KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF RENEWABLE NATURAL RESOURCES

DEPARTMENT OF FISHERIES AND WATER SHARED MANAGEMENT

AN ASSESSMENT OF WATER RE-USE AND FEED ON THE GROWTH PERFORMANCE OF TILAPIA AND POND WATER QUALITY

By

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DECLARATION

I hereby declare that the submission is my own work towards the award of MPil in Aquaculture and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

This study was conducted to evaluate the effect of the quality of water (re-use and fresh) and feed (formulated and farm-made) on the growth performance of tilapia (*Oreochromis niloticus*). It was conducted between March and October, 2011, at Oseibros farms, Kubease in Ashanti Region and Sefwi Asawinso in the Western Region. Complete randomized block design was used with four treatments (New water and farm-made feed; (NWL), new water and formulated feed: (NWR), re-use water and farm-made feed: (OWL), and re-use water and formulated feed: (OWR) in two blocks, each block containing four plots. Two of these plots (OWR and OWL) contained re- use water and the other two plots (NWR and NWL) contained fresh water. All-male tilapia fingerlings (5g) were stocked at 3 fish m^{-2} and sampled every two weeks using seine net. pH, DO, temperature and TDS were monitored with a Hanna 9828 multi-parameter probe. Water samples were collected at 30cm above the surface and 30cm from the bottom of the pond and was analysed for phosphorus and total dissolved nitrogen. Data was analysed using analysis of variance (ANOVA) with Graph-pad prism 5 package. Results indicated that, ponds that received farm-made feed and filled with re-used water (OWL: 150.7g) although not significant, had higher growth than fresh water (NWL: 143.7g). With regard to formulated feed, fish cultured in fresh water (197.5g) were larger than those grown in re-use water (164.2g). At Asawinso, the specific growth rate (1.25% day^{-1}) and daily weight gain (1.11g/day) were better than those at Kubease, specific growth rate (0.81% day^{-1}) and daily weight gain (0.84g/day). There were no differences in pH and temperature among treatments, however, differences in DO, phosphorus, total dissolved nitrogen and TDS were observed ($p<0.05$). At the end of the study, it was realized that fish in ponds that contained re-use water appear to exhibit better growth if fed with farm-made feed than with formulated feed while the growth of fish in ponds that contained fresh or renewed water appear to be promoted if fed with formulated feed.

DEDICATION

This thesis is dedicated to my husband; Mr Eric Okyere Baafi and my elder brother; Mr Emmanuel Obeng for their special support.

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I will bless the Lord at all times; His praise shall continually be in my mouth. My soul shall make its boast in the Lord; the humble shall hear of it and be glad. Oh magnify the Lord with me and let us exalt His name together." I appreciate God for His protection throughout the project.

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LIST OF ABBREVIATIONS

OWR: Old (reuse) Water Raanan feed

OWL: Old (reuse) Water Local feed

NWR: New (fresh) Water Raanan feed

NWL: New (fresh) Water Local feed

TDS: Total Dissolved Solid

DO: Dissolved Oxygen.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The main objective of the Committee for Inland Fisheries and Aquaculture of Africa (CIFAA) according to FAO (2005) is to promote the development of inland fisheries and aquaculture in Africa. According to FAO (2005) CIFAA seeks to assist in the development of fish culture and stock improvement. This is the focus of the new fisheries policy i.e. to manage the fisheries sector, conserve the aquatic resources, and protect the natural environment while improving the livelihood of fishing communities as reported in Ghana Fisheries Act. Aquaculture, according to Marine Conservation Society (MCS, 2012) is the farming of aquatic organisms: fish, molluscs, crustaceans, aquatic plants, reptiles, and amphibians. It is believed to have started over 4,000 years ago with the farming of carps in China.

Currently, aquaculture is practice all over the world, producing many species of fish, shellfish, algae and plants (MCS, 2012). Different farming methods are used depending on where and what is being produced - ranging from floating cages, ponds and tanks. Aquaculture presently produces half of the world's seafood and is set to overtake capture fisheries as a source of fish for human consumption. It is the fastest growing food sector, expanding at about 7% per year (MCS, 2012). According to Emerson (1999), aquaculture continues to be one of the most viable methods for supplying seafood to the growing human population, but the effort to maintaining sustainability, productivity and ecological compatibility threatens its development.

Food security is defined by FAO as a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Fish contributes to national food self-sufficiency through direct consumption and through trade and exports. The extreme importance of fish to food security and nutrition may be illustrated by assessments on the situation in Africa. FAO (2011) estimated that, fish provides 22% of the protein intake in Sub-Saharan Africa and this share, however, can exceed 50% in the poorest countries (especially where other sources of animal protein is scarce or expensive. In general terms, aquaculture can benefit the livelihoods of the poor through an improved food supply and/or through employment and increased income.

Nile tilapia *Oreochromis niloticus*, according to Varadara and Pandian (1987), is one of the leading farmed fish species around the world. In addition to the high growth rate, it is tolerant to adverse environmental and management conditions. However, one of the main problems of Nile tilapia is their early maturation (4-5 months). This ends up in consecutive spawning during the growing season and unwanted reproduction that usually leads to crowded condition in the ponds and consequently reduces growth (Varadara and Pandian, 1987). Tilapia aquaculture has one basic phenomenon, which usually affect the growth, that is, males grow bigger and faster than females (Phelps *et. al.*, 1995). In order to avoid unwanted spawning in a production unit, all-male populations are preferred. According to Phelps *et. al., (*1995), numerous methods are used to distort the sex ratios and increase the percentage of males in a population. Currently, the most common method of generating mostly male populations is through the use of steroid hormones fed to sexually undifferentiated fry (Phelps *et. al.,* 1995).

Water is a necessity for both individual and community well-being. As population grows, water needs increase and fresh water sources become taxed to the limit and as a result, many regions have been forced to reassess the long-term reliability of their water supply systems (Wright *et. al.*, 1995). In addition, there is a growing recognition of the need to restore and preserve our aquatic ecosystems by allowing larger volumes of water to remain within the banks of the streams. As stated by Wright *et. al.*, (1995), water resource and management issues are becoming increasingly critical. It is estimated that within the next fifty years, the world population will increase by another 40 to 50 %. The population growth, coupled with industrialization and urbanization, will result in an increasing demand for water and related consequences on the environment (World Water Council, 2010).

1.2 Problem statement and Justification

According to FAO (2012), the major environmental impacts of aquaculture have been associated mainly with high-input intensive systems which result in water pollution. Unlike mollusc farming, many species of fish depend on a diet of artificial feed. This feed is broadcast onto the surface of the water and is consumed by the fish (Emerson 1999). However, uneaten feed and organic loading of water bodies results in pollution. Unfortunately, fish farmers do not have any option with this waste but to discharge it into the environment. Discharging water with high suspended solids and nutrient into the environment over a prolonged period result in the build-up of anoxic sediments, changes in benthic communities and the eutrophication of the water body. Again, some fish farmers in this country have problem with water especially, those who depend on underground water and rainfall, are not able to produce fish during the dry season owing to the reliance on freshwater. To solve these challenges, re-use water in aquaculture could be an important consideration. However, little or no information is available on the economic importance of re-used water in aquaculture. This information is needed since it will enable fish farmers to culture fish year round thus, increasing productivity. In view of that, this study seeks to ascertain the effect of water on growth performance of *Oreochromis niloticus*.

1.3 Objectives

The objectives of the study were:

1. To examine the effect of water type (renewed and re used) on the growth performance of *O. niloticus* cultured in ponds.
2. To evaluate the effect of the feed type (farm-made feed and formulated feed) on the water quality.

1.4 Alternate Hypotheses (H1)

H_1a: Re-use of wastewater (old water) influences fish growth.

H_{1b}: Fish feed type has an effect on water quality in aquaculture.

CHAPTER TWO

2.0 LITERATURE REVIEW

FAO (2003) defines aquaculture as the farming of aquatic organisms: fish, molluscs, crustaceans, aquatic plants, crocodiles, alligators, turtles, and amphibians. The farming implies some form of involvement in the rearing process. This is done to improve production (Smith and Phillips, 2001). Despite the fact that fish culture is an age-old practice in some regions of the world, it is relatively new as a significant industry in most countries. Fish farming; which is the rearing of fish under controlled condition, is the principal form of aquaculture. It involves raising of fish commercially in concrete tanks, earthen pods, plastic tanks, cages, pens, hapas in water bodies, raceways and reservoirs. A facility that releases young fish into the wild for recreational fishing or to supplement a species natural numbers is termed as hatchery. The most common fish species raised by fish farms are salmon, carp, tilapia, European seabass, catfish and cod. Increasing demands on wild fisheries by commercial fishing has caused widespread over fishing. Fish farming offers an alternative solution to the increasing market demand for fish and fish protein (FAO, 2003).

2.2 Major categories of aquaculture systems

There are different kinds of aquaculture systems. It ranges from very extensive, through semi-intensive and highly intensive (Smith and Phillips, 2001). About 70-80% of the total global production of farmed takes place within extensive and semi- intensive farming systems. In such systems, fish are raised in earthen ponds, pens and cages, rice fields or small water bodies.

2.2.1 Extensive Aquaculture

Total dependence on natural productivity, little control over the stocks and adoption of traditional techniques of aquaculture is the extensive aquaculture system (Smith and Phillips,, 2001).The limiting factor for growth here is the available food supply by natural sources, commonly zooplankton feeding on pelagic. Tilapia species filter feed directly on phytoplankton which makes production high (FAO, 1987).

2.2.2 Intensive aquaculture

In intensive aquaculture system, fish are fed with external food supply (Smith and Phillips, 2001). According to FAO (1987), oxygen, fresh water and food are provided to fish. It involves the adoption of full complement of culture techniques including scientific pond design, fertilization, supplemental feeding or only feeding without fertilization; full measure of stock manipulation, disease control, scientific harvesting, high level inputs and high rate of production. Fish production per unit of surface is always high. It is labour and time intensive.

2.2 3 Semi-intensive

This system involves the implementation of mid-level skill, where the fish depend partially on natural productivity by phytoplankton and aquatic organisms. Fertilization is done to enrich the water which also facilitates the growth of natural feed. There is always a, supplementary feeding, with stock management. The level of input is often medium compare with the other system **(**FAO, 1987).

2.3 Pond Culture

2.3.1 Static freshwater ponds

FAO (1987) reported that, ordinary fresh water fish culture ponds are still-water ponds. Some are seasonal and some perennial. The ponds may be rainfed (also called sky ponds) and/or may have inlet and outlet systems. The water supply may be from a stream or a canal or from an underground source such as wells, tubewells etc. The water retentivity of the ponds depends on soil composition of the pond bottom and subsoil water level (FAO, 1987). The natural biological productivity of such ponds depends on soil and water qualities. Homestead ponds are usually small and shallow while's commercial freshwater ponds have an assured water supply, an inlet and drainage systems. In an organized aquaculture, the carrying capacity of still-water ponds is enhanced by manuring and/or fertilizing and exercising water quality control. Fish are also fed from an extraneous source for obtaining fast growth (FAO, 1987).

2.3.2 Brackish water ponds

According to FAO (1987), the principle of operation of brackish water ponds is different from those of freshwater ponds. Here, the pond or the farm is essentially located on a tidal creek or stream and there is a system of sluices to control the ingress and egress of water into and from the ponds. Examples are: Milkfish farms in Philippines, Taiwan, Indonesia etc. Here also there is competition with other land use agencies, especially forestry, but the extent of competition with agriculture is relatively less because coastal land is generally not suitable for agriculture.

2. 4 Growth of fish

Wootton (1992) explained that, growth is an important component of the ecology of fishes. A lot of different factors act together to determine the growth rate of fish and how large they will become. Most fishes unlike birds and mammals continue to grow in length and weight after they have reached sexual maturity, although the rate of growing declines as the fish get bigger. The growth pattern observed is the result of interaction between a potential for growth defined by the genotype of the fish and the environmental conditions experienced by the fish (Wootton, 1992). Some of these factors are constants, e.g. the species type; whiles others are variable e.g. pH, salinity and alkalinity. Rapid growth indicates abundant food and other favourable conditions, whereas slow growth is likely to indicate just the opposite.

Growth can be defined as the change in size (length, weight) over time or, energetically, as the change in calories stored as somatic and reproductive tissues (Moyle and Joseph, 1988). Moyle and Joseph (1988) noted that, metabolism is the sum of anabolism (the tissue synthesis or "building up" aspect of metabolism) plus catabolism (the energy-producing breaking of chemical bonds or "tearing down" aspect). Thus, the rate of anabolism exceeds that of catabolism in a growing fish.

From Wootton (1992), the presence of other fishes in a fish's environment can reduce growth rates through interference or exploitation competition. Growth could also be either somatic or reproductive. Somatic growth results in growth in the body cells which usually brings about a physical change or development in the body. It involves division and growth of the body cells and tissues. Reproductive growth is development of the gonads and gametes in the body, that is, maturation of the female and male sex cells and organs.

Wootton (1992), again stated that, growth can also be at negative rate and that is termed degrowth. The growth pattern in fishes may even vary within organisms of the same species. Certain organisms may even like to reach sexual maturity even with scarce amount of food and therefore tend to always be smaller in size (Brogowski *et. al.*, 2004).

According to Brogowski *et. al.*, (2004), the principal factors controlling anabolic processes are growth hormones secreted by the pituitary and steroid hormones from the gonads. However, the rate of growth of fish is highly variable because it is greatly dependent on a variety of interacting environmental factors such as water temperature, levels of dissolved oxygen and ammonia, salinity, and photoperiod. These factors interact with each other and with other factors such as the degree of competition, the amount and quality of food ingested, and the age and state of maturity of fish. These factors can be summed into physical and chemical both referred to as abiotic and biological (biotic) (Brogowski *et. al.*, 2004)

2.5 Factors affecting Fish Growth (Physical factors)

2.5.1 Temperature

Temperature influences the onset of fish spawn, aquatic vegetation growth and the biological demand for oxygen in ponds. As water temperature increases, it holds less oxygen. Additionally, plants and animals use more oxygen due to increased respiration rates. These factors commonly result in less available oxygen for fish during the summer and fall months (Russell**,** 2011).Temperature is one of the most important environmental variables. According to Woiwode *et. al.,* (1991), temperature is known to influence both ingestion and metabolism which, however, also affect growth rates. Under conditions of unlimited food supply, an increase in temperature will lead to an increase in food intake, but at high temperatures there will be an abrupt decline in rates of ingestion which will in turn affect growth (Woiwode *et. al.*, 1991).

2.5.2 Turbidity

According to Moyle (1990), turbidity refers to how clear the water is. The greater the amount of total suspended solids in the water, the higher the measured turbidity. The major source of turbidity in the open water lakes is typically phytoplankton, but closer to shore, particulate may also be clay and silts from shoreline erosion (Moyle 1990). As particulate of silt and clay and other organic materials settle to the bottom, they can suffocate newly hatched larvae and fill the spaces between rocks which could have used by aquatic organism as habitat. Fine particulate materials can also damage sensitive gills structures, decrease their resistance to diseases, prevent proper eggs and larval development and potential interfere with particle feeding activities. Increased turbidity also affects the rate of photosynthesis which causes the reduction of oxygen levels in daytime. This can lead to the state of anoxia which can result in the death of the fish (Moyle, 1990).

2.6 Chemical Factors

2.6.1 Dissolved Oxygen

DO levels, although dependent on temperature, are often by themselves an important factor affecting the growth rate of fishes. Moyle and Joseph (1988) measured a significant reduction in growth rate and food conversion efficiency in juvenile largemouth bass (*Micropterus almonides*) when dissolved oxygen fell below approximately 5mg/l at 26ºC. Presumably, the reduced oxygen below this threshold precludes “extra” aerobic, energy requiring activities such as growth and reproduction above maintenance cost. Some fishes attempt to swim to more favourable environments. However, a report by Mallya, (2007) shows that, the period of time during which the oxygen level drops below the required minimum level, will cause the fish to become stressed. It is this stress which causes fish death. More than that, fish reduce food intake, leading to a reduction in growth. Mallya, (2007), again stated that, reproduction is inhibited, and both fertilization success and larval survival are compromised. When the oxygen level is maintained near saturation or even at slightly super saturation at all times it will increase growth rates, reduce the food conversion ratio and increase overall fish production. As the dissolved oxygen concentration decreases, respiration and feeding activities also decrease. As a result, the growth rate is reduced and the possibility of a disease attack is increased. However, fish is not able to assimilate the food consumed when DO is low (Mallya, 2007)

2.6.2 pH

In an experiment by Brogowski *et. al.*, (2004), mortality of bluegills was highest (32%) for fish at the pH 5.5 treatment. This was twice as high as the loss of fish in the aquaria of pH 6.5. Significant decreases in length and weight between 5.5 and 6.5 were observed over 30 days. The length of fish in pH 5.5 was 49.6% less than that of fish in pH 6.5 and 7.5. A similar trend was observed for weight changes. Bluegill weight gain was 61.6% lower at pH 5.5 as compared to those in pH 6.5 and 7.5. Lowering pH from 7.5 to 6.5 had little effect on mortality and growth of fish. A significant difference appears when the pH level is reduced to pH 5.5.

2.6.3 Ammonia (NH_3)

Moyle and Joseph, (1988) indicated that ammonia is the primary excretory product of fishes, but if it is present in high concentrations, it will slow growth rate. For example, juvenile channel catfish display a linear drop in weight gain with increasing ammonia in their water. The mechanism of growth inhibition by ammonia is still unknown. It is generally acknowledged that un-ionized ammonia (NH_3) in the water produces more toxic effects on fishes than an equal concentration of the ionized form (NH_4^+). Although ammonia is a "natural" compound, its effects on fishes are typical of many pollutants, which also reduce growth rates when present at sublethal levels.

2.7 Biological Factors

2.7.1 Competition

Competition either within or among species, for limited food supplies may slow growth. Moyle and Joseph (1988) reported that bluegill, a species in which the adults and young both eat virtually the same aquatic invertebrates and are not cannibalistic, become stunted when the population size reaches a particular level. Fertilization, of the pond will increase the invertebrate food base and consequently bluegill total biomass. However, the average size of the bluegill remains small as growth slows and some reproduction continues. Biological constraints to the development of commercial tilapia farming are their inability to withstand sustained water temperatures below 50 to 52 ºC and early sexual maturity that results in spawning before fish reach market size (Popma and Masser, 1999).

2.7.2 Food Availability

Food availability also interact with other factors as well, particularly temperature, to affect the growth of fishes on a seasonal basis. For example, Moyle and Joseph (1988) found marked seasonal differences in growth (length increases) in northern Indiana bluegill populations. Bluegill growth was accelerated during the warmer months of plentiful food. Striped mullet (Mugilcephalus) from south Texas coastal waters show cycles of seasonal growth similar to those of bluegills, except that growth virtually ceases during the warmest months of midsummer through midautumn. Photoperiod (day length) may also affect seasonal growth phenomena. For example, Moyle (1988), found a close association between growth of Lake Whitefish (*Coregonus clupeaformis*) and seasonal photoperiod but no relationship between the spring water temperatures and growth. Small tench, captured by electro-fishing from a single wild population and then released in four farm ponds, were able, because of plentiful food, to grow as much in a single year as they would have in four years in their original lake environment (Gray and Setna, 1990).

