crude protein | 35.17 | 36.47 | 37.4 | 37.17 | 32.7 |
| Moisture | 4.62 | 7.53 | 7.47 | 8.1 | 10.57 |
| Ash | 6.63 | 9.97 | 7.73 | 7.5 | 11.33 |
| Total carbohydrate | 60.33 | 58.1 | 58.87 | 61.4 | 55.57 |
| Energy value (kcal/100g) | 367.88 | 363.59 | 372.69 | 380.38 | 350.96 |

Table 3.2.2.2 proximate analysis for BSFL feed

| Ingredients (g/kg) | Feeds | | | | |
|---|---|---|---|---|---|
| | 0% Black Soldier Fly Larvae (BSFL 1) | 25% Black Soldier Fly Larvae (BSFL 2) | 50% Black Soldier Fly Larvae (BSFL 3) | 75% Black Soldier Fly Larvae (BSFL 4) | 100% Black Soldier Fly Larvae (BSFL 5) |
| Fish meal | 26 | 19.5 | 13 | 6.5 | 0 |
| BSFL | 0 | 6.5 | 13 | 19.5 | 26 |
| Soybean meal | 30 | 30 | 30 | 30 | 30 |
| Wheat flour | 10 | 10 | 10 | 10 | 10 |
| Vitamin mineral premix | 2 | 2 | 2 | 2 | 2 |
| Molasses (binder) | 4 | 4 | 4 | 4 | 4 |
| Rice bran | 28 | 28 | 28 | 28 | 28 |
| Total | 100 | 100 | 100 | 100 | 100 |
| Proximate analysis (%) | | | | | |
| Crude fibre | 2.1 | 2 | 1.9 | 2 | 2.07 |
| Crude fat | 3.63 | 3.17 | 5.03 | 5 | 8.67 |
| Crude protein | 32.73 | 32.47 | 33.27 | 33.7 | 33.5 |
| Moisture | 4.43 | 8.27 | 6.77 | 6.83 | 7.77 |
| Ash | 6.67 | 6.4 | 7.1 | 7.1 | 6.97 |
| Total carbohydrate | 58.4 | 51.13 | 58.77 | 61.77 | 61.03 |
| Energy value (kcal/100g) | 361.42 | 327.03 | 358.44 | 389.58 | 416.66 |

### 3.3.3 Location and study design

The experiment was carried out at Animal Lab in University Malaysia Kelantan, Jeli Campus, Kelantan. The experiment was conducted for four weeks by monitoring the water quality of the *Betta Splendens*. The data was collected every week on the same day at 10 am until 1pm.

The *Betta splendens* that was purchased from a local Betta breeder from Kelantan which is 3 months old. The earthworm that was used in this experiment was obtain from Masjid UMK Jeli that was then breed using an aquarium with the soil origin of the earthworm. The earthworm was breed for about 3 months before the experiment started. Next, the Black Soldier Fly Larvae (BSFL) that was used is in a form of BSFL meal that was obtain from a local supplier. The third main ingredient is fish meal that was obtain from UMK Jeli.

### 3.3.4 Growth performance

The growth performance of the fish was observed for 4 weeks which is about 31 days. For the growth performance data, the weight gain, specific growth rate, feed conversion rate and percentage weight gain were calculated using the specific formula.

Table 3.3.4.1 Growth performance of earthworm feed

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% EW | 25% EW | 50% EW | 75% EW | 100% EW |
| Initial weight | 1.22 ± 0.65 | 1.08 ± 0.67 | 1.16 ± 0.20 | 1.16 ± 0.23 | 0.98 ± 0.26 |
| Final weight | 1.34 ± 0.20 | 1.24 ± 0.16 | 1.36 ± 0.26 | 1.34 ± 0.30 | 1.06 ± 0.27 |
| Weight gain | 0.12 ± 0.07 | 0.17 ± 0.23 | 0.20 ±0.16 | 0.18 ±0.12 | 0.08 ±0.07 |
| Specific growth rate | 0.004 ±0.002 | 0.005±0.007 | 0.006±0.005 | 0.006±0.004 | 0.003±0.002 |
| Feed conversion rate | 1.40±1.38 | 6.15 ±8.39 | 0.95±0.79 | 0.84±0.54 | 4.60±5.99 |
| Percentage weight gain (%) | 12.09±7.40 | 16.50±23.04 | 19.55±16.25 | 17.59±11.79 | 7.72±6.91 |

Table 3.3.4.2 Growth performance of BSFL feed

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% BSFL | 25% BSFL | 50% BSFL | 75% BSFL | 100% BSFL |
| Initial weight | 1.22 ± 0.16 | 1.14 ± 0.25 | 1.11 ± 0.14 | 1.13 ± 0.19 | 1.11 ± 0.07 |
| Final weight | 1.34 ± 0.20 | 1.22 ± 0.27 | 1.25 ± 0.10 | 1.29 ± 1.82 | 1.30 ± 1.12 |
| Weight gain | 0.12 ±0.07 | 0.07 ±0.07 | 0.14 ±0.14 | 0.17 ±0.06 | 0.19 ±0.10 |
| Specific growth rate | 0.004±0.002 | 0.002±0.002 | 0.004±0.004 | 0.005±0.002 | 0.006±0.003 |

| | | | | | |
|---|---|---|---|---|---|
| Feed conversion rate | 1.40±1.38 | 3.20±2.89 | 8.31±18.20 | 0.68±0.31 | 0.63±0.28 |
| Percentage weight gain (%) | 12.09±7.40 | 7.24±6.97 | 13.51±13.51 | 16.89±6.30 | 18.93±9.68 |

### 3.3.4.1 Data collection and analysis

Data of the growth performance of the betta fish was recorded and the weight was determined using an electronic balance of model. The weight gain (WG), percentage weight gain (PWG), feed conversion ratio (FCR), specific growth rate (SGR) were determined using the specific formula.

i.FCR = Total feed intake (g)

Total wet weight gain (g)

ii.PWG (%) = 100 × (Final mean body weight (g)-initial mean body weight (g))/(Initial mean body weight (g))

iii. SGR = Final body weight of fish - Initial body weight of fish / No of days reared

iv. BW(body weight gain) =Final weight of fish - Initial weight of fish

### 3.3.5 Water quality parameter

The water quality which is the oxygen dissolved level, pH level, ammonia level, and water temperature needs to be measured twice a week on the same day before the aquarium is clean. Hanna multiparameter was used to measure dissolved oxygen level and water temperature. The water from the aquarium was pour into a beaker 250 ml. The multiparameter was set according to the data that need to be observed and the cover of the multiparameter probe was open. The probe was rinse using distilled water and dry using tissue. Next, after the probe was rinse, the probe was immersed into the beaker that contain the water sample until the steel at the probe was immerse. The reading was recorded, and the probe was taken out from the beaker. After every use, the probe will be rinse with distilled water and dry with tissue. All of step except for the step which the multiparameter need to be set was repeated until all the water sample was recorded.

For ammonia, Hanna ammonia checker was used to identify the ammonia content in each water sample. Firstly, press the button at the checker until the add appear on the screen and the C1 symbol appear at the checker. 10 ml of unreacted sample was filled into the cuvette using a dropper. Before putting the sample into the checker, the outer surface of the cuvette needs to be wipe with a piece of cloth or tissue to avoid any fingerprints and to make sure that it is dry. When the cuvette was put into the checker, the cover of the checker was closed. Then, press the button and wait until the meter determine the absorbance of the unreacted sample. When the C2 appear on the screen it means that the sample had been successfully zeroed. After that, the cuvette was removed and 4 drops of HI 715A-0 or it is known as reagent A. When reagent A, close the cuvette with cap and swirl it. The cap was then removed again, and the 4 drops of HI 715B-0(reagent B) was added into the cuvette. The cuvette was closed with cap and swirl to make sure that the sample was mixed with the reagent. The outer surface of the cuvette was wipe and put back into the checker. Lastly the button was press for a couple of second until the timer was displayed on the LCD. The reagent will take 3 minutes and 3 second for the reagent to react. When the timer is over, the reading was recorded, and the ammonia was calculated using the formula. All the steps were repeated for the other sample. Before a new sample was filled in the cuvette, the previous sample in the cuvette need to be thrown away and the cuvette need to be rinse with distilled water.

## 3.4 Statistical analysis

The statistical analysis was carried out using the software SPSS (Version 16.0), and the importance of the results was determined. Duncan's multiple range test was used to analyse the difference in means. The significance of different treatments was determined using one-way analysis of variance on *B. splendens* feeding parameters. All the data was analyzed with triplicate and the significant difference (P<0.05)

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 water quality result

### i.week 1

Table 4.1.1 water quality result earthworm week1

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% EW | 25% EW | 50% EW | 75% EW | 100% EW |
| MVPH | 72.97 ± 2.81 | 85.93 ± 1.08 | 76.80 ± 5.00 | 83.40 ± 5.01 | 88.97 ± 3.53 |
| PH | 5.91 ± 0.55 | 5.68 ± 0.02 | 5.84 ± 0.93 | 5.72 ± 0.09 | 5.62 ± 0.07 |
| MVORP | 167.50 ± 2.88 | 207.47 ± 4.23 | 198.53 ± 6.16 | 218.60 ± 25.73 | 233.57 ± 2.83 |
| DO (%) | 49.07 ± 14.15 | 63.07 ± 1.26 | 66.23 ± 1.62 | 65.13 ± 0.68 | 68.20 ± 1.59 |
| MgLDO | 4.09 ± 1.17 | 5.24 ± 0.11 | 5.47 ± 0.09 | 5.39 ± 0.04 | 5.62 ± 0.10 |
| Temperature | 24.52 ± 0.15 | 24.69 ± 0.15 | 24.84 ± 0.14 | 24.95 ± 0.20 | 25.15 ± 0.17 |

| | | | | | |
|---|---|---|---|---|---|
| Ammonia | 1.08 ± 0.04 | 0.58 ± 0.08 | 1.16 ± 0.67 | 0.96 ± 0.50 | 1.68 ± 0.80 |

Table 4.1.2 water quality result BSFL week 1

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% BSFL | 25% BSFL | 50% BSFL | 75% BSFL | 100% BSFL |
| MVPH | 72.97 ± 2.81 | 82.47 ± 14.84 | 76.47 ± 9.68 | 91.67 ± 3.85 | 113.47 ± 14.67 |
| PH | 5.91 ± 0.55 | 5.74 ± 0.28 | 5.86 ± 0.17 | 5.59 ± 0.07 | 5.38 ± 0.05 |
| MVORP | 167.50 ± 2.88 | 250.20 ± 40.32 | 196.03 ± 15.37 | 181.50 ± 5.60 | 198.03 ± 4.74 |
| DO (%) | 49.07 ± 14.15 | 72.03 ± 3.27 | 75.93 ± 1.37 | 59.63 ± 0.29 | 57.00 ± 2.33 |
| MgLDO | 4.09 ± 1.17 | 5.87 ± 0.16 | 6.07 ± 0.08 | 4.59 ± 0.04 | 4.34 ± 0.13 |
| Temperature | 24.52 ± 0.15 | 25.86 ± 0.97 | 26.81 ± 0.37 | 28.36 ± 0.27 | 28.70 ± 2.69 |
| Ammonia | 72.97 ± 2.81 | 82.47 ± 14.84 | 76.47 ± 9.68 | 91.67 ± 3.85 | 113.47 ± 14.67 |

For week 1 of the water quality, it shows that 0% earthworm is only significance with 100% BSFL with the significance value of 0.000 while the other treatment is not significance is more that 0.05. For the 25%, 50%, 75% and 100% earthworm is not significance with the other treatment except for 100% BSFL. The significance of 100% earthworm with 100% BSFL is 0.029. For 0%, 25%, 50%, 75% BSFL is significance with 100% BSFL while 100% BSFL is significance with 75% BSFL. Next, 100% BSFL is also significance with 0% BSFL and 0% earthworm.

For ammonia value, 0% earthworm is significance with 100% BSFL and 0% BSFL is significance with 100% earthworm. 25% earthworm is significance with 75% BSFL and 100% BSFL with value of 0.000 and 0.019. 50%,75% and 100% earthworm is significance with 75% earthworm with value of 0.000. for 25% and 50% BSFL is it significance with 75% BSFL with value of 0.000. Next, 75% BSFL is significance with all of the treatment with a value of 0.000. 100% BSFL has a significance value of 0.000 with 75% BSFL.