2.7.3 Age and Maturation

Age and Maturity are usually the best predictors of relative growth rates in fishes, although the absolute growth rates are strongly influenced by environmental factors. Thus, fish grow typically very rapidly in length in the first few months or years of life, until maturation. Then increasing amounts of energy are diverted from growth of somatic to growth of gonadal tissues. As a consequence, growth rates of mature fish are much slower than those of immature fish. Partly in because of the amount of gonadal tissues, however, mature fish are typically heavier per unit length than immature fish. This is reflected in their high condition factor (K) (Moyle and Joseph (1988).

2.8 Tilapia Production

According Popma and Masser,(1999), the Nile tilapia (*O. niloticus*) was one of the first fish species cultured. Illustrations from Egyptian tombs suggest that Nile tilapia cultured species of tilapia in Africa. They again stated that positive aquacultural characteristics of tilapia are their tolerance of poor water quality and the fact that they eat a wide range of natural food organisms (Popma and Masser, 1999). Aquaculture of tilapias provides a classic example of a success story of a species group outside its natural range of distribution. The group currently contributes about 3.8 percent to the cultured fish and shellfish production of about 40 million tonnes globally. Aquaculture production (2002) of tilapias is about 1.5 million tonnes, the great bulk of which takes place in Asia accounting for nearly 80 percent of the total world production. It is important to note, however, that tilapia culture in Africa and South America is also increasing ((Popma and Masser 1999).

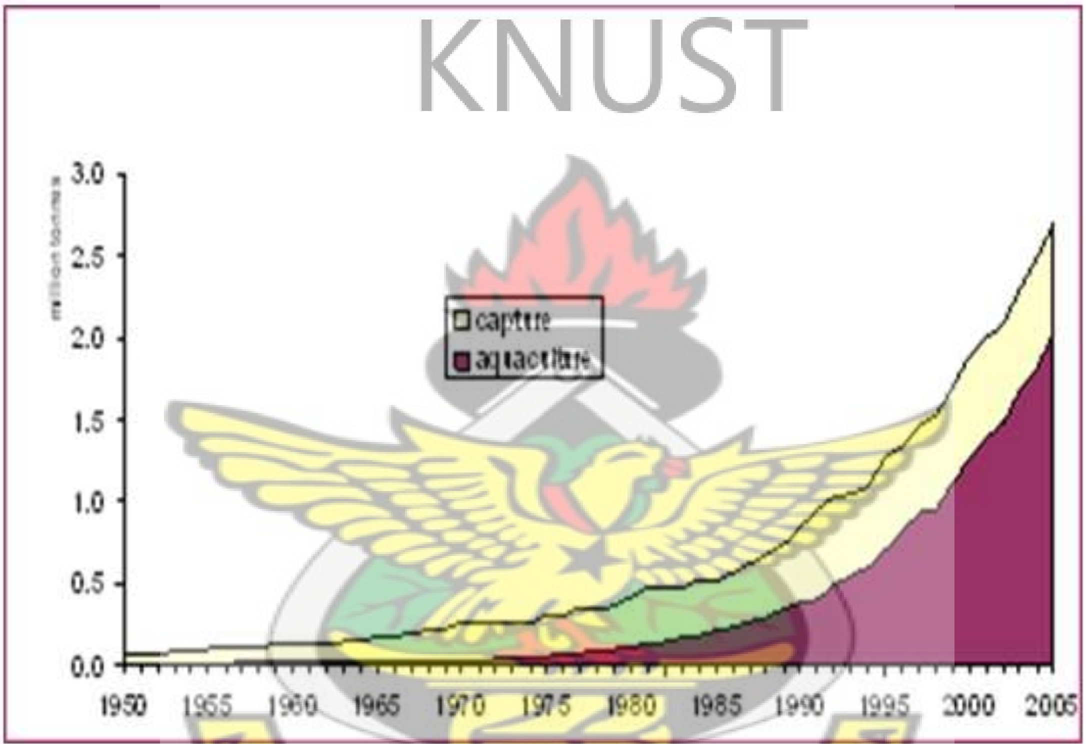

Figure 2.1 World tilapia trade (Helga *et. al.*, 2007)

2.8.1 Taxonomy of Tilapia

Tilapia is the generic name of a group of cichlids endemic to Africa. The group consists of three aquaculturally important genera *Oreochromis, Sarotherodon* and Tilapia (Popma and Masser, 1999). Several characteristics distinguish these three genera, but possibly the most critical relates to reproductive behavior. All tilapia species are nest builders; fertilized eggs are guarded in the nest by a brood parent. Species of both *Sarotherodon* and *Oreochromis* are mouth brooders; eggs are fertilized in the nest but parents immediately pick up the eggs in their mouths and hold them through incubation and for several days after hatching. In Oreochromis species only females practice mouth brooding, while in Sarotherodon species either the male or both male and female are mouth brooders (Popma and Masser, 1999).

2.8.2 Scientific classification

Kingdom: Animalia

Phylum: Chordata

Class: Actinopterygii

Order: Oercifomes

Family: Cichlidae

Subfamily: Pseudocrenilabrinae

Tribe: Tilapiini

Genera: Oreochromis

Sarotherodon

Tilapia

2.8.3 Physical Characteristics of Tilapia

Tilapia are shaped much like sunfish or crappie but can be easily identified by an interrupted lateral line characteristic of the Cichlid family of fishes. They are laterally compressed and deep-bodied with long dorsal fins. The forward portion of the dorsal fin is heavily spined. Spines are also found in the pelvis and anal fins. There are usually wide vertical bars down the sides of fry, fingerlings, and sometimes adults (Popma and Masser, 1999).

2.8.4 Reproduction of Tilapia

In all *Oreochromis* species, the male excavates a nest in the pond bottom (generally in water shallower than 3 feet) and mates with several females. After a short mating ritual the female spawns in the nest (about two to four eggs per gram of brood female), the male fertilizes the eggs, and she then holds and incubates the eggs in her mouth (buccal cavity) until they hatch. Fry remain in the female's mouth through yolk sac absorption and often seek refuge in her mouth for several days after they begin to feed (Popma and Masser, 1999).

2.8.5 Feeding Behavior and Environmental Requirements of Tilapia

According to Popma and Masser, (1999), tilapia ingests a wide variety of natural food organisms including plankton, some aquatic macrophytes, planktonic and benthic aquatic invertebrates, larval fish, detritus, and decomposing organic matter. Tilipia are often considered filter feeders because they can efficiently harvest plankton from the water. However, tilapia does not physically filter the water through gill rakers as efficiently as true filter feeders such as gizzard shad and silver carp. The gills of tilapia secrete a mucous that traps plankton. The plankton-rich mucous, or bolus, is then swallowed. Digestion and assimilation of plant material occurs along the length of the intestine (Popma and Masser 1999). Tilapia are more tolerant than most commonly farmed freshwater fish to high salinity, high water temperature, low dissolved oxygen and high ammonia concentrations.

2.8.6 Water Temperature

Tilapia does not thrive in low temperature but are very tolerant to high temperature. Optimum usually is at 28 to 32 ºC (FAO, 2005). Growth declines with decreasing temperature. The intolerance of tilapia to low temperatures is a serious constraint for commercial culture in temperate regions (Tiechert *et. al.*, 1997).

2.8.7 Dissolved Oxygen Concentration

Tilapia survive routine dawn dissolved oxygen (DO) concentrations of less than 0.3 mg/L, considerably below the tolerance limits for most other cultured fish. In research studies, Nile tilapia grew better when aerators were used to prevent morning DO concentrations from falling below 0.7 to 0.8 mg/L (compared with unaerated control ponds) (Popma and Masser, 1999). Growth was not further improved when additional aeration kept DO concentrations above 2.0 to 2.5 mg/L. Although tilapia can survive acute low DO concentrations for several hours, tilapia ponds should be managed to maintain DO concentrations above 1 mg/L. Metabolism, growth and, possibly disease resistance are depressed when DO falls below this level for prolonged periods (Popma and Masser, 1999).

2.8.8 pH

In general, tilapia can survive in pH ranging from 5 to 10 but do best in a pH range of 6 to 9. The pH of pond water may increase above 9 during periods when photosynthesis is high (Tiechert *et. al.*,1997).

2.8.9 Ammonia

Massive mortality of tilapia occurs within a few days when fish are suddenly transferred to water with unionized ammonia concentrations greater than 2 mg/L. However, when gradually acclimated to sub-lethal levels, approximately half the fish will survive 3 or 4 days at unionized ammonia concentrations as high as 3 mg/L. Prolonged exposure (several weeks) to un-ionized ammonia concentration greater than 1 mg/L causes losses, especially among fry and juveniles in water with low DO concentration. Un-ionized ammonia begins to depress food consumption at concentrations as low as 0.08 mg/L (Popma and Masser, 1999).

2.8.10 Nitrite

Nitrite is toxic to many fish because it makes the hemoglobin less capable of transporting oxygen. Tilapia are more tolerant of nitrite than many cultured freshwater fish. When dissolved oxygen concentration was high (6 mg/L) and chloride concentration was low (22 mg/L), the nitrite concentration at which 50 percent of the fish died in 4 days was 89 mg/L as nitrite. In general, for freshwater culture the nitrite concentration should be kept below 27 mg/L as nitrite. As a safeguard against nitrite toxicity in recirculating systems, chloride concentrations are often maintained at 100 to 150 mg/L chloride (Popma and Masser 1999).

2.8.11 Diseases

Tilapia is more resistant to viral, bacterial and parasitic diseases than other commonly cultured fish, especially at optimum temperatures for growth. Lymphocystis, columnaris, whirling disease, and hemorrhagic septicemia may cause high mortality, but these problems occur most frequently at water temperatures below 68°C caused by the protozoan Ichthyopthirius multifiliis, can cause serious losses of fry and juveniles in intensive recirculating systems. External protozoans such as Trichodina and Epistylis also may reach epidemic densities on stressed fry in intensive culture. In recent years the bacterial infection Steptococcusinae has caused heavy losses, primarily in recirculating and intensive flow-through systems (Popma and Masser, 1999).

2.8.12 Sex Reversal in Tilapia

According to Varadaraj & Pandian (1987**),** Nile tilapia, *Oreochromis niloticus* is among leading farmed species around the world. In addition to the high growth rate of Nile tilapia, it is also resistant to considerable levels of adverse environmental and management condition**.** Introductions of this species in many Asian and some Pacific Island countries started in the 1950s. Tilapia farming is expanding world-wide in both developed and developing countries because it can be cultured under very basic conditions and so is ideal for rural subsistence farming (Varadaraj & Pandian (1987). A report by Flimlin *et. al.* (2008) shows that tilapia culture requires minimal management and energy inputs. These fish have high reproductive and growth rates, relatively disease free and hardy in nature.

A major drawback in the culture of tilapias is their ability to mature early at 2-3months of age and breed frequently (every month at most). These characteristics cause the over-population of the stocked tilapia in ponds and the stunted growth of the fish. Moreover, with mixed-sex tilapia stocks, the sizes of the harvested fish vary from small to large because of the difference in the growth of the fast-growing males compared to the females (Macintosh, 2000). To solve these challenges, all-male production was introduced through a technique called artificial sex reversal. According to Macintosh (2000), artificial sex reversal is the process by which the physical sex direction (male or female) can be manipulated through the feeding of synthetic sex hormones (e.g., methyl estosterone) prior to and during the “sexless stage” of the fry. He again explained that, sex reversal of tilapia is now applied worldwide including Ghana. Sex reversal of newly hatched tilapia generally is accomplished via oral administration of 17-methyltestosterone (MT), which has been incorporated into a starter fish feed at 60 mg MT/kg feed. Example is a thesis by Adel *et al*., (2001) on Sex-Reversal of Nile Tilapia Fry using different doses of 17 α-Methyl

Testosterone at different dietary protein levels. They reported that, a dose of 60mg MT/kg of diets (30% and 40% crude protein) was more efficient in sex reversal, resulting in 96-100% males.

2.9 Water Quality

USGS (2006) defines water quality as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. The addition of various kinds of pollutants and nutrients through the agency sewage, industrial effluents, agricultural runoff etc. into the water bodies brings about a series of changes in the physicochemical and biological characteristics of the water, which has been the subject of several investigations (Mahananda *et. al.,* 2010). Boyd (1998) also defines water quality as all physical, chemical and biological factors that influence the beneficial use of water. He continued by saying that, where aquaculture is concerned, any characteristic of water that affect the survival, reproduction, growth and management of fish or other aquatic creatures in any way is a water quality variable. It is done to determine the suitability of the water body for the intended use.

It is also done to determine the trend in quality of the aquatic environment and how the water quality is affected by the release of contaminant (Exploring The Environment; ETE, 2004). The biological attributes of water quality refer to the number and types of organisms that inhabit a waterway. The poorer the quality of water, the fewer the number and types of organisms that can live in it. The most basic physical attribute of a stream is the path along which it flows. Most streams are classified as "meandering" or S-shaped. Meandering streams have many bends and they are characterized by deep pools of cold water along the outside banks where faster-moving water scours the bank (ETE, 2004).

Natural stream-channel patterns, with their bends and pools, are essential to decreasing flooding as well as providing a suitable habitat for certain aquatic plants and animals. Measurements of a stream's physical attributes can also serve as indicators of some forms of pollution. For example, changes in temperature may indicate the presence of certain effluents, while changes in stream width, depth, and velocity, turbidity, and rock size may indicate dredging in the area. Other commonly measured physical characteristics of a stream are elevation and catchment area, stream order, forest canopy, and total solids (ETE, 2004)

Chemical attributes of water can affect aesthetic qualities (such as how water looks, smells, and tastes), toxicity and whether or not it is safe to use. Assessment of water quality by its chemistry includes measures of many elements and molecules dissolved or suspended in the water. Chemical measures can be used to directly detect pollutants such as lead or mercury and imbalances within the ecosystem. Such imbalances may indicate the presence of certain pollutants. For example, elevated acidity levels may indicate the presence of acid mine drainage. Commonly measured chemical parameters include pH, alkalinity, hardness, nitrates, nitrites and ammonia, phosphates, dissolved oxygen and biochemical oxygen demand (ETE, 2004).

2.9.1 Water Quality Assessment

Chapman (1996) defines water quality assessment as the overall process of evaluating the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses particularly uses which may affect health and the health of aquatic system itself.

2.9. 2 Essential Water Quality Parameters

To be successful with any aquatic environment supporting fish, fish farmers must know how to achieve and maintain a suitable aquatic environment. Fish that are pale in colour and stressed are usually suffering from poor water quality. Symptoms of poor water quality are deviated pH, nitrite, nitrate, low dissolved oxygen levels and fluctuating temperature.

2.9.2.1 Dissolved Oxygen

Boyd (1998) reported that, concentration of dissolved oxygen can fall so low that creatures in ponds die. However, adverse effects of low dissolved oxygen more often are expressed as reduced growth and greater susceptibility to disease. In ponds with chronically low dissolved oxygen concentrations, creatures will eat less and they will not convert food to flesh as efficiently as in ponds with normal dissolved oxygen concentration (Boyd, 1998). Boyd (2002) reported that, Dissolved Oxygen concentration in intensive tilapia culture unit may be quite low at times. He noted that, tilapia are rather tolerant to low dissolved oxygen, and concentrations of 3 to 4mg/l apparently are not extremely harmful to them even with long-term exposure.

The dissolved Oxygen concentration also fluctuates daily in ponds, and water released during the night or early in the morning may be particularly low in this variable. Thus, effluents from tilapia culture may have less than minimum concentrate ion of 5 to 6mg/l DO usually recommended for the protection of aquatic life in natural water bodies according to (Boyd, 2002). Again, a report from Boyd (1998) proved that, feed applied for aquaculture species results in pollution of pond waters by organic and inorganic metabolic wastes. Uneaten feed also decomposes, releasing nutrient into the water. Consequently, phytoplankton becomes abundance and problems with low dissolved oxygen increase as a function of increasing feeding rate; (Boyd, 1998).

2.9.2.2 pH

pH is a measure of whether water is acidic or basic (Boyd,1998). Fish have an average blood pH of 7.4, so pond water with a pH close to this is optimum. An acceptable range would be 6.5 to 9.0. Fish can become stressed in water with a pH ranging from 4.0 to 6.5 and 9.0 to 11.0. Fish growth is limited in water pH less than 6.5, and reproduction ceases and fry can die at pH less than 5.0. Pond water pH fluctuates throughout the day due to photosynthesis and respiration by plants and vertebrates. Typically, pH is highest at dusk and lowest at dawn. This is because night time respiration increases carbon dioxide concentrations that interact with water producing carbonic acid and lowering pH. This can limit the ability of fish blood to carry oxygen (Russell, 2011).

2.9.2.3 Temperature

Boyd (1998) reported that, warm water species grow best at temperatures between 25 and 32 ºC. Water temperatures are in this range year-round at low altitude in the tropics, but they are too low in winter in temperate regions for rapid growth of warm water aquaculture species and their food organism (Boyd, 1998). Water temperature is sensitive to atmospheric temperature. It is influenced by the Sun's energy, water depth, water circulation, pump motor heat and heat from other mechanical devices. Water temperature directly impacts the level of dissolved oxygen retention. According to Stevens (2011), another temperature-related phenomenon is water stratification. This occurs in deeper ponds as increased ambient temperature causes a warm, less dense layer of water to stratify over a cool, dense layer of water. Most of the oxygen is produced in the warm surface layer of water and over time oxygen can be depleted in the cooler layer. These layers may not mix for a long period until a cold front or thunderstorm cools the surface layer allowing the two layers to mix. This is often referred to as "turn-over." The result is a sudden dilution of oxygen and a simultaneously increased demand for oxygen from decaying organic matter. This can cause severe fish kill (Stevens, 2011).

2.9.2.4 Nitrite

Nitrite is an intermediate product of the aerobic nitrification bacterial process. It is very toxic to fish because it oxidizes hemoglobin to methemoglobin in the blood (as carbon monoxide does with human hemoglobin), turning the blood and gills brown and hindering respiration.

2.9.2.5 Ammonia

It was found 0from the below source, that, too much ammonia can cause serious problems in pond management. Fish suffering from ammonia toxicity typically stop eating and become lethargic. Several causes can increase total ammonia nitrogen levels in ponds. If the fish are overfed, uneaten food sinks to the bottom, decays and releases ammonia, increasing the load on the nitrifying bacteria in the pond and filter (Creating a Healthy Environment for Ornamental Fish, 2007/).

2.9.2.6 Turbidity

Resources Information Standards Committee, (1998) reported that, turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. It was further explained that some of these are: Sediments from erosion, Suspended sediments from the bottom, Waste discharge and Algae growth (Resources Information Standards Committee, 1998). High levels of turbidity increase the total available surface area of solids in suspension upon which bacteria can grow. High turbidity reduces light penetration; therefore, it impairs photosynthesis of submerged vegetation and algae. In turn, the reduced plant growth may suppress fish productivity.

2.9.2.7 Total Dissolved Solids

Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in: molecular, ionized or micro-granular, suspended form. According to Boyd (1999), most aquatic ecosystems involving mixed fish fauna can tolerate TDS levels of 1000 mg/. These electrically charged dissolved particles make ordinary natural water a good conductor of electricity. Conversely, pure water has a high electrical resistance, and resistance is frequently used as a measure of its purity. Boyd (1998) stated that, concentration of all dissolved substances in water is the total dissolved solid. Usually concentrations of salinity and total dissolved solids are similar.

2.9.2.8 Phosphorus and Nitrogen

According to Water Quality Standard: WQS (2008), Phosphorus (P) and nitrogen (N) are the primary nutrients that in excessive amounts pollute our lakes, streams, and wetlands. Nitrogen is essential to the production of plant and animal tissue. It is used primarily by plants and animals to synthesize protein. Nitrogen enters the ecosystem in several chemical forms and also occurs in other dissolved or particulate forms, such as tissues of living and dead organisms. Nitrate, a compound that contains nitrogen, can exist in the atmosphere or as a dissolved gas in water, and at elevated levels can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. Common sources of excess nitrate reaching lakes and streams include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dump (Water Quality Standard, 2008).

Phosphorus is a vital nutrient for converting sunlight into usable energy, and essential to cellular growth and reproduction. It is one of the 20 most abundant elements in the solar system, and the 11th most abundant in the earth's crust. Under natural conditions phosphorus is typically scarce in water. In the late 1960s scientists discovered phosphorus contributed by human activity to be a major cause of excessive algae growth and degraded lake water quality.

Phosphorus, as stated by WQS, (2008) occurs in dissolved organic and inorganic forms or attached to sediment particles. Phosphates, the inorganic form, are preferred for plant growth, but other forms can be used when phosphates are unavailable. Phosphorus builds up in the sediments of a lake. When it remains in the sediments it is generally not available for use by algae; however, various chemical and biological processes can allow sediment phosphorus to be released back into the water. For example bottom-feeding rough fish such as carp can stir up bottom sediments, releasing phosphorus back into the water (Water Quality Standards, 2008).

2.9.3 Water Analysis

Water analysis is a highly specialized field and methods for measuring the concentration of almost all possible constituent of water are available. These methods may be found in several standard water analysis manuals. The most widely used of these manuals is the "Standard Methods for the Examination of Water and Wastewater" (Clesceri and Greenburg, 1995). Principal component analysis is another appropriate tool for water quality evaluation and management; a report by Parin *et. al*., (2004). The research was done to investigate the values of all analytical variables which are linked to both causes and effects of eutrophication (feedback effect). It was reported that, none of these values can accurately describe a trophic state alone. To solve this difficulty, they suggested that relationships between analytical variables are able to generate better descriptors than variables themselves. They then concluded that principal component analysis (PCA) using coefficients of linear regression are, by construction, an appropriate tool for this purpose.

2.9.4 Effect of feed on water quality (Physio-chemical parameters)

Effective water management in fish ponds is one of the important factors contributing to the success of fish, reducing the occurrence of fish disease and enhancing fish growth and survival (Abdel *et. al.*, 2005). According to Boyd (2002), the portion of fertilizer or feed not converted to fish tissue in pond culture enters the surrounding water just as it does in other production system. However, in pond, water is retained for a long period and may not be discharged except when ponds are drained. Thus, natural biological processes in ponds may assimilate much of the waste from aquaculture (Gross *et al*., 2000). Boyd (2002) again noted that, ponds that have good water quality assimilate waste better than ponds with impaired water quality. Thus, water quality tends to be poor in ponds that are stocked heavily or fed heavily. From Boyd (2002), the three most likely impacts on water quality are increased loads of nutrients, oxygen demand and suspended solid in water receiving effluent from tilapia culture. Nitrogen and phosphorus are the two main nutrients of most concern because they are responsible for eutrophication. The oxygen and suspended solid result primarily from uneaten feed, faeces, plankton and mineral particle (Boyd and Gross, 1999).

2.9.5 Aquaculture Effluent Use

According to Emerson (1999), unlike mollusc farming, many species of fish depend on a diet of artificial feed in pellet form. This feed is broadcast onto the surface of the water and is consumed by the fish as it settles through the water column (Emerson, 1999). Because not all the feed is eaten, a great deal of feed can reach the bottom where it is eaten by the benthos or decomposed by microorganisms. This alteration of the natural food web structure can significantly impact the local environment (Emerson, 1999). Many studies have shown that overfeeding in fish farms as the cause of changes in benthic community structure because a high food supply may favour some organisms over others. Environmental factors in fish farming effluent are very important elements to look at. For any successful fish farming system, it is necessary to look at the chemical balance in the water to give enough oxygen for the change in weight and length of the fish and the organismic balance to produce an optimal supply of natural food at all level. This will help reduce the build-up of toxic metabolic products (Pescod, 2004).

2.10 Impact of aquaculture on environment

FAO (2012), reported that aquaculture is among the other sectors that use natural resources which interact with the environment. However, aquaculture is increasingly confronted with issues of environmental protection. It is now generally accepted that increasing efficiency in resource use and minimizing adverse environmental interactions will be major goals for the next decades, which will require commitment and willingness to collaborate by all those involved, either directly or indirectly, in aquaculture development (FAO, 2012). Major environmental impacts of aquaculture have been associated mainly with high-input high-output intensive systems (e.g. culture of salmonids in raceways and cages) the effects of which included discharge of suspended solids, and nutrient and organic enrichment of recipient waters resulting in build-up of anoxic sediments, changes in benthic communities and the eutrophication of lakes (FAO, 2012).

According to Umanah (2008), many of the aquaculture farms operate without a negative impact on the environment. In fact, catfish, tilapia, and freshwater carp can convert harmful organic wastes into edible fish meat. However, the farming of shrimp and salmon has been found to have a negative impact on the environment. For example, when the cages are crowded, uneaten feed, fish wastes and antibiotics are released from the cages. As a source of nutrient pollution, these wastes create high levels of nutrients that increase the growth of phytoplankton and algae. The eventual degradation of algae drastically reduces the levels of oxygen in the water, which will kill fish or other organisms. Subsequently, wild fish suffer from poor water quality, the loss of bottom habitat, and the outbreaks of disease (Umanah, 2008).

Biological pollution is another environmental problem related to aquaculture because ecosystems are being altered and biodiversity is being reduced. For instance, aquaculture can be the cause of the introduction of non-native species from one area to another (FAO, 2008). The challenge for aquaculture is to develop a system that uses resources efficiently, minimizes the release of untreated wastes, and enhances the biodiversity of the surrounding area. Once this challenge is met, aquaculture will truly be a responsible, sustainable industry (FAO, 2008).

2.11 Pond Preparation

According to EPA (2008), the bottom soil, in any earthen pond culture system, play a major role in pond yield. High organic matter content in neutral soil often promotes higher primary productivity and hence higher fish yield. Fish yield in pond can also be affected by the presence of predators, deteriorating water quality and improper pond management. Hence, pond preparation is a first step towards ensuring a better pond production. Report by Boyd (1998) shows that, Organic fertilizers serve as food for zooplankton and in some types of aquaculture, use of organic fertilizers in pond preparation is desirable to encourage the rapid development of zooplankton blooms to serve as food for young fish or crustacean. Plant or animal meals are better organic fertilizers than animal manures. Usually, applications of 25 to 50 kilograms per hectare of plant meals-for example, soybean meal alfalfa leaf meal, cottonseed meal, rice bran, etc. Or fish meal-at four or five day intervals can quickly establish zooplankton bloom. Usually meals are applied in conjunction with chemical fertilizers.

2.12 Liming

According to Boyd (1998), liming is beneficial to ponds with pH less than 6 or in ponds with `low total alkalinity. In most types of aquaculture, a total alkalinity of 20 milligrams per liter is adequate, but in tilapia, channel catfish, or crustacean ponds, a total alkalinity of 50 milligrams per liter or more is desirable. Liming materials are used to neutralize acidity and increase pH of acidic soil and waters (Boyd, 1998). The three most common liming materials are agricultural limestone (pulverized calcium carbonate or dolomite), hydrated lime (calcium hydroxide) and quick lime (calcium oxide). The report again shows that, the two sources of acidity in natural water are strong acids, usually sulfuric acid, and carbon dioxide. Water with pH below 4.5 contains strong acid, while at higher pH values, acidity result from carbon dioxide. Boyd (1998), again reported that, all three liming materials have the same reaction in water. However, calcium oxide and calcium hydroxide can cause pH to increase to a level toxic to fish or other aquatic organisms. Both materials are hazardous to humans because of their caustic proper ties .Thus, agricultural limestone, which is neither hazardous to aquatic organisms nor humans, is the best liming material for aquaculture.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The experiment was conducted at two sites; Oseibros farm at Kubease, Ashanti Region (site one), 25 km from Kumasi on the Kumasi-Accra road and Sefwi Asawinso (site two) in the Western Region. These areas were selected because the study was to cover at least two regions in Ghana which are into fish farming. The experiment started in March 2011 and ended in October 2011. The criteria for farm selection were as follows:

- Number of ponds in the farm
- Status of in production (active or passive)
- Farmer's perception about research
- Ability of the farmer to influence others
- Farmer's experience on the field.

Four ponds were selected from each of the farms. Pond sizes at site one were (NWL: 375 m^2, OWL: 375 m^2, OWR: 500 m^2, NWR: 500 m^2) and at site two the pond sizes were (NWR: 800 m^2, OWR: 800 m^2, NWL: 300m^2 and OWL: 300 m^2)

Figure: 3.1 Arial view of the study site

Plate 1: Study ponds in Kubease in Ashanti Region

Plate 2: Study ponds in Sefwi-Asawinso in Western Region.

3.2Materials

All-male tilapia fingerlings (5g) were obtained from Datastreams Farms Limited a fingerling producer at Akuse , Eastern Region, and stocked at 3 fish m^{-2} in all the ponds. Seine net and castnet for sampling were obtained from the Ministry of Fisheries, Kumasi. Lime for pond preparation was purchased from the Kumasi Central Market.

3.3 Experimental Procedure

3.3.1 Pond preparation

Pond preparation was done based on the recommendations of the EPA (2008). The inlet and outlet of all the ponds were screened with 12mm-wire mesh to prevent the entry of wild fish and escapees from the pond. The bottom of the ponds were limed with hydrated lime at the rate of 10 kg / 100 m^2 to kill unwanted fish and improve the pH. The ponds were filled with water after liming and fertilized with poultry manure to increase natural food abundance. Two water treatments (new and re-use) and two feed (formulated and farm-made) were run on each farm. The feed and water treatments were: new water and farm-made feed (NWL), (new water and formulated feed (NWR), re-use water and farm-made feed (OWL), and re-use water and formulated feed (OWR). The new water ponds (NWR and NWL) at each site were comprehensively prepared by draining, weeding, liming before filling with fresh water or water in which no fish has been cultured. The other two ponds were not prepared, but were filled with old or re-used water i.e. water which has been used to culture fish previously.

3.3.2 Fingerlings Transportation and Stocking

Fingerlings were transported in polythene (plate 3) bags with oxygen over 8 hours and stocked immediately.

Plate 3: Packaging of fingerlings prior to transportation to study site

The poly bag containing fingerlings was put in the receiving pond for some few minutes to allow for equal temperature between the water in the pond and the water in the poly bag. When the poly bag was opened, some of the water from the pond was allowed into the bag with fish before allowing the fingerlings to swim gently into the pond water (plate 4).

Plate 4: Pond being stocked with fingerlings

3.3.3 Cultural Practices

The main cultural practices done were feeding, manuring and weeding. According to Marty (2001), feeding rates will vary with fish size and water temperature. The appropriate amount of feed is measured as a percent of the average body weight. As the fish weight increases, the percent body weight fed decreases. For the formulated feed, feeding was done twice a day at a body weight of 6% for the first three months and then reduced to 3% in the fourth month, reduced again to 2.5% in the fifth mouth and 2% in the sixth month. The farm-made feed was calculated base on 15% body weight for the first three months and reduced to 9% for the last 3 months. The table below shows the feeding chart used for feed calculation.

Table 3.1: Daily feeding allowances for different sizes of tilapias at 28 °C

Size of fish (gram)	Amount of daily feed (% of fish weight)
0-1	30-10
1-5	10-6
5-20	6-4
20-100	4-3
Larger than 100	3-1.5

Source: National Research Council (2010)

3.4 Experimental Design and Layout

The experimental design used was Randomized complete block design. The experiment was done in two blocks and each block contained four plots. Two of these plots (OWR and NWR) were fed with formulated feed (Ranaan) and the other two (OWL and NWL) were fed with farm-made feed which consisted of rice bran and groundnut husk mixture in ratio of 1: 2.

Table 3.2: The experimental layout of plot

TREATMENT	BLOCK 1	BLOCK 2
P 1	OWR	NWR
P 2	NWR	OWL
P 3	OWL	NWL
P 4	NWL	OWR

The treatments were re-use water, fresh water, farm-made feed and formulated feed (Ranaan). The combinations were as follows:

NWL: (Fresh Water and Farm-made feed control)

OWL: (Re-Use Water and Farm-made Feed)

OWR: (Re-Use Water and Formulated Feed)

NWR: (Fresh Water and Formulated Feed)

3.5 Sampling and Sample Parameters

Fish were sampled every two weeks and measured by taking a sample of twenty fish. It was done by seining the pond with seine net and the weight and Standard length were determined using measuring scale and measuring board respectively. The growth parameters measured were as follows:

- Weight gain = $W_2 - W_1$; Where W_1 and W_2 are the initial and final fish weight,
- Specific Growth Rate (SGR) = 100 ($\log W_2 - \log W_1$) / T

  where W_1 and W_2 are the initial and final fish weight respectively and T the number of days in the experiment
- Daily weight gain (DWG) = weight gain /time (days).

The following water quality parameters; pH, dissolved oxygen concentration (DO), total dissolve solid (TDS), temperature and conductivity were measured with a Hanna 9828 multi-parameter probe. Water sample collected 30cm above the surfaces and 30cm from the bottom of the pond were sent to the laboratory for the determination of phosphorus and total dissolved nitrogen.

Plate 5: Measurement of some growth parameter of harvested fish (length)

Plate 6: Measurement of some growth parameter of harvested fish (weight)

Plate 7: Measurement of water quality (pH, DO, TDS, Temperature and conductivity)

3.6 Data Collection and Analysis

Data was collected every two weeks over a six-month period. The growth performance data collected for the treatments were subjected the analysis of variance (ANOVA) by Graph-Pad Prism. The Duncan's multiple range test was used to compare differences between individual means when significant (P < 0.05)

CHAPTER: FOUR

4.0 RESULTS

4.1 Growth Performance (length and weight) of Nile tilapia

Figures 4.1 and 4.2 show that there was a rapid increase in mean length and weight for all the treatments in the first two weeks, however, the growth rate fluctuated from week three to week five and except for the formulated diet ponds (OWR and NWR) which showed a consistent increase in mean weight as indicated by figure 4.1 and 4.2. The ANOVA indicated differences in both growth mean length and mean weight and were significant at $p<0.05$. Growth performance at Kubease was similar as the trend observed at Asawinso (figure 4.3). There was a steady increasing in length and weight of the fish from week one up to week ten. However, each pond had a decrease in growth (length and weight) in week eleven. There were significant differences in mean length and weight in the growth of tilapia under various treatments at $p<0.05$.

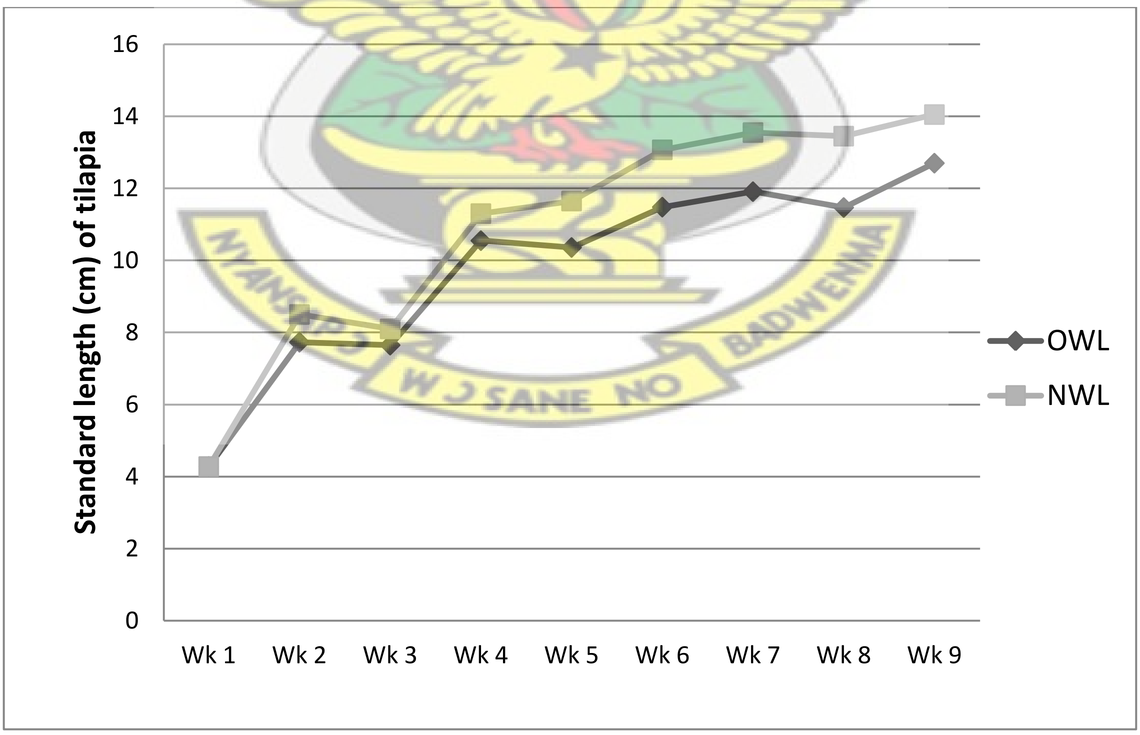

Figure 4.1: Effect of fresh and re-use water on growth (length cm) of Nile tilapia fed with farm-made feed at Asawinso