**ii.week 2**

Table 4.1.3 water quality result earthworm week 2

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% EW | 25% EW | 50% EW | 75% EW | 100% EW |
| MVPH | 51.90 ± 10.44 | 99.03 ± 18.63 | 68.57 ± 10.17 | 79.17 ± 12.10 | 89.80 ± 4.39 |
| PH | 6.31 ± 0.20 | 5.44 ± 0.33 | 6.01 ± 0.16 | 5.80 ± 0.24 | 5.61 ± 0.08 |
| MVORP | 215.67 ± 54.42 | 329.90 ± 44.50 | 234.40 ± 36.60 | 224.10 ± 5.31 | 233.10 ± 13.86 |
| DO (%) | 36.47 ± 1.10 | 37.37 ± 0.21 | 38.63 ± 1.46 | 41.50 ± 1.65 | 42.50 ± 1.10 |
| MgLDO | 3.04 ± 0.09 | 3.12 ± 0.02 | 3.19 ± 0.10 | 3.38 ± 0.11 | 3.48 ± 0.02 |
| Temperature | 24.31 ± 0.09 | 24.45 ± 0.49 | 25.34 ± 0.72 | 25.26 ± 0.22 | 25.39 ± 0.09 |
| Ammonia | 1.36 ± 1.35 | 1.20 ± 0.28 | 0.93 ± 0.29 | 1.02 ± 0.32 | 0.98 ± 0.26 |

Table 4.1.4 water quality result BSFLweek

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% BSFL | 25% BSFL | 50% BSFL | 75% BSFL | 100% BSFL |
| MVPH | 51.90 ± 10.44 | 75.67 ± 13.12 | 62.73 ± 5.64 | 69.30 ± 7.09 | 62.20 ±2.72 |
| PH | 6.31 ± 0.20 | 5.87 ± 0.22 | 6.10 ± 0.11 | 6.00 ± 0.13 | 6.12 ± 0.04 |
| MVORP | 215.67 ± 54.42 | 198.37 ± 10.33 | 169.97 ± 19.23 | 130.97 ± 12.43 | 143.87 ± 8.21 |
| DO (%) | 36.47 ± 1.10 | 44.67 ± 1.88 | 46.30 ± 0.96 | 47.90 ± 0.75 | 60.70 ± 0.35 |
| MgLDO | 3.04 ± 0.09 | 3.66 ± 0.16 | 3.83 ± 0.07 | 3.89 ± 0.05 | 4.91 ±0.03 |
| Temperature | 24.31 ± 0.09 | 25.44 ± 0.14 | 25.67 ± 0.20 | 26.26 ± 0.52 | 25.91 ± 0.05 |
| Ammonia | 1.36 ± 0.14 | 0.79 ± 0.24 | 0.93 ± 0.40 | 1.49 ± 1.21 | 1.66 ± 0.49 |

For week 2 of the MVPH water quality, 0% earthworm,50% earthworm, 0% BSFL, 50% BSFL have significance value of 0.000 with 100% BSFL. 25% of earthworm is significance with 100% BSFL with a significance value 0.011 which is less than 0.05. 100% earthworm is not significance with all the treatment except 100% BSFL with a value of 0.029. 25% BSFL is significance with 100% BSFL has a value of 0.003. 100% BSFL is significance with all of the treatment except 0.069 which is more than 0.05. For Ph level, 0% earthworm, 50% earthworm, 0% BSFL, 25% BSFL, 50% BSFL are not significance with other treatment except for 100% BSFL that is less than 0.05 for the value. For 100% BSFL, it is significance with 0% earthworm, 50% earthworm, 0% BSFL and 50% BSFL.

For the ammonia reader, 0% earthworm, 25% earthworm, 50% earthworm,75% earthworm,100% earthworm, 0% BSFL, 25% BSFL, 50% BSFL, 75% BSFL and 100% BSFL are not significance with the other treatment because the value is more than 0.05. All of the value for all of the treatment is more than 0.05.

**iii.Week 3**

Table 4.1.5 water quality result earthworm week 3

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% EW | 25% EW | 50% EW | 75% EW | 100% EW |
| MVPH | 71.23 ± 18.33 | 76.53 ± 7.48 | 94.47 ± 1.50 | 88.00 ± 6.52 | 78.33 ± 2.08 |
| PH | 5.95 ± 0.34 | 5.83 ± 0.13 | 5.49 ± 0.06 | 5.64 ± 0.13 | 5.81 ± 0.04 |
| MVORP | 119.13 ± 21.28 | 146.53 ± 23.49 | 170.40 ± 5.86 | 148.03 ± 2.30 | 158.90 ± 12.41 |
| DO (%) | 50.77 ± 6.40 | 56.27 ± 6.09 | 62.47 ± 5.44 | 44.00 ± 13.45 | 70.77 ± 7.91 |
| MgLDO | 3.89 ± 0.41 | 4.21 ± 0.10 | 4.74 ±0.76 | 3.32 ± 1.03 | 5.47 ± 0.61 |
| Temperature | 25.72 ± 0.23 | 25.87 ± 0.23 | 25.86 ± 0.16 | 25.79 ± 0.40 | 25.95 ± 0.68 |
| Ammonia | 1.74 ± 0.64 | 1.75 ± 0.19 | 1.58 ± 0.31 | 1.00 ± 0.28 | 1.62 ± 0.25 |

Table 4.1.6 water quality result BSFL week 3

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% BSFL | 25% BSFL | 50% BSFL | 75% BSFL | 100% BSFL |
| MVPH | 71.23 ± 18.34 | 75.97 ± 2.74 | 75.97 ± 6.01 | 78.03 ± 4.77 | 94.67 ± 3.52 |
| PH | 5.95 ± 0.34 | 5.88 ± 0.06 | 5.86 ±0.11 | 5.82 ±0.09 | 5.52 ± 0.07 |
| MVORP | 119.13 ± 21.28 | 169.73 ± 3.29 | 171.87 ± 19.44 | 128.67 ± 17.35 | 133.03 ± 18.58 |
| DO (%) | 50.77 ± 6.40 | 64.33 ± 5.94 | 64.37 ± 6.25 | 68.37 ± 1.55 | 67.70 ± 1.90 |
| MgLDO | 3.89 ± 0.41 | 5.00 ±0.43 | 5.01 ±0.53 | 5.63 ± 0.23 | 5.48 ± 0.89 |
| Temperature | 25.92 ± 0.71 | 26.43 ± 0.19 | 26.74 ± 0.33 | 24.88 ± 0.20 | 24.41 ± 0.38 |
| Ammonia | 1.74 ± 0.64 | 1.29 ± 0.05 | 1.43 ± 0.86 | 2.00 ± 0.53 | 1.64 ± 0.53 |

For week 3 of the Ph level, 0% earthworm is significance with 25% earworm and 100% earthworm with a value of o.oo1 and 0.006.25% earthworm is significance with 0% earthworm, 50% earthworm, 0% BSFL, 50% BSFL, 75% BSFL, and 100% BSFL. For 75% earthworm, it is not significance with other treatment due to the value of significance level. 100% earthworm is significance with 0% earthworm and 0% BSFL with a value of 0.006. 0% BSFL and 50% BSFL are significance with 25% earthworm with value of 0.010. For the ammonia value, all of the treatment is not significance with each other because the value is more than 0.05.

**iv.Week 4**

Table 4.1.7 water quality result earthworm week 4

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% EW | 25% EW | 50% EW | 75% EW | 100% EW |
| MVPH | 71.23 ± 18.33 | 76.53 ± 7.48 | 94.47 ± 1.50 | 88.00 ± 6.52 | 78.33 ± 2.08 |
| PH | 5.95 ± 0.34 | 5.83 ± 0.13 | 5.49 ± 0.06 | 5.64 ± 0.13 | 5.81 ± 0.04 |
| MVORP | 119.13 ± 21.28 | 146.53 ± 23.49 | 170.40 ± 5.86 | 148.03 ± 2.30 | 158.90 ± 12.41 |
| DO (%) | 50.77 ± 6.40 | 56.27 ± 6.09 | 62.47 ± 5.44 | 44.00 ± 13.45 | 70.77 ± 7.91 |
| MgLDO | 3.89 ± 0.41 | 4.21 ± 0.10 | 4.74 ±0.76 | 3.32 ± 1.03 | 5.47 ± 0.61 |

| | | | | | |
|---|---|---|---|---|---|
| Temperature | 25.72 ± 0.23 | 25.87 ± 0.23 | 25.86 ± 0.16 | 25.79 ± 0.40 | 25.95 ± 0.68 |
| Ammonia | 1.74 ± 0.64 | 1.75 ± 0.19 | 1.58 ± 0.31 | 1.00 ± 0.28 | 1.62 ± 0.25 |

Table 4.1.8 water quality result BSFL week 4

| Parameter | Feed (%) | | | | |
|---|---|---|---|---|---|
| | 0% BSFL | 25% BSFL | 50% BSFL | 75% BSFL | 100% BSFL |
| MVPH | 71.23 ± 18.34 | 75.97 ± 2.74 | 75.97 ± 6.01 | 78.03 ± 4.77 | 94.67 ± 3.52 |
| PH | 5.95 ± 0.34 | 5.88 ± 0.06 | 5.86 ±0.11 | 5.82 ±0.09 | 5.52 ± 0.07 |
| MVORP | 119.13 ± 21.28 | 169.73 ± 3.29 | 171.87 ± 19.44 | 128.67 ± 17.35 | 133.03 ± 18.58 |
| DO (%) | 50.77 ± 6.40 | 64.33 ± 5.94 | 64.37 ± 6.25 | 68.37 ± 1.55 | 67.70 ± 1.90 |
| MgLDO | 3.89 ± 0.41 | 5.00 ±0.43 | 5.01 ±0.53 | 5.63 ± 0.23 | 5.48 ± 0.89 |
| Temperature | 25.92 ± 0.71 | 26.43 ± 0.19 | 26.74 ± 0.33 | 24.88 ± 0.20 | 24.41 ± 0.38 |
| Ammonia | 1.74 ± 0.64 | 1.29 ± 0.05 | 1.43 ± 0.86 | 2.00 ± 0.53 | 1.64 ± 0.53 |

For week 4 of the MVPH and Ph result, all of the treatment is not significance with one another. For example, 0% BSFL has a significance value of 1.000 with 0% earthworm, 25% BSFL, and 50% BSFL for the Ph parameter. For 50% BSFL, the highest significance level is 1.000 with the other treatment except for 50% earthworm,75% earthworm and 100% BSFL. For the ammonia result, 0% earthworm is significance with 100% earthworm and 75% BSFL with a value of 0.042, 0.012 and 0.011. 25% earthworm is significance with 0% earthworm and 0% BSFL with the same significance of 0.042. 75% BSFL is significance with 0% earthworm and 0% BSFL with a significance value of 0.011.

### 4.2 Discussion

#### 4.2.1 Growth data analysis

In this research, all the fish that was used were the same age and about the same size. For the initial weight of the fish, 100% earthworm feed has the lowest weight than others. All the fish will have a weight gain after the end of the research whereby the feed that was formulate using fish meal or it is known as 0% earthworm and 0% Black Soldier Fly Larvae (BSFL). 0% earthworm and 0% BSFL have the mean weight gain of 1.34 while the standard deviation is 0.20. The second highest result of weight gain is 50% earthworm which have the mean of 1.36 and the standard deviation is 0.26. for the 75% earthworm have the mean weight gain of 1.34 and the standard deviation of 0.30.

It can also be said that the 75% earthworm have the same amount of mean with the 0% earthworm and 0% BSFL.  25 % earthworm have the amount of mean for the final weight of 1.24 and the standard deviation of 0.16.  For the earthworm feed that have the lowest mean which is 1.06 and the standard deviation of 0.27.

For BSFL, 100% feed have the highest amount of mean which is 1.30 and the lowest amount of mean is 25% BSFL which is 1.22.  100% earthworm have the standard deviation of 1.12 and 25% have 0.27. 75% BSFL is higher than 50% BSFL but both is lower than 100% feed and higher than 25% feed. the 75 % BSFL mean is 1.29 and the standard deviation is 1.82 while 50% BSFL mean is 1.25 and the standard deviation is 0.10. For the weight gain, 50% earthworm and 100% BSFL have the highest weight gain which is the mean of 0.20 and 0.19. For the standard deviation of both feeds, it has 0.16 and 0.10. The lowest weight gain is 25% BSFL that have mean 0.07 and the standard deviation of 0.07.

The specific growth rate of the betta fish in this research is the lowest than other parameter. For example, the highest value among the mean of specific growth rate is 0.006 (75% earthworm and 100% BSFL) and the lowest mean value is 0.002 (25% BSFL). For the percentage weight gain, among all the treatment, 50% earthworm have the highest amount of mean that is 19.55 and the standard deviation is 16.25. Next, for the 0% earthworm and 0% BSFL, the mean is 12.09 and the standard deviation is 7.40. 25 % earthworm mean is 16.50 and the standard deviation is 23.04. 75% earthworm have 17.59 for mean and 11.79 for standard deviation. For the feed conversion rate, 50% BSFL has the highest mean that is 8.31 and 18.20 standard deviation. The lowest feed conversion rate is 100% BSFL which is 0.63 for mean and 0.28 for standard deviation.

Based on the statistical analysis was carried out using the software SPSS, it shows that all of the parameters were not significance within the group which means that all of the significance is more than 0.05. For weight gain, 0% earthworm is not significance with 25% earthworm, 50% earthworm, 75% earthworm, 100% earthworm, 0% BSFL, 25% BSFL, 50% BSFL, 75% BSFL and 100% BSFL. For 25% earthworm, it is not significance with the other group. It can be said that when all of the feed produced a non-significance result in the weight gain, it shows that the feed cannot affect the fish.

### 4.2.2 Water quality analysis

The water quality analysis was checked using multiparameter and ammonia checker that was collected for 4 weeks. For week 1, the ph level for 0% earthworm and 0%BSFL is the highest with the mean value of 5.91 and the standard deviation is 0.55. the lowest ph level for the first week is 100% BSFL which is 5.38 for mean and 0.05 for the standard deviation. 25% earthworm has the mean of 5.68 and the standard deviation 0.02. 75% earthworm has a higher mean than 75% BSFL which is 5.72 while BSFL has 5.59. For the mvorp result or it is known as the redox reaction in the aquarium. The mvorp result for 100% earthworm has the highest mean which is 223.57. Dissolved oxygen for 0% BSFL and earthworm shows the lowest mean than others that is 49.07 with standard deviation of 14.15. 50% EW has dissolved oxygen 66.23 for mean and 1.62 standard deviation. The dissolved oxygen of 75% earthworm is 65.13 while the standard deviation is 0.68. Among the BSFL based treatment, the highest dissolved oxygen is 50% BSFL that is 75.93 mean and 1.37 standard deviation. Temperature of the water can be manipulated by the surrounding because the aquarium was put outdoor. During this first week, the highest ammonia level is 100% BSFL that is 2.10 for mean and 0.50 for standard deviation. The lowest is 25% earthworm with the mean 0.58 and the standard deviation is 0.08.

For week 2, 0% earthworm and 0% BSFL pH is the highest with mean 6.31 and standard deviation 0.02. 25% earthworm mean is 5.44 and the standard deviation is 0.33. 50% earthworm pH mean is 6.01 that is higher than 75% earthworm with standard deviation of 0.16. among the BSFL feed besides from 0%, 100% BSFL have the highest mean that is 6.12 and standard deviation of 0.04. for the dissolved oxygen result that was obtain, 100% BSFL is the highest with 60.70 for mean and 0.35 for standard deviation. The lowest is the 0% earthworm and BFSL with mean 36.47 and standard deviation 1.10. 100% earthworm mean 42.50 that is higher than 75% earthworm with mean 41.50. For ammonia level, 0% earthworm and 0% BSFL has mean 1.36 and standard deviation 1.35. The lowest mean among all of the treatment are 50% earthworm and BSFL that has the mean of 0.93. 100% BSFL has 1.66 mean and 0.49 standard deviation.

For week 3, that is known as the week that has a slight difference in water quality result due to the different procedure that was done in previous week. The procedure that was done in week 3 when changing the water is that half of previous water in the aquarium was combine with the new water. This procedure was done to reduce the stress in fish due to the water changing. Unfortunately, it shows a slight increase in ammonia in some treatment in the raw data. For the pH level, 0% earthworm and 0% BSFL shows the highest mean pH of 5.95 and standard deviation of 0.34. the lowest pH level is 100% BSFL with mean 5.52 and standard deviation 0.07. Dissolved oxygen level for 25% earthworm mean is 56.27 and the standard deviation is 6.09. 75% earthworm has the lowest mean that is 44.00 and the standard deviation 13.45. The highest dissolved oxygen is 100% earthworm that is 70.77 mean and 7.91 standard deviation. Ammonia level is the lowest at 75% BSFL that is 2.00 for mean and 0.53 standard deviation. Among the earthworm feed, 25% earthworm has 1.75 mean which is the highest with a standard deviation of 0.19. Mean for 25% BSFL is lower than 50% BSFL whereby 25% is 1.29 and 50% is 1.43.

For week 4 that is the final data, the highest pH among all of the treatment is 50% BSFL that is 6.18 mean and 0.08 standard deviation. The 0% earthworm and BSFL has the mean of 5.04 and standard deviation of 0.67. For the dissolved oxygen, 0%

earthworm and BSFL 45.40 mean and 2.10 stand deviation. 50% BSFL mean is 53.50 which is higher than 100% BSFL that has a mean of 43.50. 25% BSFL is lower in mean than 25% earthworm. 25% BSFL mean is 44.50 and 13.18 for standard deviation while 25% earthworm has 45.70 mean and 3.26 standard deviation. For ammonia, 0% BSFL and earthworm has the highest level which is 2.61 for mean and 0.55 standard deviation. Ammonia level in 50% BSFL is higher than 100% BSFL.

### 4.2.3 Water quality effect on growth performance

Based on the raw data of the growth performance, it can be shown that there are 2 fish that died after week 3 data collection whereby the final weight that was recorded is week three. The death of the fish can be due to the poor water quality in the aquarium. It can be said that the fish can died due to the high level of ammonia and pH which exceed the ideal level for betta fish. In addition, if the overall raw data was observed, we can observe that the fish that died is after the week 3 data collection. The treatment that has dead fish are 0% earthworm, 25% earthworm, 50% earthworm, 100% earthworm, 0% BSFL, and 100% BSFL.

When it comes to the pH of a Betta Fish, it should be between 6.5 and 7. The neutral pH, which is 7. It is said that both acidic and basic pH levels can be bad for fish which can kill the fish. pH can chemically burn the outside and inside of betta fish and other invertebrates at both ends of the scale. In addition, betta fish could die due to excessive amount of ammonia. When the levels of ammonia in your fish's water get too high, the water isn't safe for them. A fish that is exposed to even small amounts of ammonia can make more skin mucus, giving him a pale look the fish's skin is burned by ammonia, and bacteria can spread both inside and outside the fish. Below 0.5-1 mg/l, the fish will be fine, but keeping the ammonia level at 0.01-0.2 mg/l is better for the fish.

### 4.2.4 Proximate analysis

Proximate analysis was done using the AOAC (1997) procedure. The feed was formulated into 5 compositions for each type of feed which is 0%, 25%, 50%, 75% and 100%. Each of the composition of the feed will produce a total of 100g when it is combined. For the proximate analysis result, it shows that among the earthworm feed, 50% earthworm has the highest amount of crude fibre than others. 0% earthworm has 1.59, 25% earthworm has 1.78, 75% earthworm has 1.82 and 100% earthworm has 2.1. BSFL feed that has the highest crude fibre is the 0% that is 2.1 and the lowest crude fibre is 1.9 for the 50% BSFL. For crude fat, 75% earthworm has 3.00 and 75% BSFL has 5. If it is compared between the 100% feed composition, BSFL is higher in value with 8.67 while earthworm is 2.63. The highest crude protein value between earthworm is 50% earthworm that has 37.4. 0% earthworm has 35.17, 25% earthworm has 36.47, 75% earthworm has 37.17 and 100% earthworm has 32.7. In BSFL, 75% BSFL has the highest crude protein that is 33.7 while the lowest is 50% BSFL that is 33.27. Next, for the moisture content 0% earthworm has 4.62, 25% earthworm has 7.53, 50% earthworm has 7.47, 75% earthworm has 8.1 and 100% has 10.57. The moisture content for BSFL, shows the highest for 25% that is 8.67. Among both types of feed, the ash content that is the highest is 11.33 that is 100% earthworm while 25% BSFL is the lowest with the value of 6.4. Total carbohydrate is the highest for 0% earthworm among the earthworm feed and in the BSFL feed, 75% BSFL is the highest with 61.77. For the energy value, 100% BSFL has the highest value which is 416.66 kcal and the lowest is 25% BSFL that is 327.03 kcal. 0% earthworm has 367.88 kcal, 25% earthworm has 363.59 kcal, 50% earthworm has 372.69 kcal, 75% earthworm has 380.38 kcal, and 100% earthworm has 350.96 kcal.

# CHAPTER 5

# CONCLUSION

In conclusion, the feed that was formulated with earthworm and BSFL can be used as a substitution for fish meal because it has a better water quality than fish meal based feed. This was proven by the water quality data that was collected 100% earthworm has ammonia level that is less than 1 for 2 weeks. In addition, based on the growth performance, it shows that 50% earthworm and 100% BSFL is the highest among the type of feed and it is also higher than the weight gain of 0% BSFL and 0% earthworm. For the crude protein value for 50% earthworm is higher than 0% earthworm which can make this formulation as a substitution.



## RECOMMENDATION

If the farmers want to use earthworm as a substitution for fishmeal, it is recommended that the farmers should breed the earthworm in a vermicompost soil that can be made from leftover food. It is also recommended when taking care of the fish and put the fish in an aquarium, same gender need to be avoided to reduce the competition between the same gender.  Finally, more study should be made about earthworm in order to obtain a complete nutrient composition that an earthworm can offer.

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# APPENDIX A

## Table 5: One way ANOVA for week 1 ammonia

### Descriptives

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| AMMONIAREADER | 0% EW | 3 | .8867 | .03055 | .01764 | .8108 | .9626 | .86 | .92 |
| | 25% EW | 3 | .4767 | .06506 | .03756 | .3150 | .6383 | .41 | .54 |
| | 50% EW | 3 | .9533 | .54921 | .31709 | -.4110 | 2.3177 | .49 | 1.56 |
| | 75% EW | 3 | .7900 | .41605 | .24021 | -.2435 | 1.8235 | .44 | 1.25 |
| | 100% EW | 3 | 1.3800 | .65483 | .37807 | -.2467 | 3.0067 | .66 | 1.94 |
| | 0% BSFL | 3 | .8867 | .03055 | .01764 | .8108 | .9626 | .86 | .92 |
| | 25% BSFL | 3 | .7500 | .39737 | .22942 | -.2371 | 1.7371 | .33 | 1.12 |
| | 50% BSFL | 3 | 1.0433 | .41004 | .23674 | .0247 | 2.0619 | .57 | 1.29 |
| | 75% BSFL | 3 | 3.6567 | .29872 | .17247 | 2.9146 | 4.3987 | 3.32 | 3.89 |
| | 100% BSFL | 3 | 1.7300 | .37323 | .21548 | .8028 | 2.6572 | 1.30 | 1.97 |
| | Total | 30 | 1.2553 | .93604 | .17090 | .9058 | 1.6049 | .33 | 3.89 |
| AMMONIACHECKER | 0% EW | 3 | 1.0764 | .03709 | .02141 | .9843 | 1.1685 | 1.04 | 1.12 |
| | 25% EW | 3 | .5785 | .07871 | .04545 | .3829 | .7740 | .50 | .66 |
| | 50% EW | 3 | 1.1574 | .66674 | .38494 | -.4989 | 2.8136 | .59 | 1.89 |
| | 75% EW | 3 | .9585 | .50409 | .29104 | -.2938 | 2.2107 | .53 | 1.52 |

| | | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | 100% EW | 3 | 1.6753 | .79496 | .45897 | -.2995 | 3.6501 | .80 | 2.36 |
| | 0% BSFL | 3 | 1.0764 | .03704 | .02139 | .9844 | 1.1684 | 1.04 | 1.12 |
| | 25% BSFL | 3 | .9105 | .48240 | .27852 | -.2879 | 2.1089 | .40 | 1.36 |
| | 50% BSFL | 3 | 1.2666 | .49779 | .28740 | .0300 | 2.5032 | .69 | 1.57 |
| | 75% BSFL | 3 | 4.4387 | .36263 | .20936 | 3.5379 | 5.3395 | 4.03 | 4.72 |
| | 100% BSFL | 3 | 2.0999 | .45299 | .26153 | .9746 | 3.2252 | 1.58 | 2.39 |