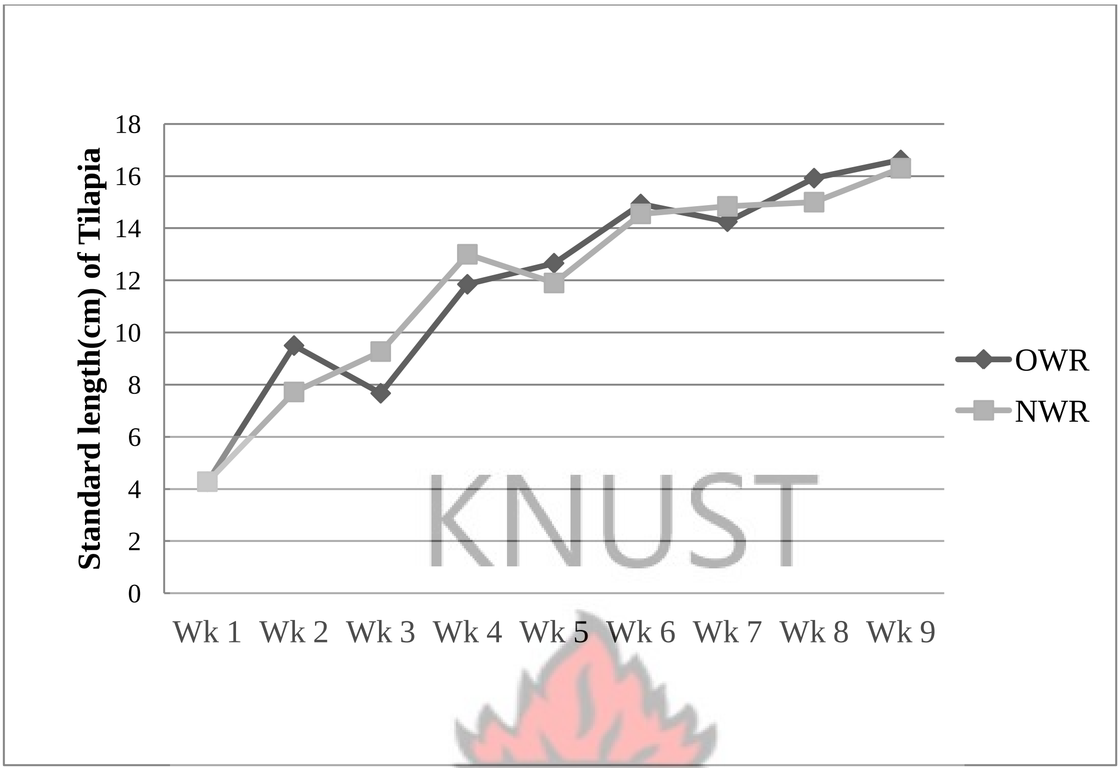

Figure 4.2: Effect of fresh and re-use water on growth (length cm) of Nile tilapia and fed with ranaan at Asawinso

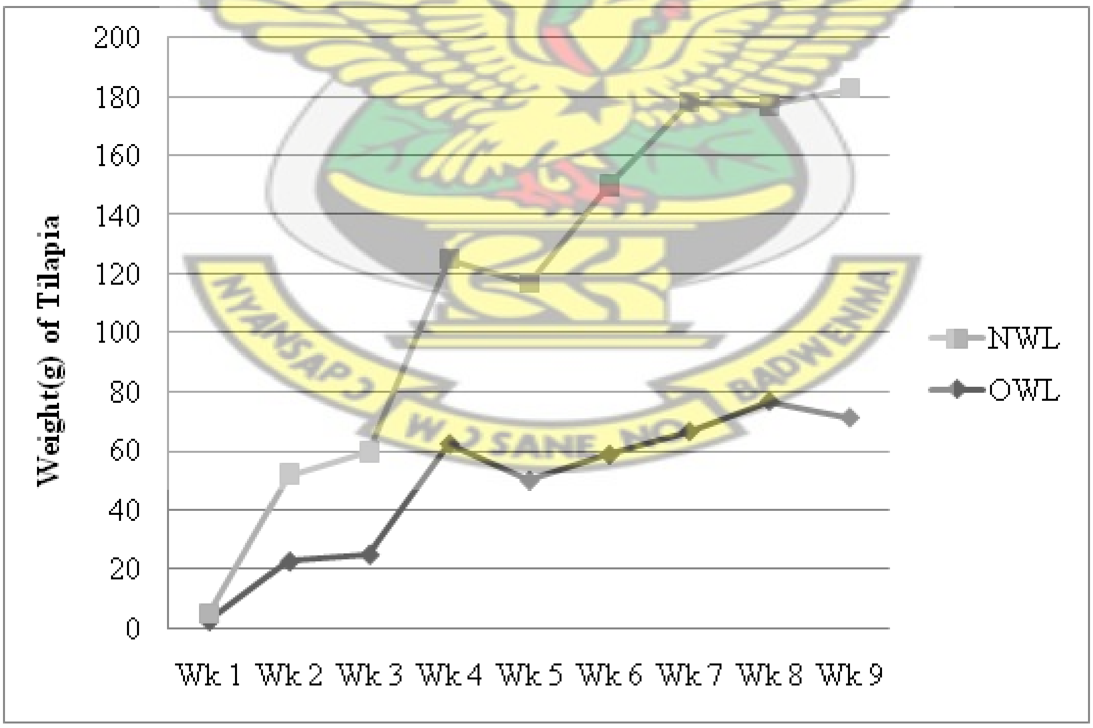

Figure 4.3: Changes in body weight (g) of tilapia cultured in fresh and re-use water and fed with Farm-made feed at Asawinso

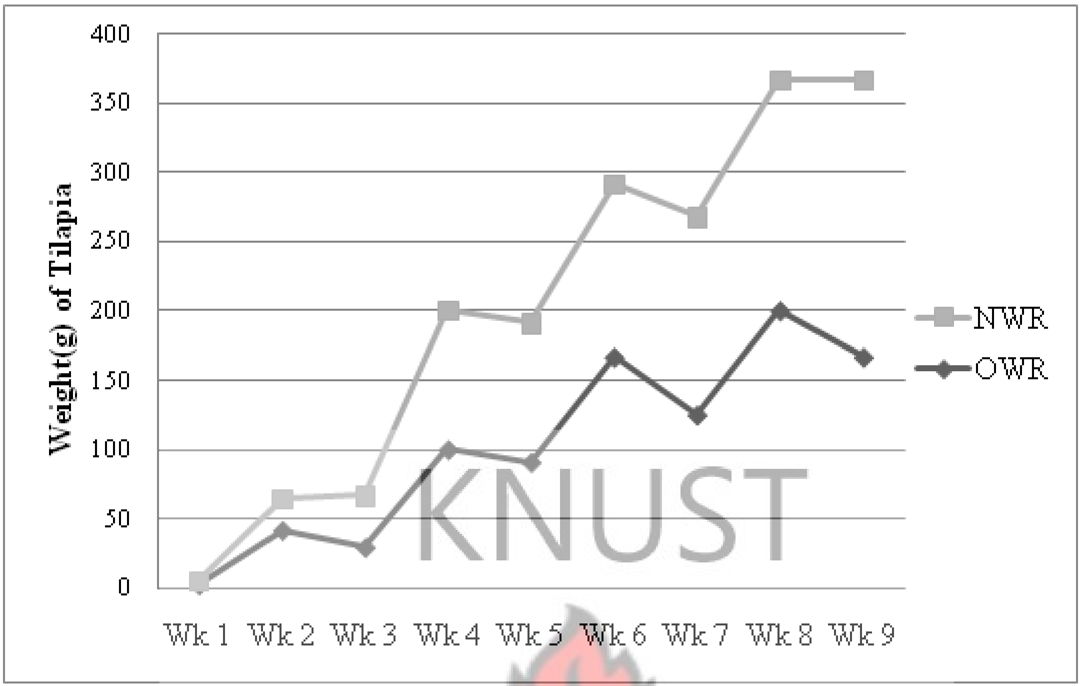

Figure 4.4: Changes in body weight (g) of tilapia cultured in fresh and re-use water and fed with Ranaan at Asawinso

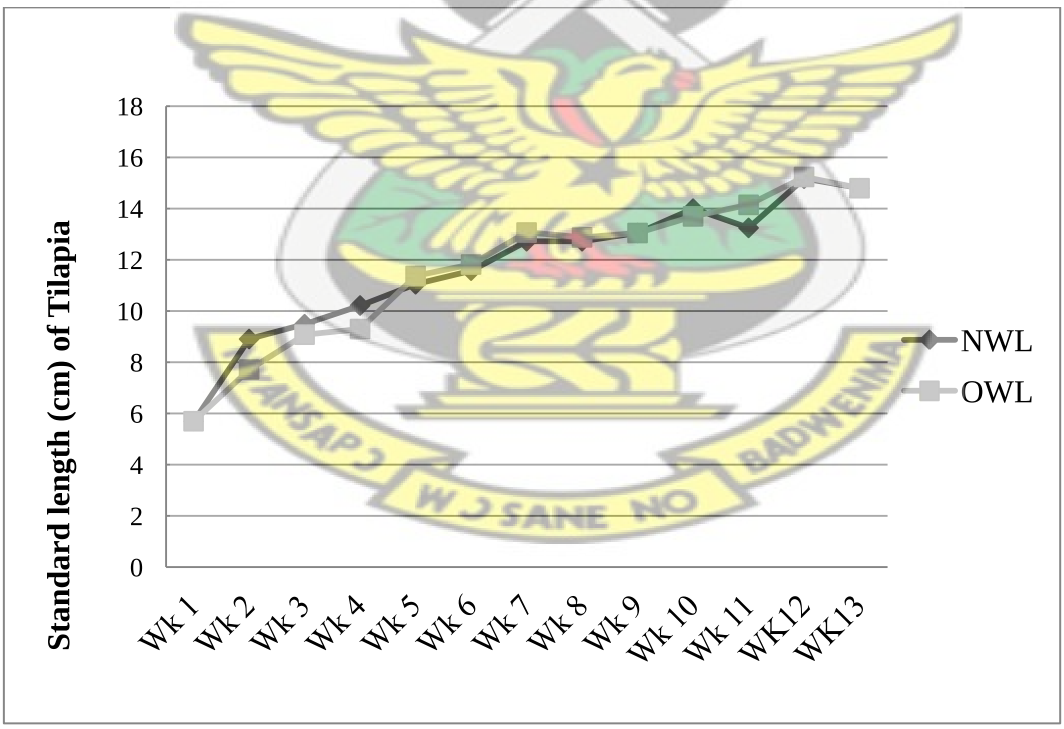

Figure 4.5: Effect of fresh and re-use water on growth (length cm) of Nile tilapia fed with farm-made feed at Kubease

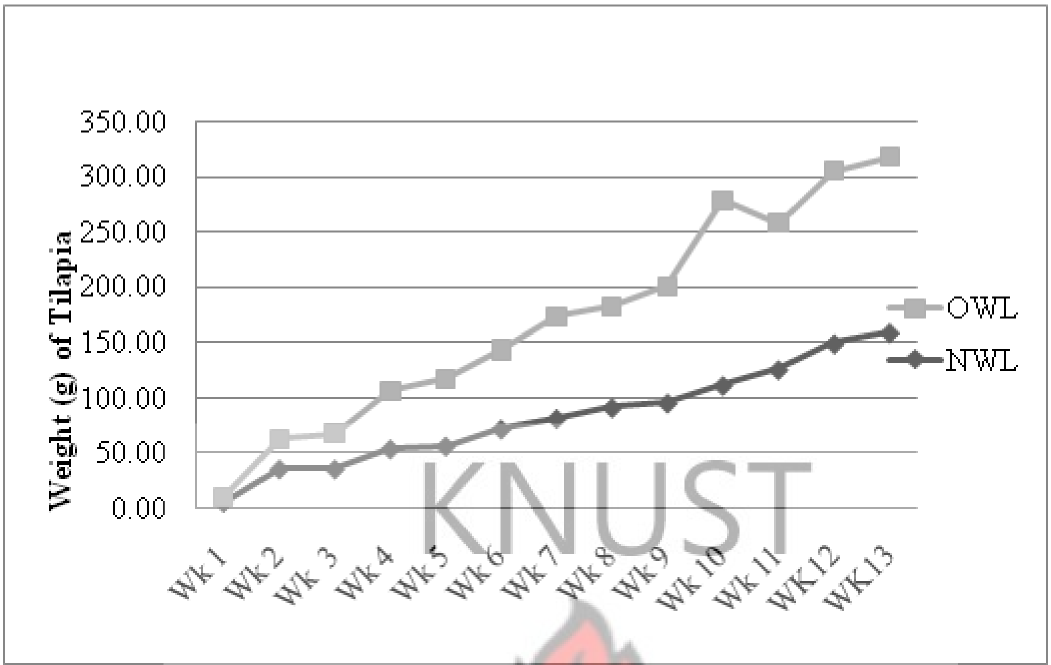

Figure 4.6: Effect of fresh and re-use water on growth (weight in g) of Nile tilapia fed with farm-made feed at Kubease

4.2 Growth indices

The growth indices; weight gain (WG), specific growth rate (SGR) and Daily weight gain (DWG) for Nile tilapia used in the study are presented (Tables 4.7 and 4.8). At Asawinso, fish cultured in fresh water (NWR) recorded the highest weight gain of (197.55g), specific growth rate (1.25% day^{-1}) and daily weight gain (1.11g/day), followed by tilapia cultured in re-use water (OWR), (Table 4.7). It was followed by fish cultured in fresh water (NWL) and that of those cultured in re-use water (OWL) recorded the lowest values (NWR> OWR > NWL > OWL).

Table 4.1: Growth performance of Nile tilapia *Oreochromis niloticus* at (Asawinso)

Treatments	Initial growth (g)	Final growth (g)	weight gain(g)	S.growth rate %	DWG (g)
OWR	2.45	166.67	164.22	1.20	0.91
OWL	2.45	71.42	68.97	0.96	0.38
NWR	2.45	200	197.55	1.25	1.11
NWL	2.45	111.11	108.66	1.08	0.60

In comparison, fish cultured in re-use water (OWL) at Kubease, recorded the highest value of weight gain (150.73g), specific growth rate (0.81% day^{-1}), and daily weight gain (0.84g/day). It was followed by Nile tilapia reared in fresh water (NWL) and those reared in re-use water (OWR) recorded the lowest value (OWL>NWL>OWR) (Table 4.8).

Table 4.2: Growth performance of Nile tilapia (*Oreochromis niloticus*) at Kubease

Treatments	initial growth (g)	Final growth(g)	weight gain(g)	S.growth rate %	DWG (g)
OWR	5	126.40	121.40	0.76	0.67
OWL	5	155.73	150.73	0.81	0.84
NWL	5	148.67	143.67	0.80	0.80

4.3 Physicochemical Parameters of the Different Pond Treatments

At Kubease, pH values were similar and ranged from 7.47 to 7.61 in both farm-made fed ponds (NWL and OWL) and Raanan feed (NWR) pond. Mean temperature in the four treatments ranged from 28.1°C to 28.7°C. Additionally, Mean Total Dissolved Solids (TDS) values in the ponds were relatively similar, and ranged between 130.6 mgl^{-1} and 168.4 mgl^{-1} recorded in farm-made feed treatment (NWL) and formulated feed treatment (OWR) respectively. Dissolved Oxygen (DO) concentrations were highly variable over the sampling period. Mean DO concentrations were very low and ranged from 2.33 mgl^{-1} to 4.73 mgl^{-1}. The DO levels in the four treatment ponds exhibited wide fluctuations and did not appear to follow any particular trend. The lowest DO reading of 1.01mgl^{-1} was recorded in May (OWR) and the highest reading of 9.73mgl^{-1} recorded in July (NWR).

Furthermore, conductivity levels were also highly variable in the treatment ponds over the sampling period with the lowest and highest values of 198 and 409 mgl^{-1}recorded in the farm-made feed treatment (OWL). Mean conductivity in the ponds at Kubease ranged from 270 mgl^{-1} to 330 mgl^{-1} during the study period.

In comparison, the mean pH values at Asawinso were similar to the levels recorded at Kubease. Mean pH levels over the sampling period ranged from 7.00 in the NWL treatment pond to 7.44 in the OWL treatment pond. The mean temperature levels ranged from 27.9°C to 28.4°C over the study period. However, the mean TDS values at Asawinso were lower than that recorded at Kubease. The TDS values ranged from a lowest value of 35.38 mgl^{-1} in OWR treatment pond to a highest value of 57.81mgl^{-1} in the OWL treatment ponds. The lowest TDS reading of 27 $mgl^{-1}$was recorded in the OWR pond in October and the highest reading of 79 $mgl^{-1}$was recorded in the OWL treatment pond in September.

Mean dissolved oxygen concentrations were similar to the concentrations recorded in the Kubease treatment ponds.

Moreover, the lowest mean DO value of 2.82 $mgl^{-1}$was recorded in the OWL pond and the highest value of 3.86 $mgl^{-1}$was recorded in the NWR pond. The fluctuations in the DO concentrations were over a wide range and exhibited no particular pattern. This irregular pattern in the fluctuations in the DO concentrations was evident in all the four treatment ponds. The lowest DO concentration recorded at Asawinso was 1.20mgl^{-1} and the highest concentration was 5.59mgl^{-1}. Mean conductivity level at Asawinso was lower as compared to the mean values recorded at Kubease. The highest conductivity value of 113 mgl^{-1} was recorded in OWL treatment pond and the lowest value of 70.13mgl^{-1} was recorded in the OWR treatment pond

Table 4.3: Physicochemical water parameters of the different pond treatments at Kubease and Asawinso

Location/ Treatment	pH (Mean ± SD) Range	Temp (Mean ± SD) Range	TDS (Mean ± SD) Range	DO (Mean ± SD) Range	Conductivity (Mean ± SD) Range
Kubease					
OWL	7.60	28.49 ± 1.09	148.2 ± 27.06	2.65 ± 1.28	294.90 ± 59.93
	4.40 – 9.17	26.49 – 30.02	105 – 204	1.01 – 5.20	198 – 409
OWR	7.47	28.13 ± 1.33	168.4 ± 18.26	2.33 ± 1.09	333.70 ± 33.73
	4.17 – 8.45	26.44 – 30.26	137 – 193	1.26 – 4.73	275 - 386
NW	7.61	28.71 ± 1.17	130.6 ± 11.2	3.52 ± 2.23	270.00 ± 28.22
	4.32 – 8.90	26.33 – 30.36	117 – 159	1.22 – 8.20	233 – 318
NWR	7.61	28.40 ± 1.40	145.7 ± 12.63	4.73 ± 3.47	293.0 ± 23.75
	4.50 – 8.90	26.26 – 30.22	117 – 158	1.27 – 9.73	233 – 316

Asawinso

OWL	7.44	27.89 ± 1.96	57.81 ± 16.71	2.82 ± 0.82	113.00 ± 13.58
	6.68 – 9.94	25.21 – 30.70	32 – 79	2.16 – 4.61	65 – 157
OWR	7.03	28.08 ± 1.19	35.38 ± 7.00	2.94 ± 1.2	70.13 ± 13.58
	6.34 – 7.85	26.38 – 30.49	27.00 – 46.00	1.24 – 5.38	55 – 91
NWL	7.00	28.44 ± 1.06	43.38 ± 9.10	3.44 ± 1.11	81.50 ± 14.33
	6.59 – 7.41	26.33 – 30.17	32 – 58	2.16 – 5.59	65 – 102
NWR	7.40	28.13 ± 1.65	57.13 ± 14.06	3.86 ±0.28	109.5 ± 26.50
	7.07 – 7.76	26.18 – 30.69	41 – 77		

OWL: Old Water Local; OWR: Old Water Raanan; NWL: New Water Local; NWR: New Water Raanan

Table 4.4: Effect of feed on some water quality parameters at Kubease and Asawinso.