**Table 6: One way ANOVA for week 1 pH,MVpH,DO,MGLDO and temperature**

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| MVPH | 0% EW | 3 | 72.9667 | 2.81484 | 1.62515 | 65.9742 | 79.9591 | 70.00 | 75.60 |
| | 25% EW | 3 | 85.9333 | 1.07858 | .62272 | 83.2540 | 88.6127 | 84.70 | 86.70 |
| | 50% EW | 3 | 76.8000 | 4.99600 | 2.88444 | 64.3893 | 89.2107 | 72.80 | 82.40 |
| | 75% EW | 3 | 83.4000 | 5.00899 | 2.89194 | 70.9570 | 95.8430 | 77.70 | 87.10 |
| | 100% EW | 3 | 88.9667 | 3.53459 | 2.04070 | 80.1863 | 97.7471 | 84.90 | 91.30 |
| | 0% BSFL | 3 | 72.9667 | 2.81484 | 1.62515 | 65.9742 | 79.9591 | 70.00 | 75.60 |
| | 25% BSFL | 3 | 82.4667 | 14.83723 | 8.56628 | 45.6089 | 119.3244 | 65.40 | 92.30 |
| | 50% BSFL | 3 | 76.4667 | 9.68211 | 5.58997 | 52.4150 | 100.5184 | 65.80 | 84.70 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 75% BSFL | 3 | 91.6667 | 3.84751 | 2.22136 | 82.1089 | 101.2244 | 89.20 | 96.10 |
| | 100% BSFL | 3 | 113.4667 | 14.66504 | 8.46686 | 77.0367 | 149.8966 | 104.90 | 130.40 |
| | Total | 30 | 84.5100 | 13.35139 | 2.43762 | 79.5245 | 89.4955 | 65.40 | 130.40 |
| PH | 0% EW | 3 | 5.9133 | .05508 | .03180 | 5.7765 | 6.0501 | 5.86 | 5.97 |
| | 25% EW | 3 | 5.6767 | .02082 | .01202 | 5.6250 | 5.7284 | 5.66 | 5.70 |
| | 50% EW | 3 | 5.8433 | .09292 | .05364 | 5.6125 | 6.0741 | 5.74 | 5.92 |
| | 75% EW | 3 | 5.7233 | .09452 | .05457 | 5.4885 | 5.9581 | 5.65 | 5.83 |
| | 100% EW | 3 | 5.6200 | .07000 | .04041 | 5.4461 | 5.7939 | 5.57 | 5.70 |
| | 0% BSFL | 3 | 5.9133 | .05508 | .03180 | 5.7765 | 6.0501 | 5.86 | 5.97 |
| | 25% BSFL | 3 | 5.7400 | .27875 | .16093 | 5.0476 | 6.4324 | 5.55 | 6.06 |
| | 50% BSFL | 3 | 5.8567 | .17474 | .10088 | 5.4226 | 6.2907 | 5.71 | 6.05 |
| | 75% BSFL | 3 | 5.5933 | .07371 | .04256 | 5.4102 | 5.7764 | 5.51 | 5.65 |
| | 100% BSFL | 3 | 5.3767 | .04619 | .02667 | 5.2619 | 5.4914 | 5.35 | 5.43 |
| | Total | 30 | 5.7257 | .19057 | .03479 | 5.6545 | 5.7968 | 5.35 | 6.06 |
| MGORP | 0% EW | 3 | 167.5000 | 2.88271 | 1.66433 | 160.3390 | 174.6610 | 164.90 | 170.60 |
| | 25% EW | 3 | 207.4667 | 4.22532 | 2.43949 | 196.9704 | 217.9629 | 203.00 | 211.40 |
| | 50% EW | 3 | 198.5333 | 6.16144 | 3.55731 | 183.2275 | 213.8392 | 192.60 | 204.90 |
| | 75% EW | 3 | 218.6000 | 25.73150 | 14.85609 | 154.6794 | 282.5206 | 189.60 | 238.70 |
| | 100% EW | 3 | 233.5667 | 2.82902 | 1.63333 | 226.5390 | 240.5943 | 231.00 | 236.60 |
| | 0% BSFL | 3 | 167.5000 | 2.88271 | 1.66433 | 160.3390 | 174.6610 | 164.90 | 170.60 |
| | 25% BSFL | 3 | 250.2000 | 40.31675 | 23.27688 | 150.0477 | 350.3523 | 204.20 | 279.40 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50% BSFL | 3 | 196.0333 | 15.37346 | 8.87587 | 157.8435 | 234.2231 | 178.30 | 205.60 |
| | 75% BSFL | 3 | 181.5000 | 5.60268 | 3.23471 | 167.5822 | 195.4178 | 176.00 | 187.20 |
| | 100% BSFL | 3 | 198.0333 | 4.73533 | 2.73394 | 186.2701 | 209.7965 | 195.20 | 203.50 |
| | Total | 30 | 201.8933 | 29.23371 | 5.33732 | 190.9773 | 212.8094 | 164.90 | 279.40 |
| DO | 0% EW | 3 | 49.0667 | 14.15392 | 8.17177 | 13.9064 | 84.2269 | 40.40 | 65.40 |
| | 25% EW | 3 | 63.0667 | 1.25831 | .72648 | 59.9409 | 66.1925 | 61.90 | 64.40 |
| | 50% EW | 3 | 66.2333 | 1.61967 | .93512 | 62.2098 | 70.2568 | 65.20 | 68.10 |
| | 75% EW | 3 | 65.1333 | .68069 | .39299 | 63.4424 | 66.8243 | 64.60 | 65.90 |
| | 100% EW | 3 | 68.2000 | 1.58745 | .91652 | 64.2566 | 72.1434 | 66.40 | 69.40 |
| | 0% BSFL | 3 | 49.0667 | 14.15392 | 8.17177 | 13.9064 | 84.2269 | 40.40 | 65.40 |
| | 25% BSFL | 3 | 72.0333 | 3.26548 | 1.88532 | 63.9214 | 80.1452 | 70.00 | 75.80 |
| | 50% BSFL | 3 | 75.9333 | 1.36504 | .78811 | 72.5424 | 79.3243 | 75.00 | 77.50 |
| | 75% BSFL | 3 | 59.6333 | .28868 | .16667 | 58.9162 | 60.3504 | 59.30 | 59.80 |
| | 100% BSFL | 3 | 57.0000 | 2.33024 | 1.34536 | 51.2114 | 62.7886 | 55.10 | 59.60 |
| | Total | 30 | 62.5367 | 10.21316 | 1.86466 | 58.7230 | 66.3503 | 40.40 | 77.50 |
| MGLDO | 0% EW | 3 | 4.0933 | 1.16732 | .67395 | 1.1936 | 6.9931 | 3.37 | 5.44 |
| | 25% EW | 3 | 5.2400 | .10536 | .06083 | 4.9783 | 5.5017 | 5.14 | 5.35 |
| | 50% EW | 3 | 5.4700 | .08888 | .05132 | 5.2492 | 5.6908 | 5.40 | 5.57 |
| | 75% EW | 3 | 5.3867 | .03786 | .02186 | 5.2926 | 5.4807 | 5.36 | 5.43 |
| | 100% EW | 3 | 5.6200 | .09849 | .05686 | 5.3753 | 5.8647 | 5.51 | 5.70 |
| | 0% BSFL | 3 | 4.0933 | 1.16732 | .67395 | 1.1936 | 6.9931 | 3.37 | 5.44 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 25% BSFL | 3 | 5.8667 | .15885 | .09171 | 5.4721 | 6.2613 | 5.77 | 6.05 |
| | 50% BSFL | 3 | 6.0733 | .08386 | .04842 | 5.8650 | 6.2817 | 6.02 | 6.17 |
| | 75% BSFL | 3 | 4.5933 | .04041 | .02333 | 4.4929 | 4.6937 | 4.55 | 4.63 |
| | 100% BSFL | 3 | 4.3433 | .13013 | .07513 | 4.0201 | 4.6666 | 4.21 | 4.47 |
| | Total | 30 | 5.0780 | .83663 | .15275 | 4.7656 | 5.3904 | 3.37 | 6.17 |
| TEMPERATURE | 0% EW | 3 | 24.5200 | .15133 | .08737 | 24.1441 | 24.8959 | 24.35 | 24.64 |
| | 25% EW | 3 | 24.6867 | .14742 | .08511 | 24.3204 | 25.0529 | 24.52 | 24.80 |
| | 50% EW | 3 | 24.8400 | .14422 | .08327 | 24.4817 | 25.1983 | 24.68 | 24.96 |
| | 75% EW | 3 | 24.9533 | .19553 | .11289 | 24.4676 | 25.4391 | 24.75 | 25.14 |
| | 100% EW | 3 | 25.1533 | .17010 | .09821 | 24.7308 | 25.5759 | 24.98 | 25.32 |
| | 0% BSFL | 3 | 24.5200 | .15133 | .08737 | 24.1441 | 24.8959 | 24.35 | 24.64 |
| | 25% BSFL | 3 | 25.8567 | .97043 | .56028 | 23.4460 | 28.2673 | 25.19 | 26.97 |
| | 50% BSFL | 3 | 26.8067 | .37099 | .21419 | 25.8851 | 27.7283 | 26.48 | 27.21 |
| | 75% BSFL | 3 | 28.3600 | .26514 | .15308 | 27.7014 | 29.0186 | 28.09 | 28.62 |
| | 100% BSFL | 3 | 28.7000 | .26851 | .15503 | 28.0330 | 29.3670 | 28.54 | 29.01 |
| | Total | 30 | 25.8397 | 1.55770 | .28440 | 25.2580 | 26.4213 | 24.35 | 29.01 |

# Table 7: One way ANOVA for week 2 ammonia

## Descriptives

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| MVPH | 0% EW | 3 | 51.9000 | 10.43600 | 6.02522 | 25.9756 | 77.8244 | 42.00 | 62.80 |
| | 25% EW | 3 | 99.0333 | 18.62803 | 10.75490 | 52.7588 | 145.3079 | 79.50 | 116.60 |
| | 50% EW | 3 | 68.5667 | 10.16923 | 5.87121 | 43.3049 | 93.8284 | 62.30 | 80.30 |
| | 75% EW | 3 | 79.1667 | 12.10055 | 6.98626 | 49.1072 | 109.2261 | 69.70 | 92.80 |
| | 100% EW | 3 | 89.8000 | 4.38634 | 2.53246 | 78.9037 | 100.6963 | 85.00 | 93.60 |
| | 0% BSFL | 3 | 51.9000 | 10.43600 | 6.02522 | 25.9756 | 77.8244 | 42.00 | 62.80 |
| | 25% BSFL | 3 | 75.6667 | 13.11539 | 7.57217 | 43.0862 | 108.2471 | 60.80 | 85.60 |
| | 50% BSFL | 3 | 62.7333 | 5.63590 | 3.25389 | 48.7330 | 76.7337 | 57.50 | 68.70 |
| | 75% BSFL | 3 | 69.3000 | 7.09295 | 4.09512 | 51.6801 | 86.9199 | 62.70 | 76.80 |
| | 100% BSFL | 3 | 62.2000 | 2.71846 | 1.56950 | 55.4470 | 68.9530 | 59.20 | 64.50 |
| | Total | 30 | 71.0267 | 17.14713 | 3.13062 | 64.6238 | 77.4295 | 42.00 | 116.60 |
| PH | 0% EW | 3 | 6.3067 | .19604 | .11319 | 5.8197 | 6.7937 | 6.10 | 6.49 |
| | 25% EW | 3 | 5.4433 | .32716 | .18889 | 4.6306 | 6.2560 | 5.14 | 5.79 |
| | 50% EW | 3 | 6.0100 | .16462 | .09504 | 5.6011 | 6.4189 | 5.82 | 6.11 |
| | 75% EW | 3 | 5.7967 | .23629 | .13642 | 5.2097 | 6.3836 | 5.53 | 5.98 |
| | 100% EW | 3 | 5.6133 | .08083 | .04667 | 5.4125 | 5.8141 | 5.54 | 5.70 |
| | 0% BSFL | 3 | 6.3067 | .19604 | .11319 | 5.8197 | 6.7937 | 6.10 | 6.49 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 25% BSFL | 3 | 5.8700 | .22338 | .12897 | 5.3151 | 6.4249 | 5.69 | 6.12 |
| | 50% BSFL | 3 | 6.1033 | .10599 | .06119 | 5.8400 | 6.3666 | 5.99 | 6.20 |
| | 75% BSFL | 3 | 6.0000 | .12530 | .07234 | 5.6887 | 6.3113 | 5.87 | 6.12 |
| | 100% BSFL | 3 | 6.1200 | .04359 | .02517 | 6.0117 | 6.2283 | 6.09 | 6.17 |
| | Total | 30 | 5.9570 | .31302 | .05715 | 5.8401 | 6.0739 | 5.14 | 6.49 |
| MVORP | 0% EW | 3 | 215.6667 | 54.42355 | 31.42145 | 80.4711 | 350.8623 | 183.30 | 278.50 |
| | 25% EW | 3 | 329.9000 | 44.50270 | 25.69364 | 219.3492 | 440.4508 | 284.20 | 373.10 |
| | 50% EW | 3 | 234.4000 | 36.60096 | 21.13157 | 143.4782 | 325.3218 | 211.30 | 276.60 |
| | 75% EW | 3 | 224.1000 | 5.31131 | 3.06649 | 210.9060 | 237.2940 | 218.10 | 228.20 |
| | 100% EW | 3 | 233.1000 | 13.85893 | 8.00146 | 198.6725 | 267.5275 | 223.00 | 248.90 |
| | 0% BSFL | 3 | 215.6667 | 54.42355 | 31.42145 | 80.4711 | 350.8623 | 183.30 | 278.50 |
| | 25% BSFL | 3 | 198.3667 | 10.33263 | 5.96555 | 172.6990 | 224.0344 | 187.10 | 207.40 |
| | 50% BSFL | 3 | 169.9667 | 19.23469 | 11.10515 | 122.1850 | 217.7483 | 157.30 | 192.10 |
| | 75% BSFL | 3 | 130.9667 | 12.42632 | 7.17434 | 100.0980 | 161.8353 | 120.50 | 144.70 |
| | 100% BSFL | 3 | 143.8667 | 8.21056 | 4.74037 | 123.4705 | 164.2628 | 134.80 | 150.80 |
| | Total | 30 | 209.6000 | 60.08572 | 10.97010 | 187.1636 | 232.0364 | 120.50 | 373.10 |
| DO | 0% EW | 3 | 36.4667 | 1.10151 | .63596 | 33.7304 | 39.2030 | 35.20 | 37.20 |
| | 25% EW | 3 | 37.3667 | .20817 | .12019 | 36.8496 | 37.8838 | 37.20 | 37.60 |
| | 50% EW | 3 | 38.6333 | 1.45717 | .84130 | 35.0135 | 42.2531 | 37.00 | 39.80 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 75% EW | 3 | 41.5000 | 1.64621 | .95044 | 37.4106 | 45.5894 | 39.60 | 42.50 |
| | 100% EW | 3 | 42.5000 | .10000 | .05774 | 42.2516 | 42.7484 | 42.40 | 42.60 |
| | 0% BSFL | 3 | 36.4667 | 1.10151 | .63596 | 33.7304 | 39.2030 | 35.20 | 37.20 |
| | 25% BSFL | 3 | 44.6667 | 1.88237 | 1.08679 | 39.9906 | 49.3427 | 42.50 | 45.90 |
| | 50% BSFL | 3 | 46.3000 | .96437 | .55678 | 43.9044 | 48.6956 | 45.60 | 47.40 |
| | 75% BSFL | 3 | 47.9000 | .75498 | .43589 | 46.0245 | 49.7755 | 47.20 | 48.70 |
| | 100% BSFL | 3 | 60.7000 | .34641 | .20000 | 59.8395 | 61.5605 | 60.30 | 60.90 |
| | Total | 30 | 43.2500 | 7.17273 | 1.30956 | 40.5717 | 45.9283 | 35.20 | 60.90 |
| MGLDO | 0% EW | 3 | 3.0433 | .08963 | .05175 | 2.8207 | 3.2660 | 2.94 | 3.10 |
| | 25% EW | 3 | 3.1233 | .02309 | .01333 | 3.0660 | 3.1807 | 3.11 | 3.15 |
| | 50% EW | 3 | 3.1867 | .10214 | .05897 | 2.9329 | 3.4404 | 3.07 | 3.26 |
| | 75% EW | 3 | 3.3800 | .11269 | .06506 | 3.1001 | 3.6599 | 3.25 | 3.45 |
| | 100% EW | 3 | 3.4800 | .01732 | .01000 | 3.4370 | 3.5230 | 3.46 | 3.49 |
| | 0% BSFL | 3 | 3.0433 | .08963 | .05175 | 2.8207 | 3.2660 | 2.94 | 3.10 |
| | 25% BSFL | 3 | 3.6600 | .15716 | .09074 | 3.2696 | 4.0504 | 3.48 | 3.77 |
| | 50% BSFL | 3 | 3.8267 | .06807 | .03930 | 3.6576 | 3.9958 | 3.75 | 3.88 |
| | 75% BSFL | 3 | 3.8867 | .04509 | .02603 | 3.7747 | 3.9987 | 3.84 | 3.93 |
| | 100% BSFL | 3 | 4.9067 | .03055 | .01764 | 4.8308 | 4.9826 | 4.88 | 4.94 |
| | Total | 30 | 3.5537 | .55260 | .10089 | 3.3473 | 3.7600 | 2.94 | 4.94 |
| TEMPERATURE | 0% EW | 3 | 24.3100 | .09000 | .05196 | 24.0864 | 24.5336 | 24.22 | 24.40 |
| | 25% EW | 3 | 24.4467 | .04933 | .02848 | 24.3241 | 24.5692 | 24.39 | 24.48 |

| | | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | 50% EW | 3 | 25.3367 | .71933 | .41530 | 23.5498 | 27.1236 | 24.83 | 26.16 |
| | 75% EW | 3 | 25.2633 | .21502 | .12414 | 24.7292 | 25.7975 | 25.08 | 25.50 |
| | 100% EW | 3 | 25.3933 | .09292 | .05364 | 25.1625 | 25.6241 | 25.33 | 25.50 |
| | 0% BSFL | 3 | 24.3100 | .09000 | .05196 | 24.0864 | 24.5336 | 24.22 | 24.40 |
| | 25% BSFL | 3 | 25.4400 | .13528 | .07810 | 25.1040 | 25.7760 | 25.30 | 25.57 |
| | 50% BSFL | 3 | 25.6700 | .19925 | .11504 | 25.1750 | 26.1650 | 25.55 | 25.90 |
| | 75% BSFL | 3 | 26.2567 | .52166 | .30118 | 24.9608 | 27.5526 | 25.87 | 26.85 |
| | 100% BSFL | 3 | 25.9133 | .04619 | .02667 | 25.7986 | 26.0281 | 25.86 | 25.94 |
| | Total | 30 | 25.2340 | .69874 | .12757 | 24.9731 | 25.4949 | 24.22 | 26.85 |

**Table 8: One way ANOVA for week 2 pH,MVpH,DO,MGLDO and temperature**

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| AMMONIAREADER | 0% EW | 3 | 1.4333 | .52729 | .30443 | .1235 | 2.7432 | 1.03 | 2.03 |
| | 25% EW | 3 | 1.4433 | .15308 | .08838 | 1.0631 | 1.8236 | 1.27 | 1.56 |
| | 50% EW | 3 | 1.3000 | .25000 | .14434 | .6790 | 1.9210 | 1.05 | 1.55 |
| | 75% EW | 3 | .8233 | .23288 | .13445 | .2448 | 1.4018 | .66 | 1.09 |
| | 100% EW | 3 | 1.3367 | .20841 | .12032 | .8190 | 1.8544 | 1.11 | 1.52 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0% BSFL | 3 | 1.4333 | .52729 | .30443 | .1235 | 2.7432 | 1.03 | 2.03 |
| | 25% BSFL | 3 | 1.0667 | .03786 | .02186 | .9726 | 1.1607 | 1.04 | 1.11 |
| | 50% BSFL | 3 | 1.1967 | .70571 | .40744 | -.5564 | 2.9498 | .51 | 1.92 |
| | 75% BSFL | 3 | 1.6433 | .95553 | .55167 | -.7303 | 4.0170 | .78 | 2.67 |
| | 100% BSFL | 3 | 1.3500 | .43863 | .25325 | .2604 | 2.4396 | .85 | 1.67 |
| | Total | 30 | 1.3027 | .45861 | .08373 | 1.1314 | 1.4739 | .51 | 2.67 |
| AMMONIACHECKER | 0% EW | 3 | 1.7397 | .64012 | .36957 | .1495 | 3.3298 | 1.25 | 2.46 |
| | 25% EW | 3 | 1.7500 | .18520 | .10693 | 1.2899 | 2.2101 | 1.54 | 1.89 |
| | 50% EW | 3 | 1.5767 | .30501 | .17610 | .8190 | 2.3344 | 1.27 | 1.88 |
| | 75% EW | 3 | .9984 | .28093 | .16220 | .3005 | 1.6962 | .80 | 1.32 |
| | 100% EW | 3 | 1.6225 | .25287 | .14600 | .9943 | 2.2507 | 1.35 | 1.85 |
| | 0% BSFL | 3 | 1.7397 | .64012 | .36957 | .1495 | 3.3298 | 1.25 | 2.46 |
| | 25% BSFL | 3 | 1.2949 | .04596 | .02654 | 1.1808 | 1.4091 | 1.26 | 1.35 |
| | 50% BSFL | 3 | 1.4325 | .85905 | .49597 | -.7015 | 3.5665 | .62 | 2.33 |
| | 75% BSFL | 3 | 1.9948 | 1.16008 | .66977 | -.8870 | 4.8766 | .95 | 3.24 |
| | 100% BSFL | 3 | 1.6380 | .53336 | .30794 | .3131 | 2.9629 | 1.03 | 2.03 |
| | Total | 30 | 1.5787 | .55756 | .10180 | 1.3705 | 1.7869 | .62 | 3.24 |

**Table 9: One way ANOVA for week 3 water quality**

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| MVPH | 0% EW | 3 | 71.2333 | 18.33721 | 10.58699 | 25.6812 | 116.7855 | 56.30 | 91.70 |
| | 25% EW | 3 | 76.5333 | 7.47953 | 4.31831 | 57.9532 | 95.1135 | 68.70 | 83.60 |
| | 50% EW | 3 | 94.4667 | 1.50111 | .86667 | 90.7377 | 98.1956 | 93.60 | 96.20 |
| | 75% EW | 3 | 88.0000 | 6.52074 | 3.76475 | 71.8016 | 104.1984 | 81.80 | 94.80 |
| | 100% EW | 3 | 78.3333 | 2.08167 | 1.20185 | 73.1622 | 83.5045 | 76.00 | 80.00 |
| | 0% BSFL | 3 | 71.2333 | 18.33721 | 10.58699 | 25.6812 | 116.7855 | 56.30 | 91.70 |
| | 25% BSFL | 3 | 75.9667 | 2.74287 | 1.58360 | 69.1530 | 82.7803 | 74.00 | 79.10 |
| | 50% BSFL | 3 | 75.9667 | 6.01360 | 3.47195 | 61.0281 | 90.9053 | 69.20 | 80.70 |
| | 75% BSFL | 3 | 78.0333 | 4.77109 | 2.75459 | 66.1813 | 89.8854 | 74.00 | 83.30 |
| | 100% BSFL | 3 | 94.6667 | 3.52326 | 2.03415 | 85.9144 | 103.4189 | 91.40 | 98.40 |
| | Total | 30 | 80.4433 | 11.42721 | 2.08631 | 76.1763 | 84.7103 | 56.30 | 98.40 |
| PH | 0% EW | 3 | 5.9467 | .33710 | .19462 | 5.1093 | 6.7841 | 5.57 | 6.22 |
| | 25% EW | 3 | 5.8267 | .12583 | .07265 | 5.5141 | 6.1392 | 5.71 | 5.96 |
| | 50% EW | 3 | 5.4933 | .05508 | .03180 | 5.3565 | 5.6301 | 5.43 | 5.53 |
| | 75% EW | 3 | 5.6400 | .12530 | .07234 | 5.3287 | 5.9513 | 5.51 | 5.76 |
| | 100% EW | 3 | 5.8133 | .04041 | .02333 | 5.7129 | 5.9137 | 5.79 | 5.86 |
| | 0% BSFL | 3 | 5.9467 | .33710 | .19462 | 5.1093 | 6.7841 | 5.57 | 6.22 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 25% BSFL | 3 | 5.8800 | .06245 | .03606 | 5.7249 | 6.0351 | 5.81 | 5.93 |
| | 50% BSFL | 3 | 5.8633 | .11150 | .06438 | 5.5863 | 6.1403 | 5.78 | 5.99 |
| | 75% BSFL | 3 | 5.8200 | .09165 | .05292 | 5.5923 | 6.0477 | 5.72 | 5.90 |
| | 100% BSFL | 3 | 5.5167 | .06506 | .03756 | 5.3550 | 5.6783 | 5.45 | 5.58 |
| | Total | 30 | 5.7747 | .21412 | .03909 | 5.6947 | 5.8546 | 5.43 | 6.22 |
| MVORP | 0% EW | 3 | 119.1333 | 21.28035 | 12.28622 | 66.2700 | 171.9967 | 99.00 | 141.40 |
| | 25% EW | 3 | 146.5333 | 23.48624 | 13.55979 | 88.1903 | 204.8764 | 120.10 | 165.00 |
| | 50% EW | 3 | 170.4000 | 5.86430 | 3.38575 | 155.8323 | 184.9677 | 164.10 | 175.70 |
| | 75% EW | 3 | 148.0333 | 2.30290 | 1.32958 | 142.3126 | 153.7540 | 145.50 | 150.00 |
| | 100% EW | 3 | 158.9000 | 12.40685 | 7.16310 | 128.0797 | 189.7203 | 151.00 | 173.20 |
| | 0% BSFL | 3 | 119.1333 | 21.28035 | 12.28622 | 66.2700 | 171.9967 | 99.00 | 141.40 |
| | 25% BSFL | 3 | 169.7333 | 3.28684 | 1.89766 | 161.5684 | 177.8983 | 166.10 | 172.50 |
| | 50% BSFL | 3 | 171.8667 | 19.44025 | 11.22383 | 123.5744 | 220.1589 | 149.50 | 184.70 |
| | 75% BSFL | 3 | 128.6667 | 17.35002 | 10.01704 | 85.5668 | 171.7665 | 118.50 | 148.70 |
| | 100% BSFL | 3 | 133.0333 | 18.58288 | 10.72883 | 86.8709 | 179.1958 | 119.40 | 154.20 |
| | Total | 30 | 146.5433 | 24.27957 | 4.43282 | 137.4772 | 155.6095 | 99.00 | 184.70 |
| DO | 0% EW | 3 | 50.7667 | 6.39557 | 3.69248 | 34.8792 | 66.6541 | 43.40 | 54.90 |
| | 25% EW | 3 | 56.2667 | 6.09125 | 3.51679 | 41.1352 | 71.3982 | 52.70 | 63.30 |
| | 50% EW | 3 | 62.4667 | 5.44273 | 3.14236 | 48.9462 | 75.9872 | 56.30 | 66.60 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 75% EW | 3 | 44.0000 | 13.45251 | 7.76681 | 10.5821 | 77.4179 | 30.70 | 57.60 |
| | 100% EW | 3 | 70.7667 | 7.91539 | 4.56995 | 51.1038 | 90.4296 | 61.70 | 76.30 |
| | 0% BSFL | 3 | 50.7667 | 6.39557 | 3.69248 | 34.8792 | 66.6541 | 43.40 | 54.90 |
| | 25% BSFL | 3 | 64.3333 | 5.94082 | 3.42993 | 49.5755 | 79.0911 | 59.60 | 71.00 |
| | 50% BSFL | 3 | 64.3667 | 6.25007 | 3.60848 | 48.8406 | 79.8927 | 58.10 | 70.60 |
| | 75% BSFL | 3 | 68.3667 | 1.55027 | .89505 | 64.5156 | 72.2177 | 66.80 | 69.90 |
| | 100% BSFL | 3 | 67.7000 | 1.90000 | 1.09697 | 62.9801 | 72.4199 | 66.10 | 69.80 |
| | Total | 30 | 59.9800 | 10.39530 | 1.89791 | 56.0983 | 63.8617 | 30.70 | 76.30 |
| MGLDO | 0% EW | 3 | 3.8867 | .40501 | .23383 | 2.8806 | 4.8928 | 3.44 | 4.23 |
| | 25% EW | 3 | 4.2100 | .09849 | .05686 | 3.9653 | 4.4547 | 4.13 | 4.32 |
| | 50% EW | 3 | 4.7433 | .75805 | .43766 | 2.8602 | 6.6264 | 3.88 | 5.30 |
| | 75% EW | 3 | 3.3167 | 1.03016 | .59476 | .7576 | 5.8757 | 2.38 | 4.42 |
| | 100% EW | 3 | 5.4667 | .60929 | .35177 | 3.9531 | 6.9802 | 4.77 | 5.90 |
| | 0% BSFL | 3 | 3.8867 | .40501 | .23383 | 2.8806 | 4.8928 | 3.44 | 4.23 |
| | 25% BSFL | 3 | 5.0033 | .42852 | .24741 | 3.9388 | 6.0678 | 4.65 | 5.48 |
| | 50% BSFL | 3 | 5.0133 | .53379 | .30818 | 3.6873 | 6.3393 | 4.52 | 5.58 |
| | 75% BSFL | 3 | 5.6333 | .23029 | .13296 | 5.0613 | 6.2054 | 5.41 | 5.87 |
| | 100% BSFL | 3 | 5.4833 | .24685 | .14252 | 4.8701 | 6.0965 | 5.21 | 5.69 |
| | Total | 30 | 4.6643 | .89135 | .16274 | 4.3315 | 4.9972 | 2.38 | 5.90 |
| TEMPERATURE | 0% EW | 3 | 25.7233 | .23438 | .13532 | 25.1411 | 26.3056 | 25.55 | 25.99 |
| | 25% EW | 3 | 25.8667 | .22745 | .13132 | 25.3017 | 26.4317 | 25.68 | 26.12 |

| | | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | 50% EW | 3 | 25.8600 | .15716 | .09074 | 25.4696 | 26.2504 | 25.72 | 26.03 |
| | 75% EW | 3 | 25.7933 | .40017 | .23104 | 24.7993 | 26.7874 | 25.40 | 26.20 |
| | 100% EW | 3 | 25.9533 | .68486 | .39540 | 24.2520 | 27.6546 | 25.49 | 26.74 |
| | 0% BSFL | 3 | 25.9167 | .71445 | .41249 | 24.1419 | 27.6914 | 25.46 | 26.74 |
| | 25% BSFL | 3 | 26.4267 | .18930 | .10929 | 25.9564 | 26.8969 | 26.21 | 26.56 |
| | 50% BSFL | 3 | 26.7433 | .33292 | .19221 | 25.9163 | 27.5703 | 26.36 | 26.96 |
| | 75% BSFL | 3 | 24.8800 | .20224 | .11676 | 24.3776 | 25.3824 | 24.73 | 25.11 |
| | 100% BSFL | 3 | 24.4133 | .37978 | .21927 | 23.4699 | 25.3568 | 24.16 | 24.85 |
| | Total | 30 | 25.7577 | .73015 | .13331 | 25.4850 | 26.0303 | 24.16 | 26.96 |