Sample	PO_4 (mg/L)	Total PO_4^{3-} (mg/L)	TSS (mg/L)	SS (mgl)	BOD (mg/L)	DIN (mg/L)	TDN (mg/L)	DON (mg/L)
Kubease								
1K-OWL-S	1.85	2.80	52	0.1	27	0.55	0.76	0.27
2K-NWR-B	2.80	3.30	90	0.5	23	0.60	0.83	0.23
3K-OWL-B	1.3	3.00	55	0.2	30	0.53	0.70	0.17
4K-OWR-S	3.90	5.20	66	0.4	30	0.44	0.57	0.13
5K-NWR-S	2.70	5.00	30	0.4	23	0.51	0.57	0.06
6K-OWL-B	3.25	5.40	84	0.7	41	0.32	0.67	0.35
7K-NWL-B	0.78	3.00	150	0.3	56	0.48	0.65	0.17
8K-NWL-S	2.20	4.60	65	-0.1	25	0.45	0.57	0.12
Asanwinso								
2A-OWR-B	0.34	1.90	245	1.9	32	0.58	0.81	0.23
3A-NWR-B	0.95	2.30	155	1.3	53	0.55	0.67	0.12
4A-NWR-S	0.62	2.10	105	1.0	42	0.51	0.61	0.10
5A-OWL-B	2.30	5.40	775	1.7	19	0.40	0.51	0.11
6A-OWL-S	2.00	2.50	90	0.1	15	0.49	0.56	0.07
7A-NWR-S	0.64	1.40	235	0.7	26	0.18	0.21	0.03
8K-NWL-B	0.60	0.72	155	3.5	10	0.38	0.51	0.13
8A-NWL-S	0.41	0.98	35	0.2	12	0.29	0.42	0.13

CHAPTER FIVE

DISCUSSIONS

As shown in Figure 4.1, there was a steady increase in growth of the fish from week one to week eight for the treatments (OWR, OWL, and NWL). However, a decrease in growth was recorded in week nine for all the treatments except NWR which had earlier in week seven had a slowed growth similar to that reported by Wootton (1992) who stated that the rate of growth of fish declines as the fish get larger. There were significant differences in growth (mean length and weight) for the fish under the four treatments ($p < 0.05$) (Appendices 1-6). However, based on growth indices, ponds that were filled with fresh water and fed with formulated feed had the best final weight among all the treatments (Tables 4.1 and 4.2).

5.1 Effect of water (fresh and re-use) on growth of fish under farm-made feed

Results from the ponds that received the farm- made feed indicated that, growth was not significant, between ponds that were filled with re-use (OWL: 155.73g) than that containing fresh water (148.67g). This result is supported by the findings of San and Preston (2003) who studied the growth rate of Tilapia (*Oreochromis niloticus*) in a pond fertilized with effluents from biodigesters with 30 days retention time (0.133g $N/m^2/day$). Results on weight gain for the two treatments were higher than the result reported by Nhi and Preston (2011) when they looked at the growth and economics of integrated culture of Tilapia (*Oreochomis niloticus*) with density of 3 $/m^2$(138.36g) and 5 $/m^2$(100.2g). Similarly, Shoko *et. al.*,(2011) reported on growth performance of (O*reochromis niloticus)* and kales *brassica oleracea* cultured under vegetable-fish culture integration and their result stated that, fish cultured in a pond fertilized with chicken manure (Treated fish pond*)* under an integrated system exhibited higher growth rates than those in non-integrated systems. However, their result on final weight of fish (102.55 ± 0.89 g) for the treated fish pond was lower than the final weight for the present study (Table 4.2). Rosati *et. al.*,(1997) found that the individual weights of Nile tilapia culture for 239 days ranged from 600 g to 700 g. This finding was far contradictory to the result of this present study. However, it could be that their environmental conditions were far better than the conditions in this present study and the stocking density was also lower, even though, not stated. It could also be attributed to the number of days fish was cultured (239days), as this study was done for 180 days.

The specific growth rate recorded in this study (0.81%/day in OWL and 0.80%/day in NWL) was similar to the result by Diana, (2010) who studied the effect of fertilization on the growth and production of Nile tilapia cultured in rain-fed ponds (0.86 %/day), but was far lower than the specific growth rate recorded by Nhi and Preston (2011) and Shoko *et. al.*,(2011) (2.67%/day and1.13 ± 0.43%/day respectively). Conversely, it was not in agreement with the findings of San *et. al.*, (2008) where effluent was used to culture tilapia in a poly-culture system in which the fish were fed with duckweed. Again, data was close to the findings of Graaf, (2004) whose growth rate was 0.78± 0.03 when Tilapia was cultured in a polyculture system. Furthermore, there were no differences in the daily weight gained between the treatments (Table 4.2) which is in agreement with the findings of **(**Mandal, 2001; Sophin and Preston 2001; San *et. al.*, 2008). However, they were lower than those found by Nhi and Preston (2011) (1.32g/day, 0.95g/day). On the other hand, daily weight in this study was higher than that reported by Chhay *et. al.*,(2010). They recorded daily weight gain of 0.50g/day when Tilapia was fed with sun-dried cassava leaves. They concluded that growth in weight was not different when Tilapia were fed with fresh or dried cassava leaves together with rice bran or rice bran mixed with cassava root meal.

Although, the water was not analyzed for nutrients and natural food availability, using the greenness of the water as an indication of natural food availability, in general, re-use water had a better effect on growth performance than fresh water. This could be attributed to the fact that re-use water contained more nutrients and natural food which enhanced the growth of the fish compared with fresh water which was low in nutrients (Wootton, 1992*)*. It could also be that, almost all the environmental requirements needed by tilapia for its growth were provided by re-use water (Popma and Masser, 1999). The low growth recorded in fresh water (NWL) was due to the unexpected reproduction, even though all- male tilapia was used. Result of the study was also in agreement with Wootton (1992), who reported that, the presence of other fishes in a fish's environment can reduce growth rates through interference or exploitation and competition. It can be concluded that the condition that affected fish growth from ponds fed with farm- made feed was mainly biological (Moyle and Joseph 1988;Woiwode 1991;Mallya, 2007;Brogowski*et. al.*, 2004 and Boyd, 1998).

5.2 Effect of water (Fresh and reuse) on growth of fish under formulated feed

Results from ponds fed with the formulated feed were different from fish that received the farm-made feed. Fish cultured in fresh water (NWR) were larger than those grown in re-use water (Table 4.1). Mean weight of fish grown in re-use (OWR) was lower; 164.22 ± 0.11g, compared to fish grown in fresh water (NWR)

197.6 ± 0.13g). The result of San *et. al.*, (2008) when tilapia was cultured in reclaimed water (sewage water) and fed with water spinach (83.8g) and duckweed (101g) supplement was lower than the result of this study. However, it was also higher than those recorded by Nhi and Preston (2011). Again, results from the fresh water pond were higher than that recorded by Paz (2004) when he cultured tilapia in a clear-water recirculation systems (83g).

The results obtained for tilapia cultured in re-use water (OWR) were far lower when the similar trial was done in green water recirculation systems (453g) (Paz, 2004). This could be attributed to the better water quality and more importantly the additional nutrition the fish derived from feeding on the natural food in the green water. Additionally, specific growth rate (OWR) for this study was higher than that recorded by Shoaib (2007) when the effect of fertilisation of fish pond with poultry manure on the growth performance of *Labeo Rohita* was studied. It was also lower than that reported by Abdelhamid *et. al*., (2010) on effect of fertilisation and feeding regimen on growth performance of mono-sex and mixed-sex nile tilapia reared in earthen ponds (2.32%/ day).

Furthermore, daily weight gained reported in this study was similar to that reported by (Nhi and Preston, 2011), but was higher than those reported by San and Preston, (2003) who reported on the effect of effluent from biodigesters with 10 or 30 days retention times on growth and length/ weight ratio of Tilapia (0.27g and 0.43g). A similar result was reported (Paz, 2004) where growth of four tilapia species were determined in recirculation systems. Similarly, it was different from the study by Sorphea *et. al.*,(2010). The increased in growth performance can be attributed to low turbidity in the water (Bash *et. al.*, 2001). This allowed more light to penetrate the water to facilitate photosynthesis by algae.

On the other hand, the low value recorded in re-use water pond (OWR = 164.2g) was due to competition for feed and space owing to reproduction in these ponds. This reproduction occurred because re-use water ponds could not be completed drained and were not limed. In effect, some of the old fish left in the water started to reproduce and their fingerlings competed with the stocked fish for feed. Research has shown that a species in which the adults and young both eat virtually the same aquatic invertebrates and are not cannibalistic, become stunted when the population size reaches a particular size. Additionally, the low growth could be caused by low dissolved oxygen (Russell, 2011). Owing to the high density of fish, the pond could not provide adequate oxygen for growth resulting in poor growth (Mallya, 2007). The results indicated that, culturing fish in fresh water and feeding it with formulated feed is the best, nevertheless, in the absence of fresh water, re-use water could be used provided the pond is completely drained and limed to eliminate tilapia eggs and fry.

5.3 Feed effect on growth

Effect of feed on growth performance was quite significant. The formulated feed (which was balanced) performed better than the farm-made feed (which was mainly a mixture of energy sources) (San *et. al.*,2008 ;Ghosh *et. al.*, 2010; Nguyen, 2010). Because farm made feeds are unbalanced and are lower in protein, the mean weight, day weight gain and specific growth rate for formulated feed (Raanan) were higher than the average weight gain, daily weight gain and specific growth rate for farm-made feed. This result was directly opposite to the result of Ghosh *et. al.*,(2010). Their result stated that formulated diets with plant protein, performed better than the conventional diet, which has animal ingredients. However, their results on specific growth rate (3.57, 3.55, 3.66 and 3.75) for both conventional and formulated diets were higher than the specific growth rates for all treatments in this study (Table 4.1 and 4.2). Also, final weights of fish for farm-made feed were not different from the results of San *et. al.*, (2008) when the fish were fed with duckweed (62.3g, 101g and 161g).

5.4: Effect of feed on water quality (Physio-chemical parameters)

There was no significant variation in pH, among the treatments at both sites (Boyd, 1990; San, 2003). The mean values recorded were within the optimum range for tilapia culture (pH: 6.5 to 10) as reported by Tiechert *et. al.*, (1997) and FAO, (2005). They were similar to values recorded by Davies and Ansa, (n.d) who worked on comparative assessment of water quality parameters of freshwater tidal earthen ponds and stagnant concrete tanks for fish production. This indicated that, both formulated feed and farm-made feed did not have any negative effect on pH. This was confirmed by the findings of Diana *et. al.*, (1996) who reported that, on the efficient use of supplemental feed at a limiting rate along with fertilizer and natural feed did not adversely affect water quality. According to Boyd (2002), the pH of pond water may increase above 9 during period of high photosynthesis. This could essentially be explained by the physico-chemical and biological reactions due to the presence of dense phytoplankton growth. The result of this study indicated that, temperature was favorable for fish culture as mentioned by Boyd (1990).

Secondly, TDS was low compared with the optimum range given by Boyd (1999) which was 1000 mg/l. However, the mean values at Kubease were higher than those recorded at Asawinso (Table 4.3). This shows that some feed were uneaten and these increased the organic matter load of the pond (Boyd, 1992). This could be the cause of low dissolved oxygen observed at Kubease. In general, both feed did not pollute the water, however, comparing the formulated feed and the farm-made feed in re-use water, it was recorded that, pond containing formulated feed had higher level of TDS than pond containing farm-made feed.

5.5: Effect of feed on Dissolved Oxygen

Dissolved oxygen concentration in the ponds, even though, dropped below 2mg/l, fish were not sighted gulping for air at the surface of the water in the morning as sign of oxygen stress (Floyd, 1997). The DO levels recorded in this study were similar to the report of (San and Preston, 2003). The lowest values, recorded from ponds that were filled with re-use and fed farm-made feed at Asawinso and formulated feed at Kubease, can be attributed to muddy sediments at the bottom. The sediments were made up of organic matter whose decomposition utilized dissolved oxygen. This supports the report by Boyd (1998) that bottom sediments especially in old ponds where large amounts of organically-enriched sediment have accumulated, may exert large oxygen demands. This is also in agreement with Boyd (1998) who found that, respiration by organisms in ponds may cause dissolved oxygen levels to decline.

Additionally, high BOD values recorded at Kubease (31.88 mg/litre) and Asawinso (avg; 26.13 mg/litre), can be a contributing factor for the low level of DO. These figures were far higher than those recorded by (San and Preston, 2003). High BOD level shows that more oxygen is required for the oxidation of the carbon in any environment (Boyd, 1998; San and Preston, 2003). The higher DO (9.73mg/l), which was recorded from ponds containing formulated feed (Raanan) was due to the abundance of phytoplankton that increase photosynthetic activity leading to production of higher DO (Boyd, 1990; San, 2003) and the good quality of the feed.

It can be concluded that, the growth performance of the fish was poor due to the low levels of dissolved oxygen (Floyd, 1997: Boyd, 1998). However, Lin *et. al.,* (1999) disagreed with the reports by Boyd (1998) and Floyd, (1997). Their report suggested that, oxygen level of 2.40 - 3.52 mg/litre was good for tilapia in pond culture; when they worked on optimization of nitrogen fertilization rate in freshwater tilapia production ponds. According to them, feed used in this study did not affect the DO of the water; hence, tilapia growth performance was not limited by DO.

5.6 Effect of Feed Type on Phosphorus and Nitrogen

The feed type used affected the phosphorus and nitrogen level in the pond as noted by (Boyd, 1998). Total dissolved nitrogen was recorded at the bottom of pond that received farm-made feed (Table 4.3). This could be attributed to the fact that, there was more organic matter at the bottom of the water, hence high metabolic processes since nutrients present in the soil, such as phosphorus, nitrogen and carbon etc, originated from the feed. However, the figures recorded for nitrogen were below optimum recommended by Boyd, (1998) (more than 75ppm). According to Sherif *et. al.,(*2008), ammonia is toxic to tilapia at concentrations of 2.5 mg/l and unionized ammonia become toxic to fish at 7.1 mg/l.

The phosphorus levels recorded in all the ponds were lower than the optimum requirement of phosphorus for tilapia as produced by (Mjoun, *et. al.*, 2010). However, they were far above the desired concentration reported by Boyd, 1998 (0.005-0.2mg/liter)). Also, the result was not different from those recorded by Kenawy *et. al.*,(n.d.) when fishmeal was totally replaced with soybean meal in diets for tilapia in pre-fertilized ponds. This could be attributed to high amount of uneaten feed in the water especially in re-use water. The low phosphorus can be a contributing factor for the poor growth of fish, since it was considered as the nutrient that limits natural productivity of ponds (Carlson and Simpson, 1996).

It was observed that the phytoplankton growth (indicated by the greenness of water) was intense in freshwater ponds that received formulated feed. However, scums, from floating algae were observed on some days over the study period. This was observed in re-use water ponds that received farm-made feed. The scum found during sampling could be another factor for the low level of dissolved oxygen recorded during the study (Nwabueze, 2004).

5.7 Parasites and Predators Identified

Various injuries, including abrasions, loss of scales and were found on some of the fish during sampling, especially around the gill. Some of these injuries were caused by leeches since a lot of them were found in the water during sampling. Parasitic leech fed on the blood of the fish leaving behind a distinctive circular lesion on the fish body. These were mostly found in the re-use water which was not limed prior to filling. The leech infestation could easily be controlled by liming and drying the pond bottom after each cycle.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

Resources like water are currently in short supply hence there is the need to promote more efficient use of existing sources. The efficient utilization of water is to encourage the re-use of water in integrated farming systems and aquaculture. Common practice of aquaculture in Ghana involves frequent discharge of polluted water into rivers which results in eutrophication and degradation of receiving water bodies. This discharge also serves as source of nutrient pollution, which creates high levels of nutrients that increase the growth of phytoplankton and algae. This eventually reduces the level of oxygen in the water, which results in fish kills. Also most fish farmers in Ghana depend on rainfall hence they are unable to farm during the dry season. This has become a challenge to most fish farmers in the country. There was, therefore, the need to develop improved aquaculture systems which have a more efficient use of water and less environmental impact, hence, this study.

6.1 Conclusion

At the end of the study, results from ponds fed with farm- made feed indicated that, growth was better in ponds containing re-use than freshwater. The daily weight gain was significantly not different between treatments. The low growth recorded in fresh water (NWL) was due to the unexpected reproduction whiles the high growth could be attributed to the fact that re-use water contained more nutrients and natural food which enhanced the growth of the fish compared with fresh water which was low in nutrients. Meanwhile, result from pond fed with formulated feed revealed that, fish cultured in fresh water (NWR) had the higher value growth indices. Growth indices recorded under formulated feed were higher than those under farm-made feed .The high growth performance can be attributed to quality of the feed which was balanced and extruded compared with the farm-made feed. It was realized that fish in ponds that contained re-use water exhibited better growth if fed with farm-made feed than with formulated feed. However for a better growth to be achieved with fresh water than with re-use water, a formulated feed may be required.

There was no significant variation in pH, among the treatments at both sites. The mean values recorded were within the optimum range of water quality for tilapia. The mean DO concentration was not within the desired concentration. The higher DO (9.73mg/l), which was recorded from ponds containing formulated feed (Raanan) was due to the abundance of phytoplankton that increased photosynthetic activity.Year round production in fish farming could be achieved by screening and re use water in which fish has been cultured for another cycle especially during the dry season.

6.2 Recommendation

It is recommended that;

- Further research be carried out to ascertain the Cost-Benefit component of formulated feed and farm-made feed with respect to growth performance.
- Where farmers are unable to use formulated feed throughout the cycle, they should be used at the early stage of production to promote fast growth of juvenile fish
- Further research be carried out to assess the pest and diseases cause by re-use water and for how long should the re-use water be used before discharging into the environment

- This study should be carried out again by students using catfish to control reproduction.