**Table 10: One way ANOVA for week 3 pH,MVpH,DO,MGLDO and temperature**

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| AMMONIAREADING | 0% EW | 3 | 2.1467 | .45545 | .26295 | 1.0153 | 3.2781 | 1.63 | 2.49 |
| | 25% EW | 3 | .6267 | .31786 | .18352 | -.1629 | 1.4163 | .40 | .99 |
| | 50% EW | 3 | 1.0500 | .52716 | .30436 | -.2595 | 2.3595 | .48 | 1.52 |
| | 75% EW | 3 | 1.2200 | .28000 | .16166 | .5244 | 1.9156 | .94 | 1.50 |
| | 100% EW | 3 | .6567 | .45786 | .26434 | -.4807 | 1.7940 | .33 | 1.18 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0% BSFL | 3 | 2.1467 | .45545 | .26295 | 1.0153 | 3.2781 | 1.63 | 2.49 |
| | 25% BSFL | 3 | 1.0200 | .64861 | .37448 | -.5912 | 2.6312 | .28 | 1.49 |
| | 50% BSFL | 3 | 1.7000 | .31432 | .18148 | .9192 | 2.4808 | 1.42 | 2.04 |
| | 75% BSFL | 3 | .6367 | .15275 | .08819 | .2572 | 1.0161 | .47 | .77 |
| | 100% BSFL | 3 | 1.2367 | .42665 | .24633 | .1768 | 2.2965 | .86 | 1.70 |
| | Total | 30 | 1.2440 | .66114 | .12071 | .9971 | 1.4909 | .28 | 2.49 |
| AMMONIACHECKER | 0% EW | 3 | 2.6060 | .55291 | .31922 | 1.2325 | 3.9795 | 1.98 | 3.02 |
| | 25% EW | 3 | 1.0488 | .50442 | .29123 | -.2042 | 2.3019 | .49 | 1.46 |
| | 50% EW | 3 | 1.2746 | .63985 | .36942 | -.3149 | 2.8640 | .58 | 1.85 |
| | 75% EW | 3 | 1.4803 | .34050 | .19659 | .6345 | 2.3262 | 1.14 | 1.82 |
| | 100% EW | 3 | .7968 | .55614 | .32109 | -.5847 | 2.1784 | .40 | 1.43 |
| | 0% BSFL | 3 | 2.6049 | .55176 | .31856 | 1.2343 | 3.9756 | 1.98 | 3.02 |
| | 25% BSFL | 3 | 1.2379 | .78791 | .45490 | -.7193 | 3.1952 | .34 | 1.81 |
| | 50% BSFL | 3 | 2.0635 | .38198 | .22054 | 1.1146 | 3.0124 | 1.72 | 2.48 |
| | 75% BSFL | 3 | .7716 | .18536 | .10702 | .3111 | 1.2320 | .57 | .93 |
| | 100% BSFL | 3 | 1.5010 | .51755 | .29881 | .2153 | 2.7867 | 1.04 | 2.06 |
| | Total | 30 | 1.5386 | .78394 | .14313 | 1.2458 | 1.8313 | .34 | 3.02 |

**Table 11: One way ANOVA for initial and final body weight**

**Descriptives**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| INITIALWEIGHT | 0% EW | 6 | 1.2191 | .16483 | .06729 | 1.0461 | 1.3921 | .99 | 1.36 |
| | 25% EW | 6 | 1.0789 | .16729 | .06830 | .9033 | 1.2544 | .88 | 1.29 |
| | 50% EW | 6 | 1.1599 | .20139 | .08222 | .9485 | 1.3712 | .94 | 1.45 |
| | 75% EW | 6 | 1.1631 | .23263 | .09497 | .9190 | 1.4072 | .70 | 1.34 |
| | 100% EW | 6 | .9794 | .25844 | .10551 | .7081 | 1.2506 | .65 | 1.34 |
| | 0% BSFL | 6 | 1.2191 | .16483 | .06729 | 1.0461 | 1.3921 | .99 | 1.36 |
| | 25% BSFL | 6 | 1.1429 | .25261 | .10313 | .8778 | 1.4080 | .95 | 1.57 |
| | 50% BSFL | 6 | 1.1122 | .14461 | .05904 | .9604 | 1.2640 | .89 | 1.26 |
| | 75% BSFL | 6 | 1.1251 | .19135 | .07812 | .9243 | 1.3259 | .86 | 1.32 |
| | 100% BSFL | 6 | 1.1059 | .07052 | .02879 | 1.0319 | 1.1799 | .98 | 1.19 |
| | Total | 60 | 1.1305 | .18938 | .02445 | 1.0816 | 1.1795 | .65 | 1.57 |
| FINALWEIGHT | 0% EW | 6 | 1.3400 | .20233 | .08260 | 1.1276 | 1.5523 | 1.05 | 1.55 |
| | 25% EW | 6 | 1.2381 | .15553 | .06350 | 1.0749 | 1.4013 | 1.04 | 1.43 |
| | 50% EW | 6 | 1.3554 | .25756 | .10515 | 1.0851 | 1.6257 | 1.08 | 1.83 |
| | 75% EW | 6 | 1.3389 | .30263 | .12355 | 1.0213 | 1.6565 | .76 | 1.58 |
| | 100% EW | 6 | 1.0566 | .27346 | .11164 | .7696 | 1.3435 | .79 | 1.40 |
| | 0% BSFL | 6 | 1.3400 | .20233 | .08260 | 1.1276 | 1.5523 | 1.05 | 1.55 |
| | 25% BSFL | 6 | 1.2153 | .27278 | .11136 | .9290 | 1.5016 | .99 | 1.59 |
| | 50% BSFL | 6 | 1.2473 | .09989 | .04078 | 1.1424 | 1.3521 | 1.08 | 1.38 |
| | 75% BSFL | 6 | 1.2941 | .18199 | .07430 | 1.1031 | 1.4851 | 1.03 | 1.49 |
| | 100% BSFL | 6 | 1.2951 | .11645 | .04754 | 1.1729 | 1.4173 | 1.12 | 1.46 |
| | Total | 60 | 1.2721 | .21737 | .02806 | 1.2159 | 1.3282 | .76 | 1.83 |

Table 12: Raw data for weight of fish in 5 weeks

| Treatment | Replicate | Colour | Weight | Weight | Weight | Weight | Weight |
|---|---|---|---|---|---|---|---|
| | | | WEEK 1 | WEEK 2 | WEEK 3 | WEEK 4 | WEEK 5 |
| 0% EARTHWORM | 1 | BLUE(M) | 1.2501 | 1.4006 | 1.4352 | 1.3515 | 1.3679 |
| | 1 | BLUE(F) | 0.9882 | 0.9978 | 1.051 | DEAD | DEAD |
| | 2 | CANDY(M) | 1.3452 | 1.3797 | 1.3891 | 1.394 | 1.53 |
| | 2 | CANDY(F) | 1.3619 | 1.3703 | 1.38631 | DEAD | DEAD |
| | 3 | BLUE RED(M) | 1.0381 | 1.0608 | 1.073 | 1.084 | 1.15 |
| | 3 | WHITE REDTAIL (F) | 1.331 | 1.485 | 1.493 | 1.6125 | 1.5546 |
| 25% EARTHWORM | 1 | RED | 1.272 | 1.235 | 1.251 | | |
| | 1 | ORANGE | 1.2934 | 1.2853 | 1.2715 | 1.285 | 1.299 |
| | 2 | BLUE RED | 0.9911 | 1.256 | 1.3443 | DEAD | DEAD |
| | 2 | WHITE RED | 0.8812 | 0.877 | 0.7993 | 1.4781 | 1.4293 |
| | 3 | CANDY | 1.052 | 0.9806 | 1.0102 | 1.0358 | 1.0649 |
| | 3 | BLUE | 0.9834 | 0.9966 | 1.0817 | 0.9829 | 1.04 |
| 50% EARTHWORM | 1 | WHITE | 1.2412 | 1.3209 | 1.352 | **DEAD** | DEAD |
| | 1 | BLUE RED | 1.2854 | 1.291 | 1.3272 | DEAD | DEAD |
| | 2 | RED | 0.9381 | 0.9231 | 0.9879 | 1.235 | 1.3616 |
| | 2 | BLUE | 0.9564 | 1.0051 | 1.0821 | **DEAD** | **DEAD** |
| | 3 | ORANGE | 1.4507 | 1.4601 | 1.492 | 1.621 | 1.83 |
| | 3 | BLUE | 1.0874 | 1.1424 | 1.1796 | **DEAD** | **DEAD** |
| | 1 | RED WHITE | 1.2904 | 1.3238 | 1.504 | 1.4815 | 1.581 |
| 75% EARTHWORM | 1 | BLUE | 1.3364 | 1.2353 | 1.2423 | 1.0648 | 1.4399 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | WHITE | | | | | |
| | 2 | BLUE WHITE | 0.699 | 0.7176 | 0.7364 | 0.6369 | 0.7582 |
| | 2 | BLUE RED | 1.2225 | 1.2905 | 1.2598 | 1.2736 | 1.3058 |
| | 3 | CANDY | 1.2125 | 1.2797 | 1.3371 | 1.4606 | 1.5583 |
| | 3 | BLUE RED | 1.2177 | 1.2587 | 1.3252 | 1.3659 | 1.3904 |
| 100% EARTHWORM | 1 | YELLOW FANCY | 1.2172 | 1.2465 | 1.2768 | 1.3121 | 1.39877 |
| | 1 | RED WHITE | 0.786 | 0.7995 | 0.8385 | 0.811 | 0.8487 |
| | 2 | RED WHITE | 0.65 | 0.7277 | 0.7689 | 0.7751 | 0.7862 |
| | 2 | BLUE RED | 0.954 | 0.949 | 0.8732 | 0.9246 | 0.9604 |
| | 3 | WHITE | 0.931 | 0.9509 | 0.964 | 0.8727 | 0.9443 |
| | 3 | BLUE | 1.3379 | 1.3891 | 1.401 | **DEAD** | **DEAD** |
| 0% BSFL | 1 | BLUE(M) | 1.2501 | 1.4006 | 1.4352 | 1.3515 | 1.3679 |
| | 1 | BLUE(F) | 0.9882 | 0.9978 | 1.051 | DEAD | DEAD |
| | 2 | CANDY(M) | 1.3452 | 1.3797 | 1.3891 | 1.394 | 1.53 |
| | 2 | CANDY(F) | 1.3619 | 1.3703 | 1.38631 | DEAD | DEAD |
| | 3 | BLUE RED(M) | 1.0381 | 1.0608 | 1.073 | 1.084 | 1.15 |
| | 3 | WHITE REDTAIL (F) | 1.331 | 1.485 | 1.493 | 1.6125 | 1.5546 |
| 25% BSFL | 1 | WHITE BLUE | 0.9522 | 0.9636 | 0.9751 | 0.9801 | 0.9891 |
| | 1 | RED | 1.042 | 1.162 | 1.205 | 1.1078 | 1.158 |
| | 2 | WHITE RED | 0.9861 | 0.9714 | 0.9543 | 0.9751 | 1.045 |
| | 2 | WHITE BLUE | 1.336 | 1.2458 | 1.1588 | 1.3317 | 1.5283 |
| | 3 | WHITE RED | 0.9721 | 0.9606 | 0.9693 | 0.98755 | 0.9851 |
| | 3 | YELLOW | 1.5689 | 1.5784 | 1.5753 | 1.5829 | 1.5863 |
| 50% BSFL | 1 | NAVY BLUE | 0.8898 | 0.9162 | 0.9333 | 0.9875 | 1.284 |
| | 1 | TURQUOISE | 1.0957 | 1.1713 | 1.2153 | 1.2237 | 1.2196 |
| | 2 | DARK BLUE | 1.0096 | 1.0294 | 1.069 | 1.1315 | 1.0756 |
| | 2 | WHITE RED | 1.2591 | 1.2459 | 1.2288 | 1.2565 | 1.2613 |
| | 3 | BLUE | 1.166 | 1.1475 | 1.1588 | 1.2503 | 1.2621 |
| | 3 | RED | 1.253 | 1.265 | 1.2363 | 1.2971 | 1.381 |
| | 1 | RED WHITE | 1.0961 | 1.0483 | 1.174 | 1.1169 | 1.1752 |
| | 1 | BLUE | 1.3201 | 1.3813 | 1.465 | 1.4837 | 1.4931 |
| | 2 | BLUE | 1.285 | 1.3303 | 1.3439 | 1.3921 | 1.464 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | RED | 1.2465 | 1.235 | 1.261 | 1.356 | 1.3832 |
| | 3 | BLUE RED | 0.946 | 0.9527 | 0.8981 | 1.1563 | 1.218 |
| | 3 | SOFT BLUE | 0.8571 | 0.8681 | 0.9245 | 1.0233 | 1.0309 |
| 100% BSFL | 1 | BLUE | 1.187 | 1.2535 | 1.3665 | 1.3462 | 1.3665 |
| | 1 | YELLOW BLACK | 1.127 | 1.0404 | 1.063 | 1.25 | 1.306 |
| | 2 | BLUE | 1.082 | 1.2166 | 1.2933 | 1.4236 | 1.4554 |
| | 2 | RED GREEN | 1.1301 | 1.09 | 1.305 | **DEAD** | **DEAD** |
| | 3 | RED GREEN | 0.979 | 0.9714 | 1.1688 | 1.1415 | 1.1191 |
| | 3 | BLUE RED | 1.1301 | 1.0729 | 1.0296 | 1.1655 | 1.2188 |

Table 13: Raw data for growth performance

| **Treatment** | **Replicate** | **Colour** | **Total Feed intake** | **Weight gain** | **Specific Growth rate** | **Feed Conversion rate** | **% Weight gain** |
|---|---|---|---|---|---|---|---|
| 0% EARTHWORM | 1 | BLUE(M) | 0.1 | 0.1178 | 0.0038 | 0.848896435 | 11.78 |
| | 1 | BLUE(F) | 0.1 | 0.0628 | 0.002025806 | 1.592356688 | 6.28 |
| | 2 | CANDY(M) | 0.1 | 0.1848 | 0.00596129 | 0.541125541 | 18.48 |
| | 2 | CANDY(F) | 0.1 | 0.02441 | 0.000787419 | 4.096681688 | 2.441 |
| | 3 | BLUE RED(M) | 0.1 | 0.1119 | 0.003609677 | 0.893655049 | 11.19 |
| | 3 | WHITE REDTAIL (F) | 0.1 | 0.2236 | 0.007212903 | 0.447227191 | 22.36 |
| 25% EARTHWORM | 1 | RED | 0.1 | 0.0148 | 0.000477419 | 6.756756757 | 1.48 |
| | 1 | ORANGE | 0.1 | 0.0046 | 0.000148387 | 21.73913043 | 0.46 |
| | 2 | BLUE RED | 0.1 | 0.3532 | 0.011393548 | 0.283125708 | 35.32 |
| | 2 | WHITE RED | 0.1 | 0.5481 | 0.017680645 | 0.182448458 | 54.81 |
| | 3 | CANDY | 0.1 | 0.0129 | 0.0004161 | 7.7519379 | 1.29 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | 0.0...29 | ...84 | |
| | 3 | BLUE | 0.1 | 0.0566 | 0.001825806 | 1.766784452 | 5.66 |
| 50% EARTHWORM | 1 | WHITE | 0.1 | 0.1108 | 0.003574194 | 0.902527076 | 11.08 |
| | 1 | BLUE RED | 0.1 | 0.0418 | 0.001348387 | 2.392344498 | 4.18 |
| | 2 | RED | 0.1 | 0.4235 | 0.01366129 | 0.236127509 | 42.35 |
| | 2 | BLUE | 0.1 | 0.1257 | 0.004054839 | 0.795544948 | 12.57 |
| | 3 | ORANGE | 0.1 | 0.3793 | 0.012235484 | 0.263643554 | 37.93 |
| | 3 | BLUE | 0.1 | 0.0922 | 0.002974194 | 1.084598698 | 9.22 |
| | 1 | RED WHITE | 0.1 | 0.2906 | 0.009374194 | 0.344115623 | 29.06 |
| 75% EARTHWORM | 1 | BLUE WHITE | 0.1 | 0.1035 | 0.00333871 | 0.966183575 | 10.35 |
| | 2 | BLUE WHITE | 0.1 | 0.0592 | 0.001909677 | 1.689189189 | 5.92 |
| | 2 | BLUE RED | 0.1 | 0.0833 | 0.002687097 | 1.200480192 | 8.33 |
| | 3 | CANDY | 0.1 | 0.3458 | 0.011154839 | 0.2891845 | 34.58 |
| | 3 | BLUE RED | 0.1 | 0.1727 | 0.005570968 | 0.579038796 | 17.27 |
| 100% EARTHWORM | 1 | YELLOW FANCY | 0.1 | 0.18157 | 0.005857097 | 0.550751776 | 18.157 |
| | 1 | RED WHITE | 0.1 | 0.0627 | 0.002022581 | 1.594896332 | 6.27 |
| | 2 | RED WHITE | 0.1 | 0.1362 | 0.004393548 | 0.734214391 | 13.62 |
| | 2 | BLUE RED | 0.1 | 0.0064 | 0.000206452 | 15.625 | 0.64 |
| | 3 | WHITE | 0.1 | 0.0133 | 0.000429032 | 7.518796992 | 1.33 |
| | 3 | BLUE | 0.1 | 0.0631 | 0.002035484 | 1.584786054 | 6.31 |
| 0% BSFL | 1 | BLUE(M) | 0.1 | 0.0369 | 0.001190323 | 2.7100271 | 3.69 |
| | 1 | BLUE(F) | 0.1 | 0.116 | 0.003741935 | 0.862068966 | 11.6 |
| | 2 | CANDY(M) | 0.1 | 0.0589 | 0.0019 | 1.697792869 | 5.89 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | CANDY(F) | 0.1 | 0.1923 | 0.006203226 | 0.520020801 | 19.23 |
| | 3 | BLUE RED(M) | 0.1 | 0.013 | 0.000419355 | 7.692307692 | 1.3 |
| | 3 | WHITE REDTAIL (F) | 0.1 | 0.0174 | 0.00056129 | 5.747126437 | 1.74 |
| | 1 | WHITE BLUE | 0.1 | 0.3942 | 0.012716129 | 0.253678336 | 39.42 |
| | 1 | RED | 0.1 | 0.1239 | 0.003996774 | 0.807102502 | 12.39 |
| | 2 | WHITE RED | 0.1 | 0.066 | 0.002129032 | 1.515151515 | 6.6 |
| | 2 | WHITE BLUE | 0.1 | 0.0022 | 7.09677E-05 | 45.45454545 | 0.22 |
| 25% BSFL | 3 | WHITE RED | 0.1 | 0.0961 | 0.0031 | 1.040582726 | 9.61 |
| | 3 | YELLOW | 0.1 | 0.128 | 0.004129032 | 0.78125 | 12.8 |
| | 1 | NAVY BLUE | 0.1 | 0.0791 | 0.002551613 | 1.264222503 | 7.91 |
| | 1 | TURQUOISE | 0.1 | 0.173 | 0.005580645 | 0.578034682 | 17.3 |
| | 2 | DARK BLUE | 0.1 | 0.179 | 0.005774194 | 0.558659218 | 17.9 |
| | 2 | WHITE RED | 0.1 | 0.1367 | 0.004409677 | 0.731528895 | 13.67 |
| | 3 | BLUE | 0.1 | 0.272 | 0.008774194 | 0.367647059 | 27.2 |
| 50% BSFL | 3 | RED | 0.1 | 0.1738 | 0.005606452 | 0.575373993 | 17.38 |
| | 1 | RED WHITE | 0.1 | 0.1795 | 0.005790323 | 0.557103064 | 17.95 |
| | 1 | BLUE | 0.1 | 0.179 | 0.005774194 | 0.558659218 | 17.9 |
| | 2 | BLUE | 0.1 | 0.3734 | 0.012045161 | 0.26780932 | 37.34 |
| | 2 | RED | 0.1 | 0.1749 | 0.005641935 | 0.571755289 | 17.49 |
| | 3 | BLUE RED | 0.1 | 0.1401 | 0.004519355 | 0.713775874 | 14.01 |
| 75% BSFL | 3 | SOFT BLUE | 0.1 | 0.0887 | 0.00286129 | 1.127395716 | 8.87 |
| | 1 | BLUE | 0.1 | 0.1178 | 0.0038 | 0.848896435 | 11.78 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | YELLOW BLACK | 0.1 | 0.0628 | 0.002025806 | 1.592356688 | 6.28 |
| | 2 | BLUE | 0.1 | 0.1848 | 0.00596129 | 0.541125541 | 18.48 |
| | 2 | RED GREEN | 0.1 | 0.02441 | 0.000787419 | 4.096681688 | 2.441 |
| | 3 | RED GREEN | 0.1 | 0.1119 | 0.003609677 | 0.893655049 | 11.19 |
| | 3 | BLUE RED | 0.1 | 0.2236 | 0.007212903 | 0.447227191 | 22.36 |

**Table 13: Raw data water quality week 1**

| TREATMENT | % | MVPH | PH | MVORP | DO | MGLDO | TEMPERATURE | AMMONIA READING | AMMONIA LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| Earthworm | 0 | 50.9 | 6.33 | 183.3 | 35.2 | 2.94 | 24.31 | 0.92 | 1.12 |
| | 0 | 42 | 6.49 | 185.2 | 37 | 3.1 | 24.22 | 0.86 | 1.04 |
| | 0 | 62.8 | 6.1 | 278.5 | 37.2 | 3.09 | 24.4 | 0.88 | 1.07 |
| Earthworm | 25 | 79.5 | 5.79 | 284.2 | 37.3 | 3.11 | 24.48 | 0.48 | 0.58 |
| | 25 | 101 | 5.4 | 332.4 | 37.6 | 3.15 | 24.39 | 0.54 | 0.66 |
| | 25 | 116.6 | 5.14 | 373.1 | 37.2 | 3.11 | 24.47 | 0.41 | 0.5 |
| Earthworm | 50 | 80.3 | 5.82 | 276.6 | 37 | 3.07 | 24.83 | 0.81 | 0.98 |
| | 50 | 62.3 | 6.11 | 215.3 | 39.1 | 3.23 | 25.02 | 1.56 | 1.89 |
| | 50 | 63.1 | 6.1 | 211.3 | 39.8 | 3.26 | 26.16 | 0.49 | 0.59 |
| Earthworm | 75 | 69.7 | 5.98 | 218.1 | 39.6 | 3.25 | 25.21 | 0.44 | 0.53 |
| | 75 | 75 | 5.88 | 228.2 | 42.5 | 3.45 | 25.08 | 0.68 | 0.83 |
| | 75 | 92.8 | 5.53 | 226 | 42.4 | 3.44 | 25.5 | 1.25 | 1.52 |
| Earthworm | 100 | 85 | 5.7 | 227.4 | 42.5 | 3.49 | 25.35 | 1.94 | 2.36 |
| | 100 | 93.6 | 5.54 | 248.9 | 42.6 | 3.49 | 25.33 | 0.66 | 0.8 |
| | 100 | 90.8 | 5.6 | 223 | 42.4 | 3.46 | 25.5 | 1.54 | 1.87 |
| BSFL | 0 | 50.9 | 6.33 | 183.3 | 35.2 | 2.94 | 24.31 | 0.92 | 1.12 |
| | 0 | 42 | 6.49 | 185.2 | 37 | 3.1 | 24.22 | 0.86 | 1.04 |
| | 0 | 62.8 | 6.1 | 278.5 | 37.2 | 3.09 | 24.4 | 0.88 | 1.07 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BSFL | 25 | 85.6 | 5.69 | 207.4 | 42.5 | 3.48 | 25.45 | 0.33 | 0.4 |
| | 25 | 80.6 | 5.8 | 200.6 | 45.9 | 3.77 | 25.3 | 0.8 | 0.97 |
| | 25 | 60.8 | 6.12 | 187.1 | 45.6 | 3.73 | 25.57 | 1.12 | 1.36 |
| BSFL | 50 | 68.7 | 5.99 | 192.1 | 47.4 | 3.85 | 25.56 | 1.27 | 1.54 |
| | 50 | 62 | 6.12 | 157.3 | 45.9 | 3.75 | 25.55 | 0.57 | 0.69 |
| | 50 | 57.5 | 6.2 | 160.5 | 45.6 | 3.88 | 25.9 | 1.29 | 1.57 |
| BSFL | 75 | 76.8 | 5.87 | 120.5 | 47.8 | 3.89 | 25.87 | 3.89 | 4.72 |
| | 75 | 68.4 | 6.01 | 127.7 | 48.7 | 3.93 | 26.85 | 3.76 | 4.56 |
| | 75 | 62.7 | 6.12 | 144.7 | 47.2 | 3.84 | 26.05 | 3.32 | 4.03 |
| BSFL | 100 | 62.9 | 6.1 | 150.8 | 60.9 | 4.94 | 25.94 | 1.3 | 1.58 |
| | 100 | 59.2 | 6.17 | 146 | 60.3 | 4.88 | 25.94 | 1.97 | 2.39 |
| | 100 | 64.5 | 6.09 | 134.8 | 60.9 | 4.9 | 25.86 | 1.92 | 2.33 |