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APPENDICES

Appendix 1: ANOVA for growth responds (length) for treatments (NWL and OWL) at study site one

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	2488.747	10	248.8747	326.5282	7.2E-234	1.846632
Columns	2.996042	1	2.996042	3.930862	0.047868	3.857161
Interaction	23.6713	10	2.36713	3.105719	0.000716	1.846632
Within	452.7376	594	0.762184			
Total	2968.152	615				

Appendices 2: ANOVA for growth responds (weight) for treatments (NWL and OWL) at study site one

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	783110.6	10	78311.06	339.6956	3.5E-238	1.846632
Columns	2321.754	1	2321.754	10.07124	0.001584	3.857161
Interaction	5575.253	10	557.5253	2.418418	0.007971	1.846632
Within	136936.6	594	230.533			
Total	927944.2	615				

Appendix 3:ANOVA for growth responds (length) for treatments(NWL and OWL) at study site two

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	143.3936	8	17.9242	87.75917	5.49E-07	3.438101
Columns	5.357356	1	5.357356	26.23029	0.000905	5.317655
Error	1.633944	8	0.204243			
Total	150.3849	17				

Appendix 4: ANOVA for growth responds (weight) for treatments(NWL and OWL) at study site two

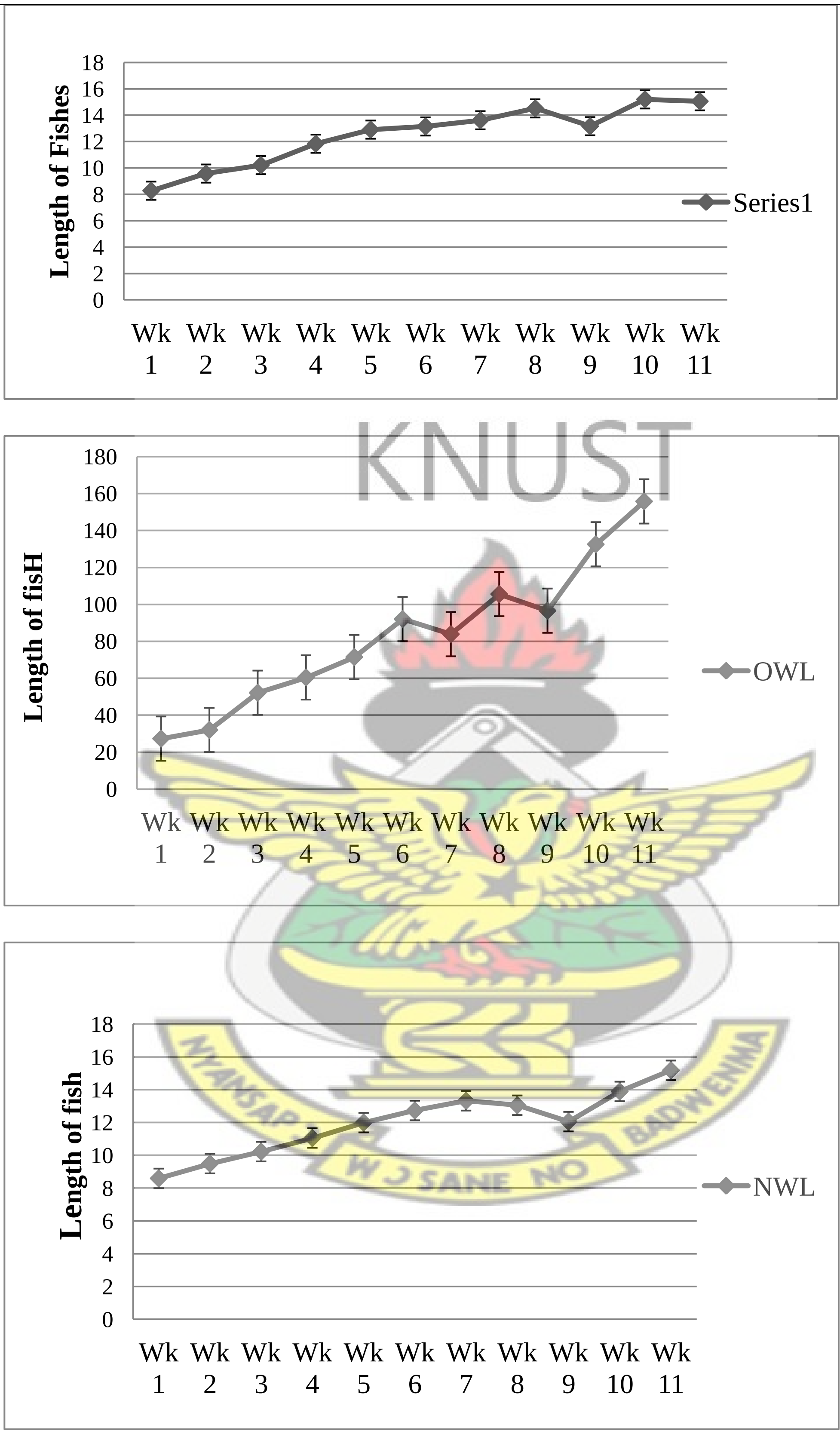
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	16408.73	8	2051.091	14.65717	0.000498	3.438101
Columns	1642.409	1	1642.409	11.73671	0.009009	5.317655
Error	1119.502	8	139.9377			
Total	19170.64	17				

Appendix 5: ANOVA for growth responds (length) for treatments (NWR and OWR) at study site two

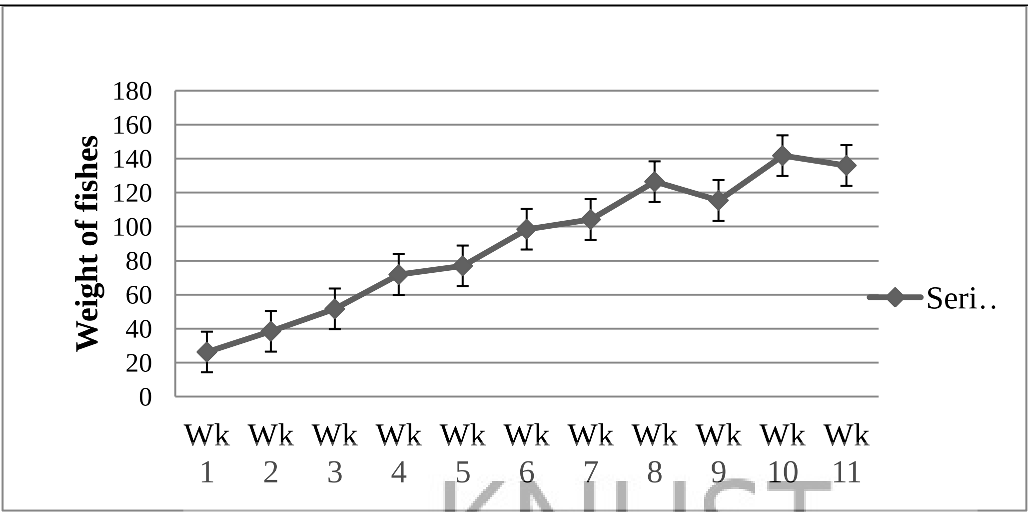
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Weeks	259.9314	8	32.49143	3.283446	0.056291	3.438101
Treatments	11.17069	1	11.17069	1.128863	0.319036	5.317655
Error	79.16421	8	9.895526			
Total	350.2663	17				

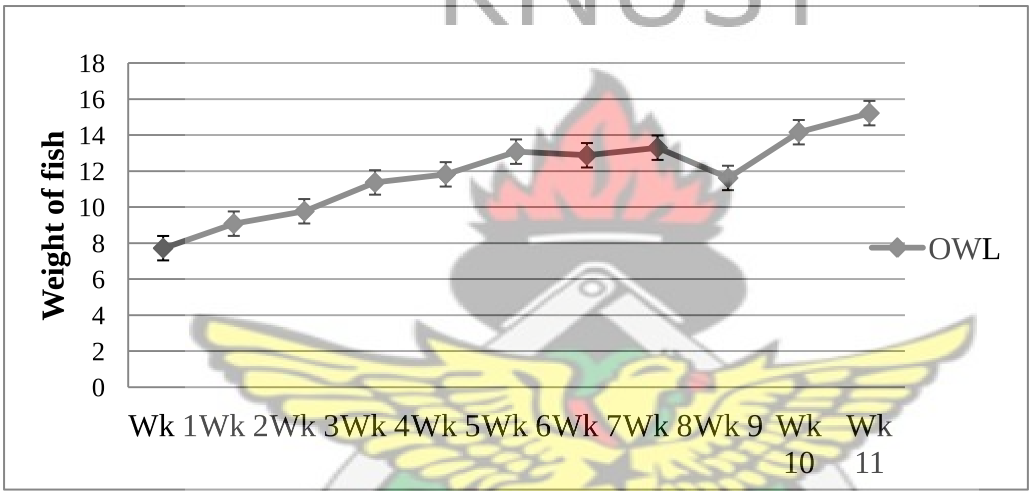
Appendix 6: ANOVA for growth responds (weight) for treatments (NWR and OWR) at study site two

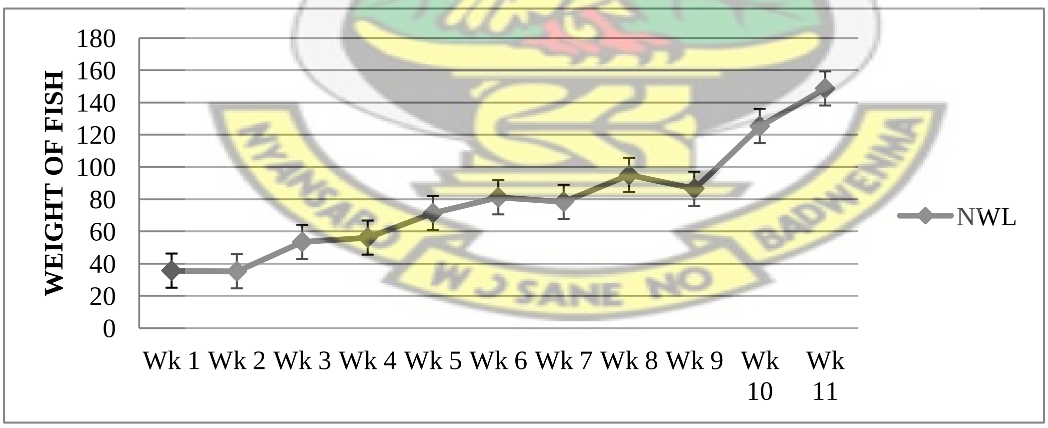
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	79869.22	8	9983.652	36.12774	1.73E-05	3.438101
Columns	1.041606	1	1.041606	0.003769	0.952551	5.317655
Error	2210.745	8	276.3431			
Total	82081	17				



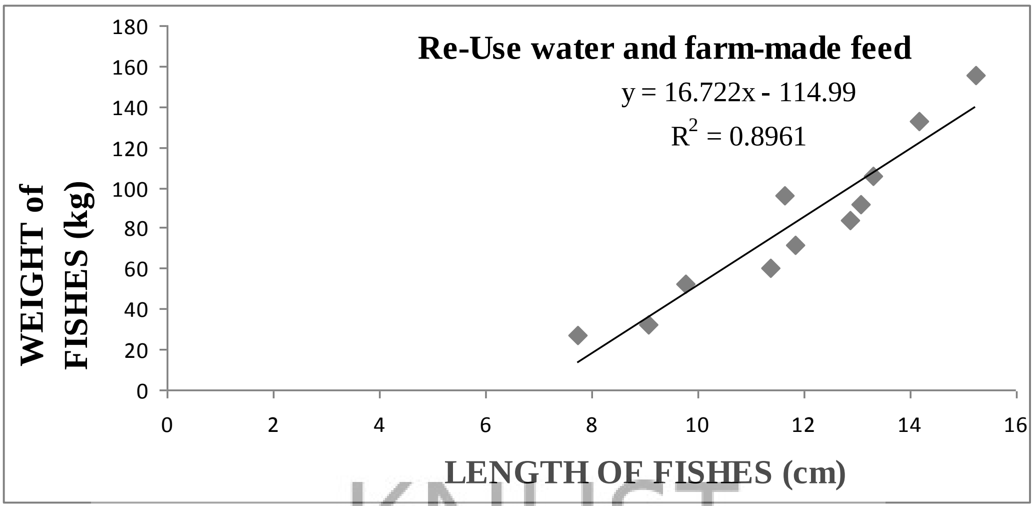
Appendix 7: Growth response (length) of Oreochromisniloticus at Kubease

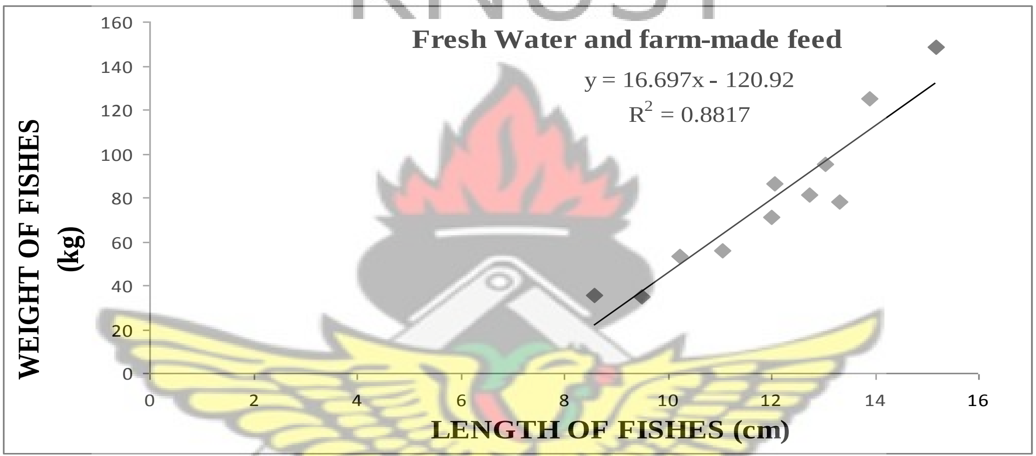


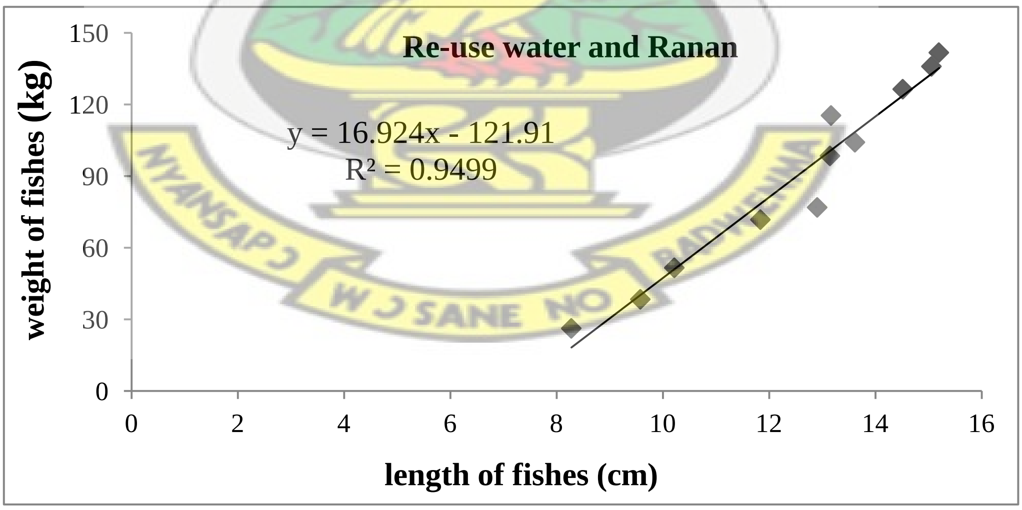




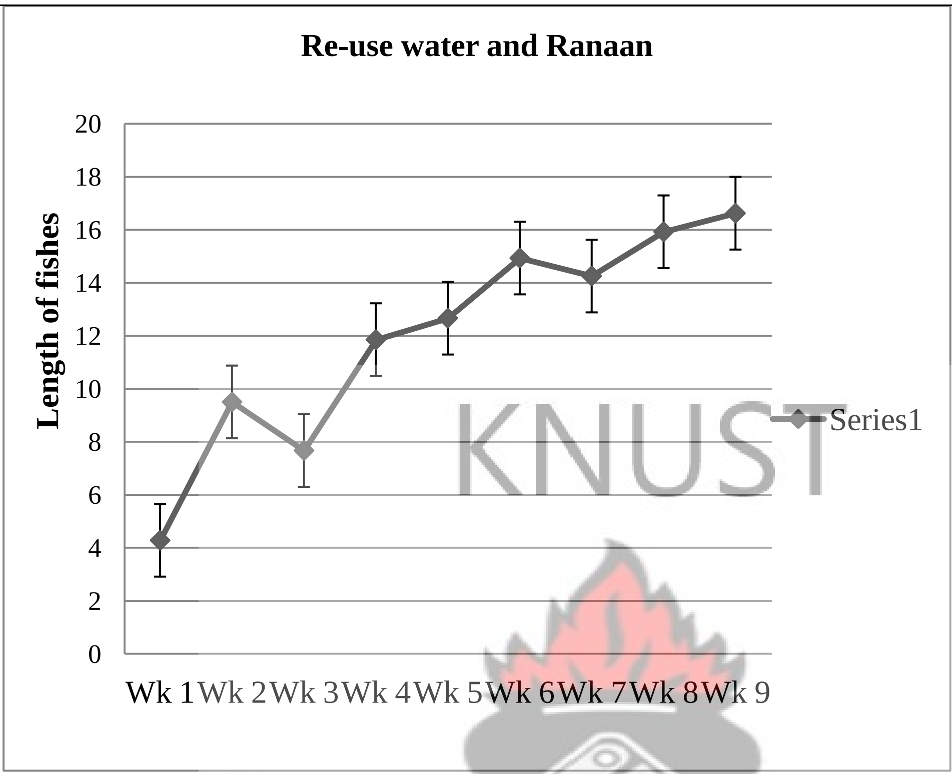
Appendix 8: Growth response (weight) of *Oreochromis niloticus* at Kubease



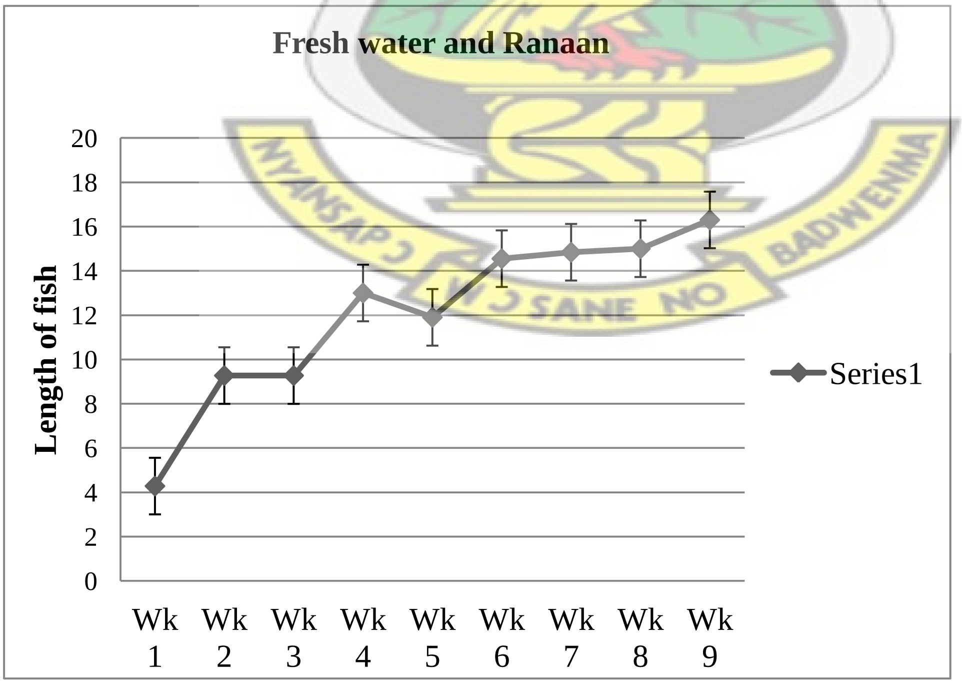




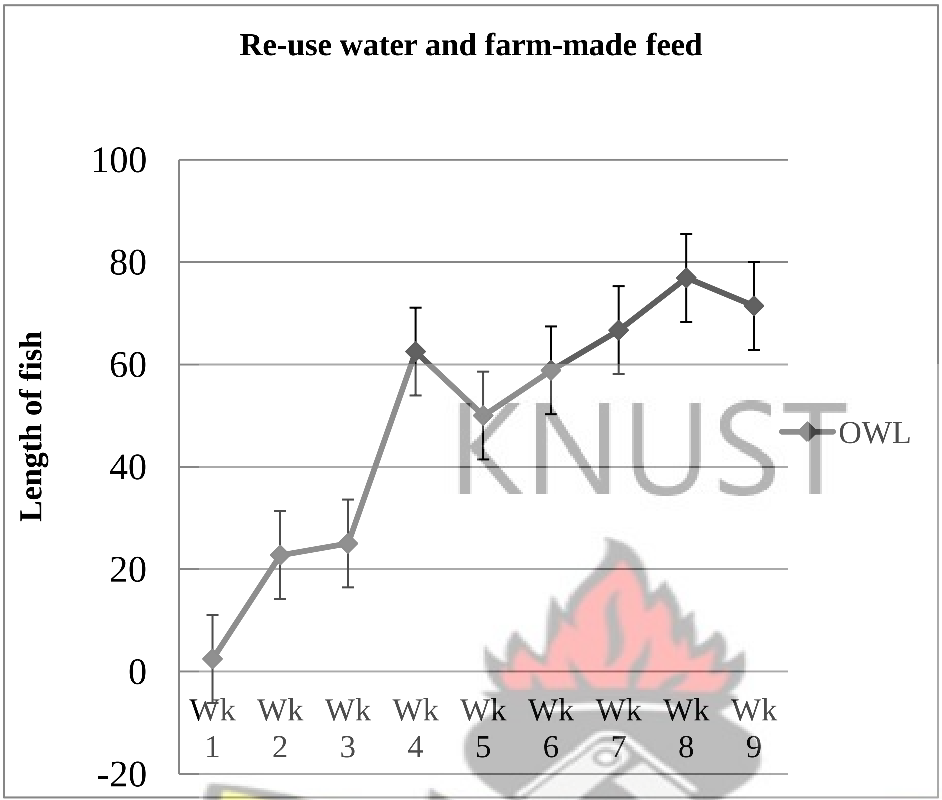
Appendix 9: Relationship between weight and length of treatment at Kubease