**Table 14: Raw data water quality week 2**

| TREATMENT | % | MVPH | PH | MVORP | DO | MGLDO | TEMPERATURE | AMMONIA READING | AMMONIA LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| Earthworm | 0 | 75.6 | 5.86 | 167 | 40.4 | 3.37 | 24.57 | 0.92 | 1.12 |
| | 0 | 73.3 | 5.91 | 164.9 | 41.4 | 3.47 | 24.35 | 0.86 | 1.04 |
| | 0 | 70 | 5.97 | 170.6 | 65.4 | 5.44 | 24.64 | 0.88 | 1.07 |
| Earthworm | 25 | 86.4 | 5.67 | 208 | 61.9 | 5.14 | 24.74 | 0.48 | 0.58 |
| | 25 | 84.7 | 5.7 | 203 | 64.4 | 5.35 | 24.52 | 0.54 | 0.66 |
| | 25 | 86.7 | 5.66 | 211.4 | 62.9 | 5.23 | 24.8 | 0.41 | 0.5 |
| Earthworm | 50 | 82.4 | 5.74 | 204.9 | 68.1 | 5.57 | 24.88 | 0.81 | 0.98 |
| | 50 | 72.8 | 5.92 | 192.6 | 65.4 | 5.44 | 24.68 | 1.56 | 1.89 |
| | 50 | 75.2 | 5.87 | 198.1 | 65.2 | 5.4 | 24.96 | 0.49 | 0.59 |
| Earthworm | 75 | 77.7 | 5.83 | 189.6 | 64.9 | 5.37 | 24.97 | 0.44 | 0.53 |
| | 75 | 87.1 | 5.65 | 238.7 | 64.6 | 5.36 | 24.75 | 0.68 | 0.83 |
| | 75 | 85.4 | 5.69 | 227.5 | 65.9 | 5.43 | 25.14 | 1.25 | 1.52 |
| Earthworm | 100 | 90.7 | 5.59 | 233.1 | 68.8 | 5.65 | 25.16 | 1.94 | 2.36 |
| | 100 | 84.9 | 5.7 | 231 | 66.4 | 5.51 | 24.98 | 0.66 | 0.8 |
| | 100 | 91.3 | 5.57 | 236.6 | 69.4 | 5.7 | 25.32 | 1.54 | 1.87 |
| BSFL | 0 | 75.6 | 5.86 | 167 | 40.4 | 3.37 | 24.57 | 0.92 | 1.12 |
| | 0 | 73.3 | 5.91 | 164.9 | 41.4 | 3.47 | 24.35 | 0.86 | 1.04 |
| | 0 | 70 | 5.97 | 170.6 | 65.4 | 5.44 | 24.64 | 0.88 | 1.07 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 25 | 92.3 | 5.55 | 279.4 | 70 | 5.77 | 25.41 | 0.33 | 0.4 |
| BSFL | 25 | 89.7 | 5.61 | 267 | 70.3 | 5.78 | 25.19 | 0.8 | 0.97 |
| | 25 | 65.4 | 6.06 | 204.2 | 75.8 | 6.05 | 26.97 | 1.12 | 1.36 |
| | 50 | 65.8 | 6.05 | 204.2 | 75.3 | 6.03 | 26.73 | 1.27 | 1.54 |
| BSFL | 50 | 78.9 | 5.81 | 205.6 | 75 | 6.02 | 26.48 | 0.57 | 0.69 |
| | 50 | 84.7 | 5.71 | 178.3 | 77.5 | 6.17 | 27.21 | 1.29 | 1.57 |
| | 75 | 89.2 | 5.65 | 176 | 59.8 | 4.6 | 28.37 | 3.89 | 4.72 |
| BSFL | 75 | 89.7 | 5.62 | 181.3 | 59.8 | 4.63 | 28.09 | 3.76 | 4.56 |
| | 75 | 96.1 | 5.51 | 187.2 | 59.3 | 4.55 | 28.62 | 3.32 | 4.03 |
| | 100 | 130.4 | 5.43 | 195.2 | 56.3 | 4.35 | 28.54 | 1.3 | 1.58 |
| BSFL | 100 | 104.9 | 5.35 | 195.4 | 55.1 | 4.21 | 28.55 | 1.97 | 2.39 |
| | 100 | 105.1 | 5.35 | 203.5 | 59.6 | 4.47 | 29.01 | 1.92 | 2.33 |

**Table 15: Raw data water quality week 3**

| TREATMENT | % | MVPH | PH | MVORP | DO | MGLDO | TEMPERATURE | AMMONIA READING | AMMONIA LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 91.7 | 5.57 | 141.4 | 54.9 | 3.99 | 25.63 | 1.03 | 1.25 |
| Earthworm | 0 | 56.3 | 6.22 | 99 | 43.4 | 3.44 | 25.55 | 1.24 | 1.51 |
| | 0 | 65.7 | 6.05 | 117 | 54 | 4.23 | 25.99 | 2.03 | 2.46 |
| | 25 | 68.7 | 5.96 | 154.5 | 63.3 | 4.32 | 25.68 | 1.5 | 1.82 |
| Earthworm | 25 | 77.3 | 5.81 | 165 | 52.8 | 4.18 | 25.8 | 1.27 | 1.54 |
| | 25 | 83.6 | 5.71 | 120.1 | 52.7 | 4.13 | 26.12 | 1.56 | 1.89 |
| | 50 | 93.6 | 5.53 | 171.4 | 66.6 | 5.3 | 25.83 | 1.55 | 1.88 |
| Earthworm | 50 | 93.6 | 5.52 | 175.7 | 64.5 | 5.05 | 26.03 | 1.3 | 1.58 |
| | 50 | 96.2 | 5.43 | 164.1 | 56.3 | 3.88 | 25.72 | 1.05 | 1.27 |
| | 75 | 94.8 | 5.51 | 145.5 | 43.7 | 3.15 | 25.4 | 1.09 | 1.32 |
| Earthworm | 75 | 87.4 | 5.65 | 148.6 | 30.7 | 2.38 | 26.2 | 0.72 | 0.87 |
| | 75 | 81.8 | 5.76 | 150 | 57.6 | 4.42 | 25.78 | 0.66 | 0.8 |
| | 100 | 80 | 5.79 | 151 | 61.7 | 4.77 | 25.49 | 1.11 | 1.35 |
| Earthworm | 100 | 76 | 5.86 | 152.5 | 76.3 | 5.9 | 26.74 | 1.38 | 1.68 |
| | 100 | 79 | 5.79 | 173.2 | 74.3 | 5.73 | 25.63 | 1.52 | 1.85 |
| | 0 | 91.7 | 5.57 | 141.4 | 54.9 | 3.99 | 25.46 | 1.03 | 1.25 |
| BSFL | 0 | 56.3 | 6.22 | 99 | 43.4 | 3.44 | 25.55 | 1.24 | 1.51 |
| | 0 | 65.7 | 6.05 | 117 | 54 | 4.23 | 26.74 | 2.03 | 2.46 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BSFL | 25 | 74 | 5.93 | 166.1 | 62.4 | 4.88 | 26.56 | 1.11 | 1.35 |
| | 25 | 74.8 | 5.9 | 170.6 | 71 | 5.48 | 26.21 | 1.05 | 1.27 |
| | 25 | 79.1 | 5.81 | 172.5 | 59.6 | 4.65 | 26.51 | 1.04 | 1.26 |
| BSFL | 50 | 69.2 | 5.99 | 149.5 | 70.6 | 5.58 | 26.36 | 1.92 | 2.33 |
| | 50 | 78 | 5.82 | 184.7 | 64.4 | 4.94 | 26.91 | 0.51 | 0.62 |
| | 50 | 80.7 | 5.78 | 181.4 | 58.1 | 4.52 | 26.96 | 1.16 | 1.35 |
| BSFL | 75 | 74 | 5.9 | 148.7 | 66.8 | 5.87 | 24.73 | 2.67 | 3.24 |
| | 75 | 76.8 | 5.84 | 118.5 | 69.9 | 5.62 | 25.11 | 0.78 | 0.95 |
| | 75 | 83.3 | 5.72 | 118.8 | 68.4 | 5.41 | 24.8 | 1.48 | 1.8 |
| BSFL | 100 | 91.4 | 5.58 | 119.4 | 67.2 | 5.55 | 24.16 | 0.85 | 1.03 |
| | 100 | 94.2 | 5.52 | 125.5 | 69.8 | 5.69 | 24.23 | 1.67 | 2.03 |
| | 100 | 98.4 | 5.45 | 154.2 | 66.1 | 5.21 | 24.85 | 1.53 | 1.86 |

**Table 16: Raw data water quality week 4**

| TREATMENT | % | MVPH | PH | MVORP | DO | MGLDO | TEMPERATURE | AMMONIA READING | AMMONIA LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| Earthworm | 0 | 124.8 | 4.97 | 122.4 | 43 | 3.26 | 24.27 | 1.63 | 1.98 |
| | 0 | 119.3 | 5.06 | 127 | 46.9 | 3.21 | 24.08 | 2.32 | 2.82 |
| | 0 | 117.4 | 5.1 | 130 | 46.3 | 3.35 | 24.07 | 2.49 | 3.02 |
| Earthworm | 25 | 112.4 | 5.19 | 132.6 | 46 | 3.64 | 24.09 | 0.4 | 0.49 |
| | 25 | 107.5 | 5.28 | 132.9 | 48.8 | 3.36 | 24.09 | 0.99 | 1.2 |
| | 25 | 103.5 | 5.35 | 133 | 42.3 | 2.67 | 24.16 | 0.49 | 1.46 |
| Earthworm | 50 | 97.6 | 5.46 | 131.4 | 48.3 | 3.37 | 24.16 | 1.52 | 1.85 |
| | 50 | 86.6 | 5.66 | 128.6 | 50.2 | 3.44 | 24.14 | 0.48 | 0.58 |
| | 50 | 86.5 | 5.66 | 127.4 | 28 | 2.31 | 24.29 | 1.15 | 1.4 |
| Earthworm | 75 | 83.6 | 5.72 | 131.1 | 41.1 | 3.4 | 24.3 | 0.94 | 1.14 |
| | 75 | 82.5 | 5.74 | 124.6 | 35.2 | 2.84 | 24.38 | 1.5 | 1.82 |
| | 75 | 71.7 | 5.94 | 103.1 | 57.7 | 3.74 | 24.39 | 1.22 | 1.48 |
| Earthworm | 100 | 81 | 5.77 | 115 | 81.5 | 3.86 | 24.45 | 0.33 | 0.4 |
| | 100 | 85.9 | 5.67 | 124.7 | 41.7 | 3.09 | 24.42 | 0.46 | 0.56 |
| | 100 | 86.7 | 5.66 | 134.3 | 35.4 | 2.43 | 24.56 | 1.18 | 1.43 |
| BSFL | 0 | 124.8 | 4.97 | 122.4 | 43 | 3.26 | 24.27 | 1.63 | 1.98 |
| | 0 | 119.3 | 5.06 | 127 | 46.9 | 3.21 | 24.08 | 2.32 | 2.82 |
| | 0 | 117.4 | 5.1 | 130 | 46.3 | 3.35 | 24.07 | 2.49 | 3.02 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BSFL | 25 | 83.8 | 5.71 | 136.4 | 30.4 | 2.46 | 24.45 | 0.28 | 0.34 |
| | 25 | 86.8 | 5.77 | 139.2 | 46.6 | 3.35 | 24.44 | 1.29 | 1.57 |
| | 25 | 75.6 | 5.77 | 140.2 | 56.5 | 4.22 | 24.6 | 1.49 | 1.81 |
| BSFL | 50 | 54.8 | 6.25 | 131 | 33.9 | 2.69 | 24.74 | 1.42 | 1.72 |
| | 50 | 58.3 | 6.19 | 130.9 | 70.2 | 4.47 | 24.56 | 2.04 | 2.48 |
| | 50 | 63.3 | 6.1 | 141.5 | 56.4 | 3.46 | 24.67 | 1.64 | 1.99 |
| BSFL | 75 | 72.8 | 5.92 | 152.5 | 55 | 3.35 | 24.75 | 0.47 | 0.57 |
| | 75 | 74.1 | 5.9 | 154.5 | 60 | 3.53 | 24.68 | 0.77 | 0.93 |
| | 75 | 64.4 | 6.1 | 127.3 | 41.4 | 2.89 | 24.79 | 0.67 | 0.81 |
| BSFL | 100 | 60.8 | 6.14 | 112.8 | 68.6 | 2.46 | 24.72 | 1.7 | 2.06 |
| | 100 | 60.9 | 6.14 | 115.5 | 23 | 2 | 24.76 | 0.86 | 1.04 |
| | 100 | 68.5 | 5.99 | 95.8 | 38.9 | 2.72 | 24.88 | 1.15 | 1.4 |

## APPENDIX B


FIGURE 3: Hanna multiparameter


FIGURE 4: Hanna ammonia checker


FIGURE 5: Breeding container of earthworm

FIGURE 6: Earthworm

FIGURE 7: Fish formulated feed

Figure 8: Betta Splendens fish (*Fancy sp*

Figure 9: earthworm that was separated from the soil.