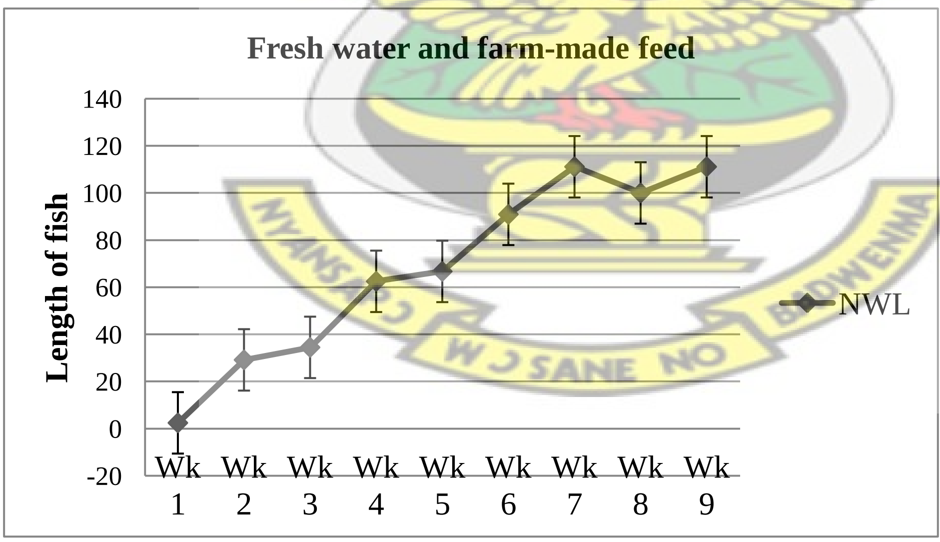


Re-use water and Ranaan
Length of fishes
20
18
16
14
12
10
8
6
4
2
0
Wk 1 Wk 2 Wk 3 Wk 4 Wk 5 Wk 6 Wk 7 Wk 8 Wk 9
Series1

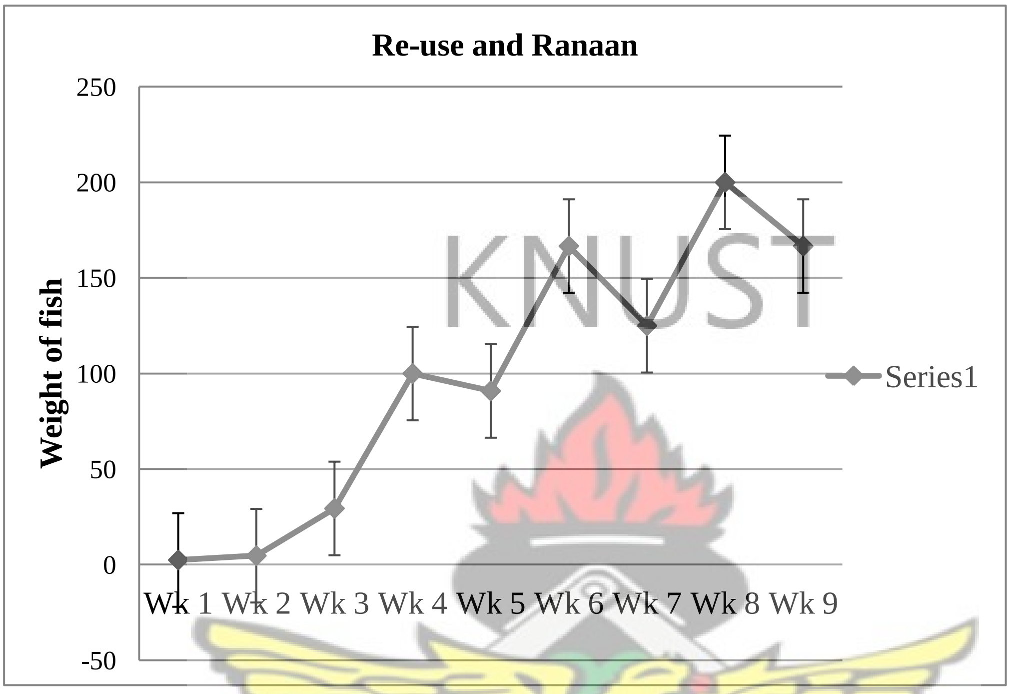


Fresh water and Ranaan
Length of fish
20
18
16
14
12
10
8
6
4
2
0
Wk 1 Wk 2 Wk 3 Wk 4 Wk 5 Wk 6 Wk 7 Wk 8 Wk 9
Series1

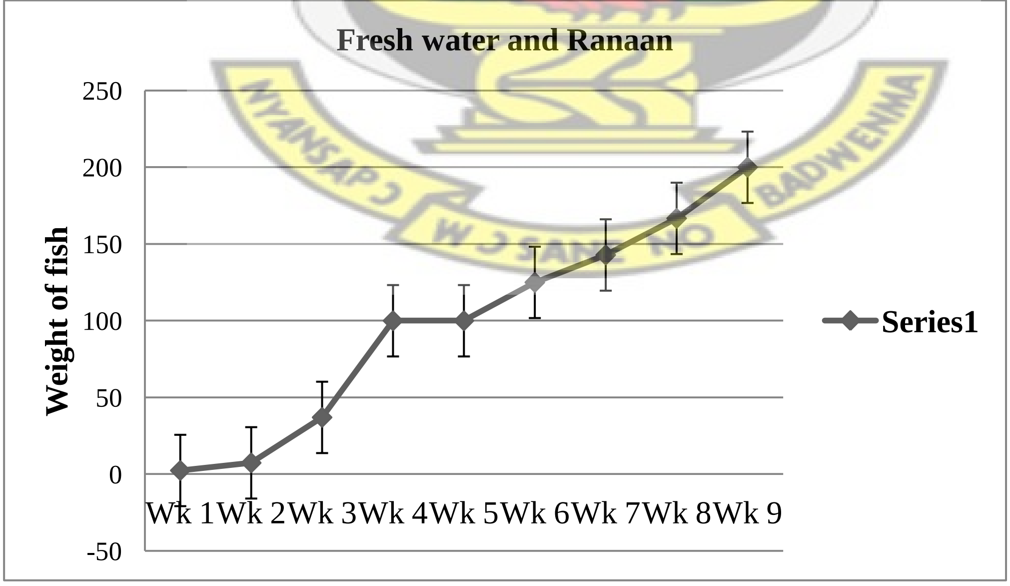




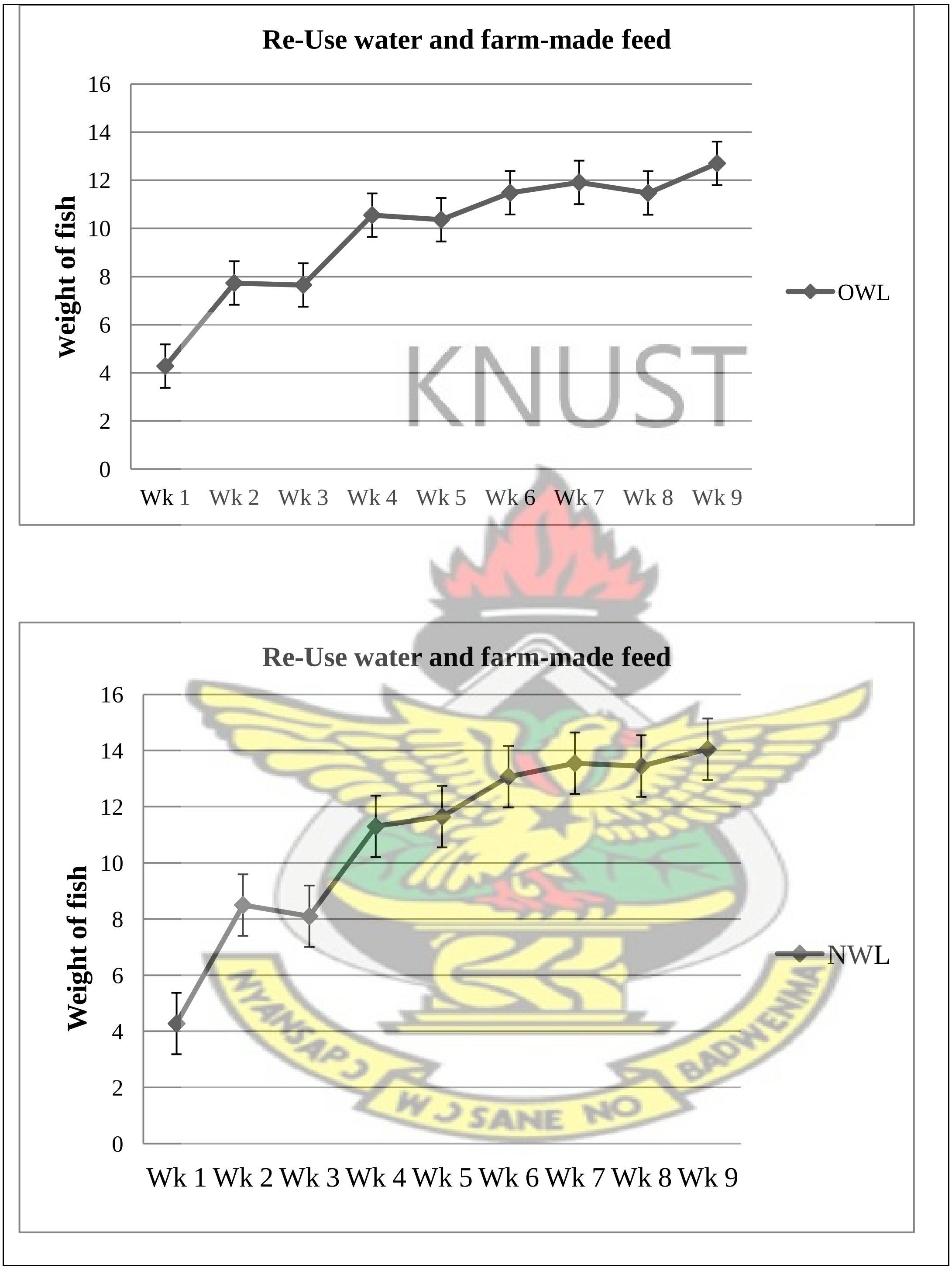
Appendix 10: Growth response (length) of Oreochromis niloticus at Asawinso



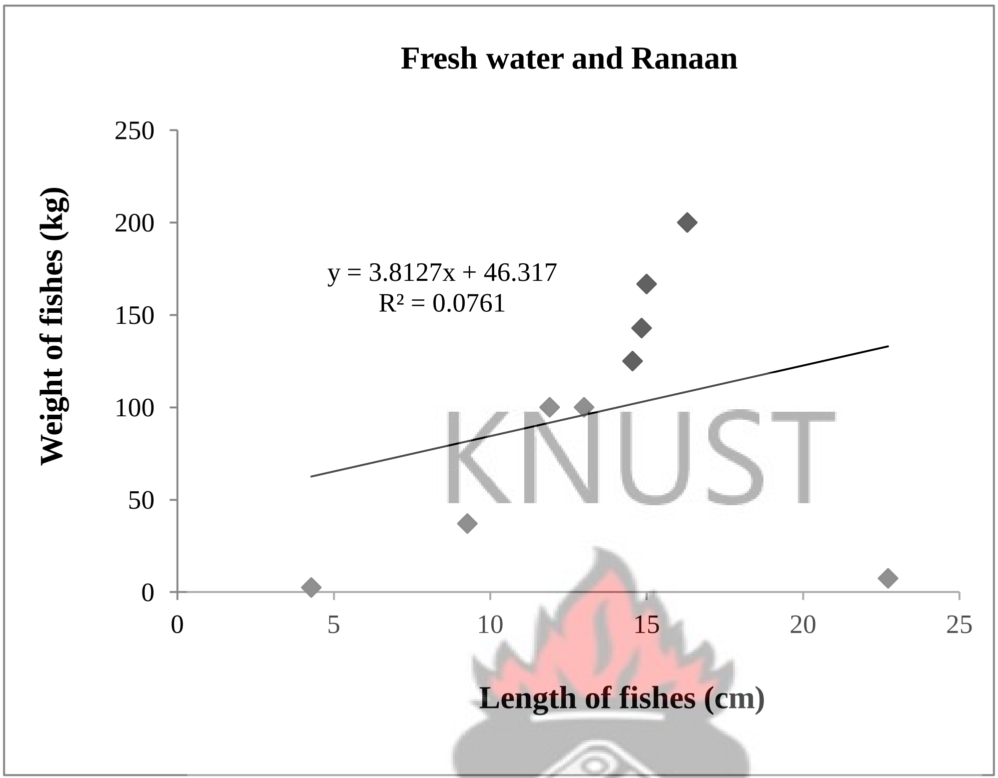
Re-use and Ranaan
250
200
150
100
50
0
-50
Weight of fish
Wk 1 Wk 2 Wk 3 Wk 4 Wk 5 Wk 6 Wk 7 Wk 8 Wk 9
Series1

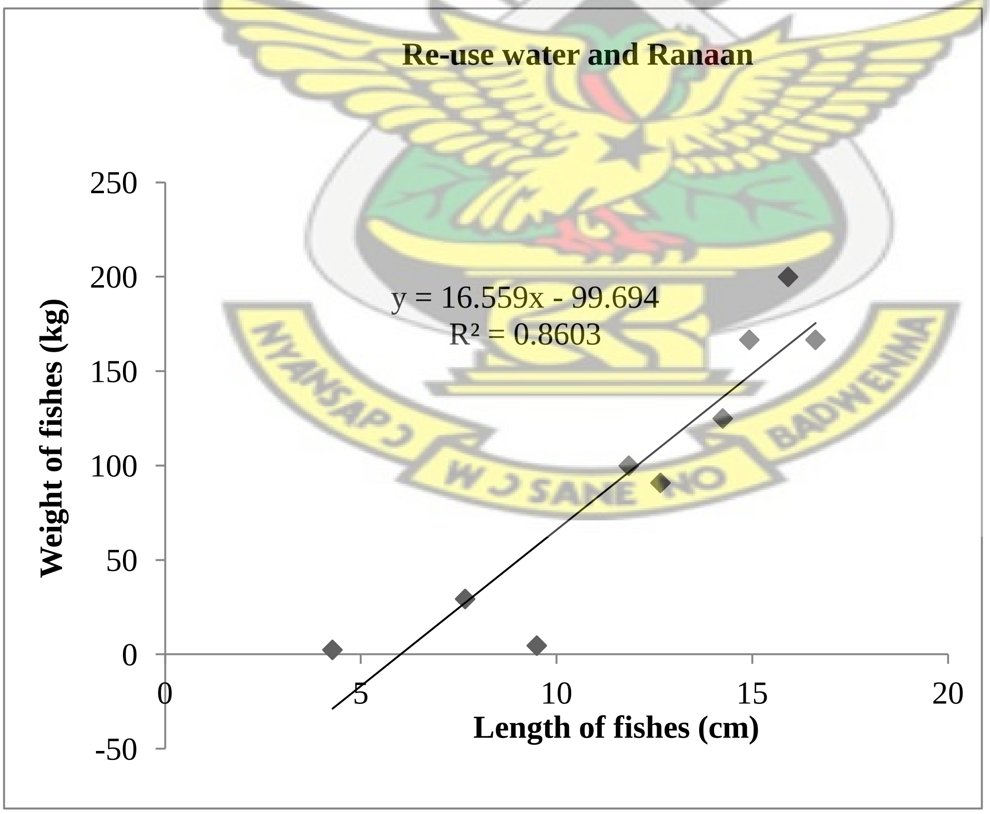


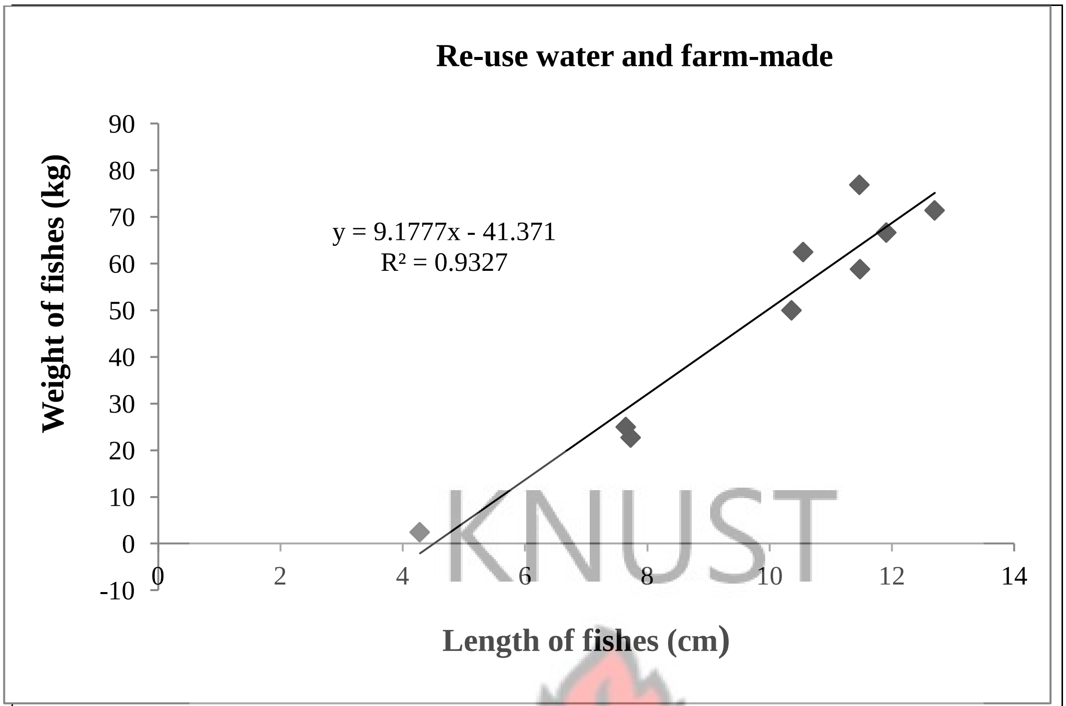
Fresh water and Ranaan
250
200
150
100
50
0
-50
Weight of fish
Wk 1Wk 2Wk 3Wk 4Wk 5Wk 6Wk 7Wk 8Wk 9
Series1

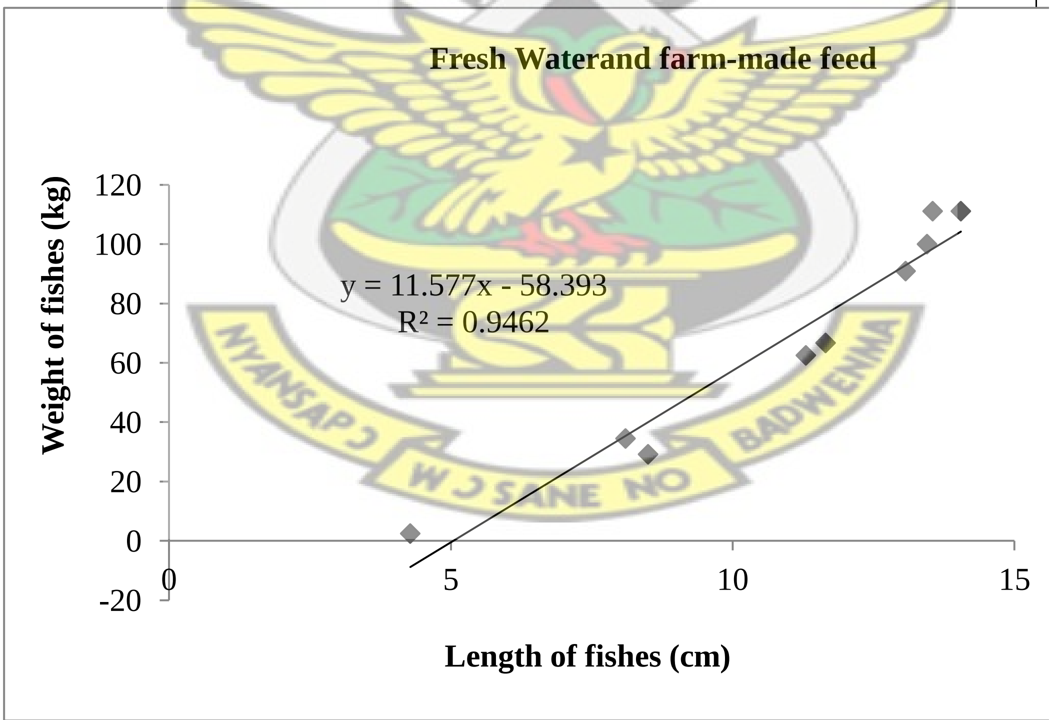


Appendix 11: Growth response (weight) of *Oreochromis niloticus* at Asawinso

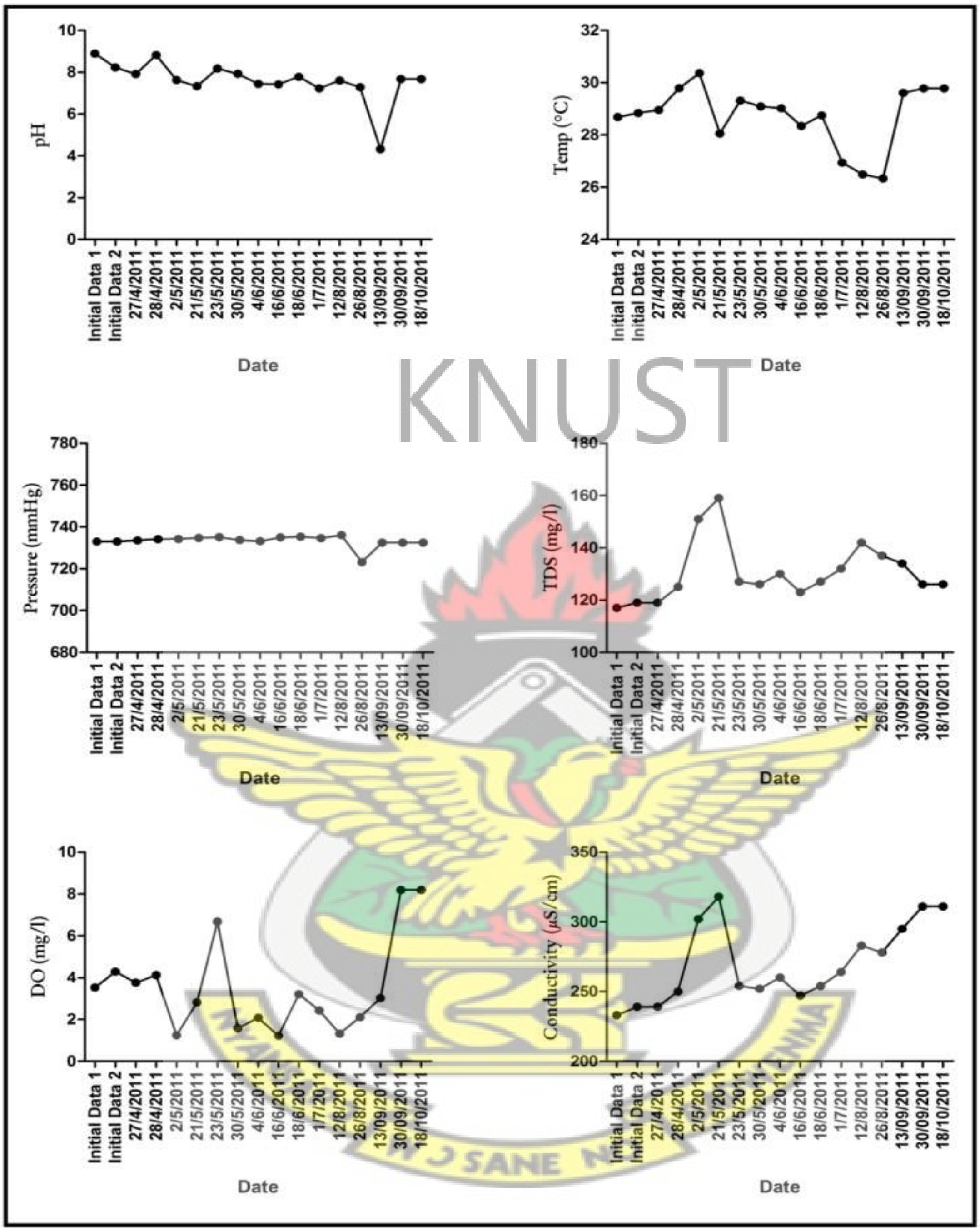

Fresh water and Ranaan
y = 3.8127x + 46.317
R² = 0.0761
Weight of fishes (kg)
Length of fishes (cm)
250
200
150
100
50
0
0
5
10
15
20
25


Re-use water and Ranaan
y = 16.559x - 99.694
R² = 0.8603
Weight of fishes (kg)
Length of fishes (cm)
250
200
150
100
50
0
-50
0
5
10
15
20

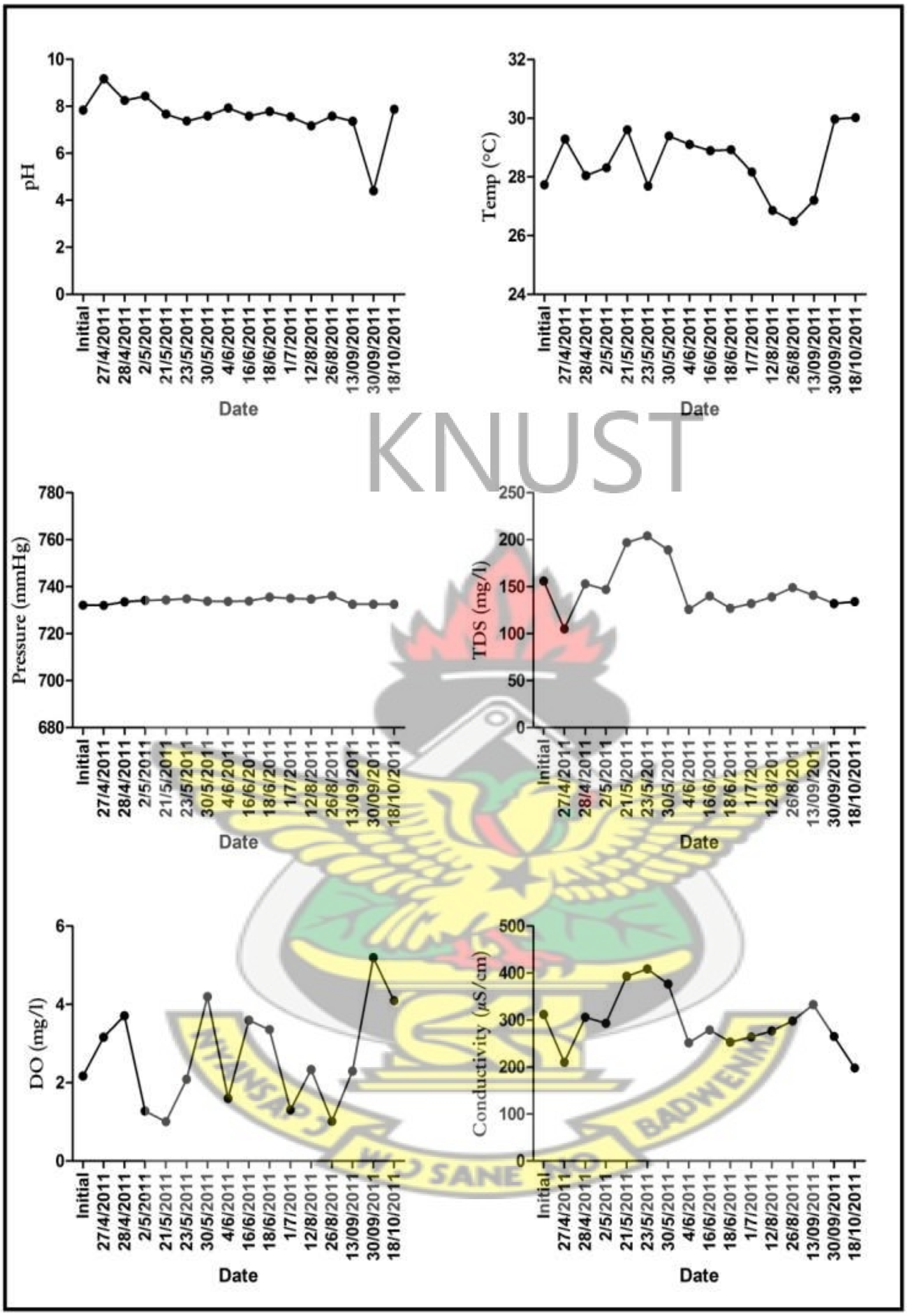




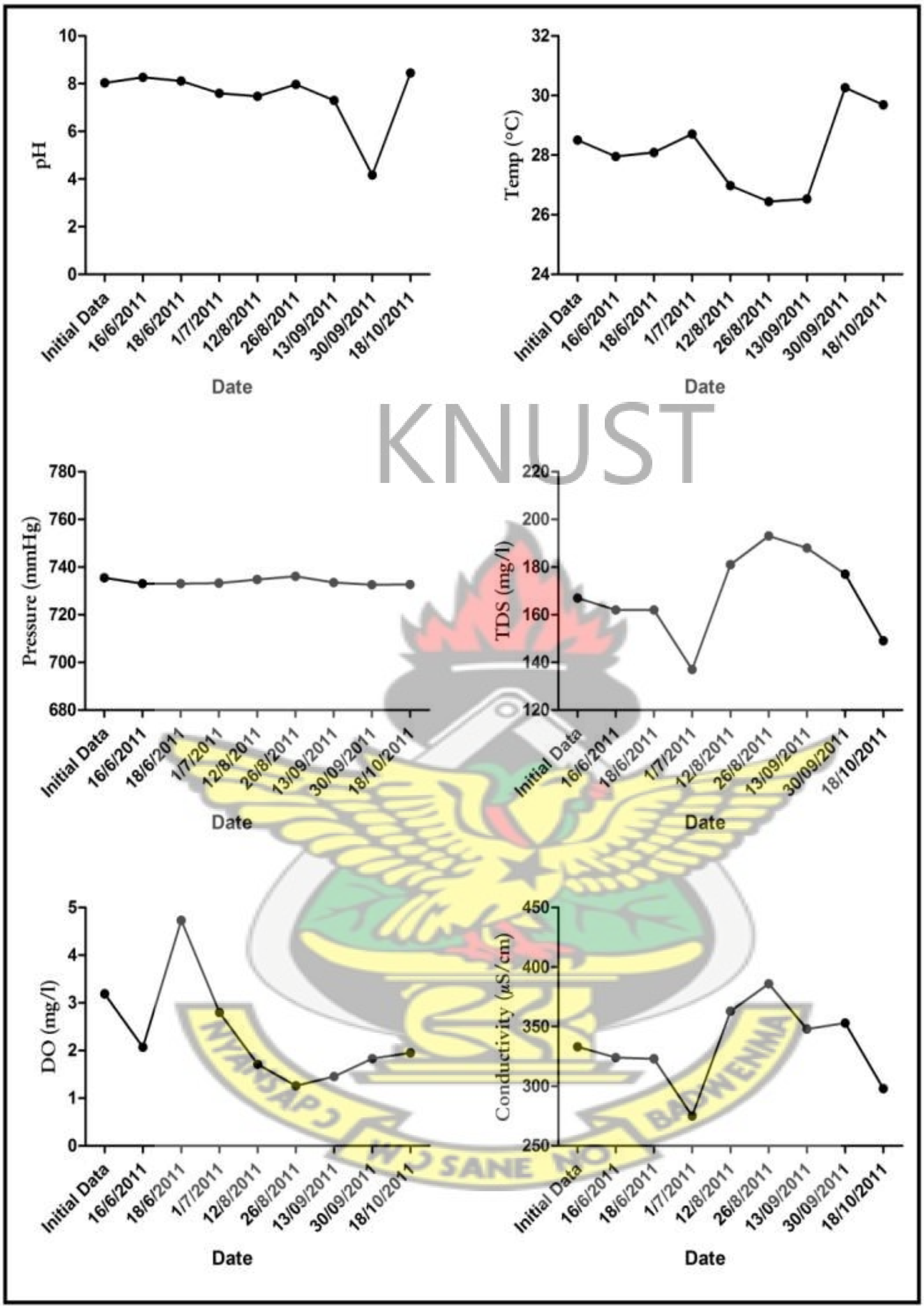
Appendix 12: Relationship between weight and length of treatments at Asawinso



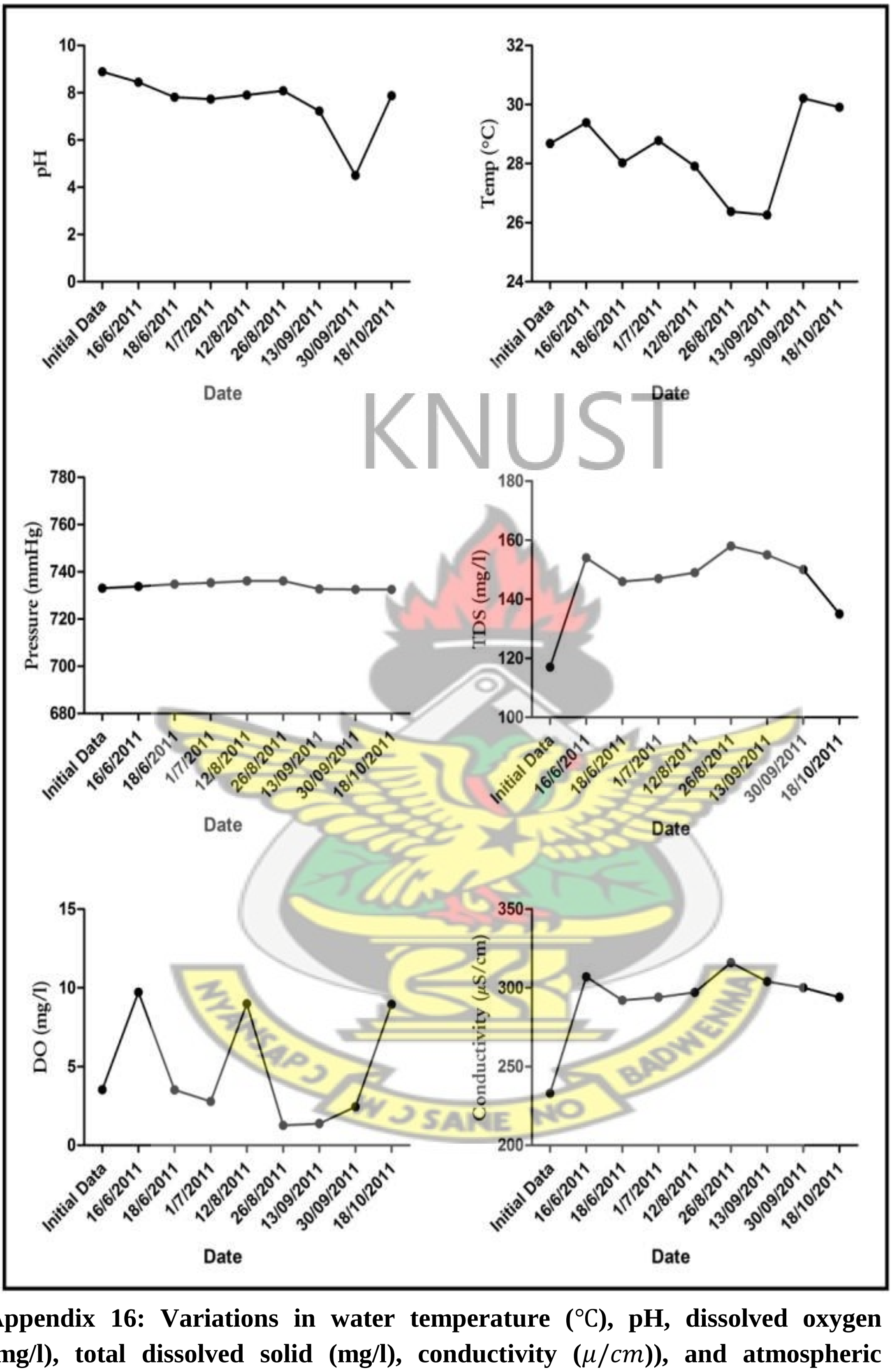
Appendix 1.3: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing fresh water and subjected to farm-made feed (NWL)at study site one.



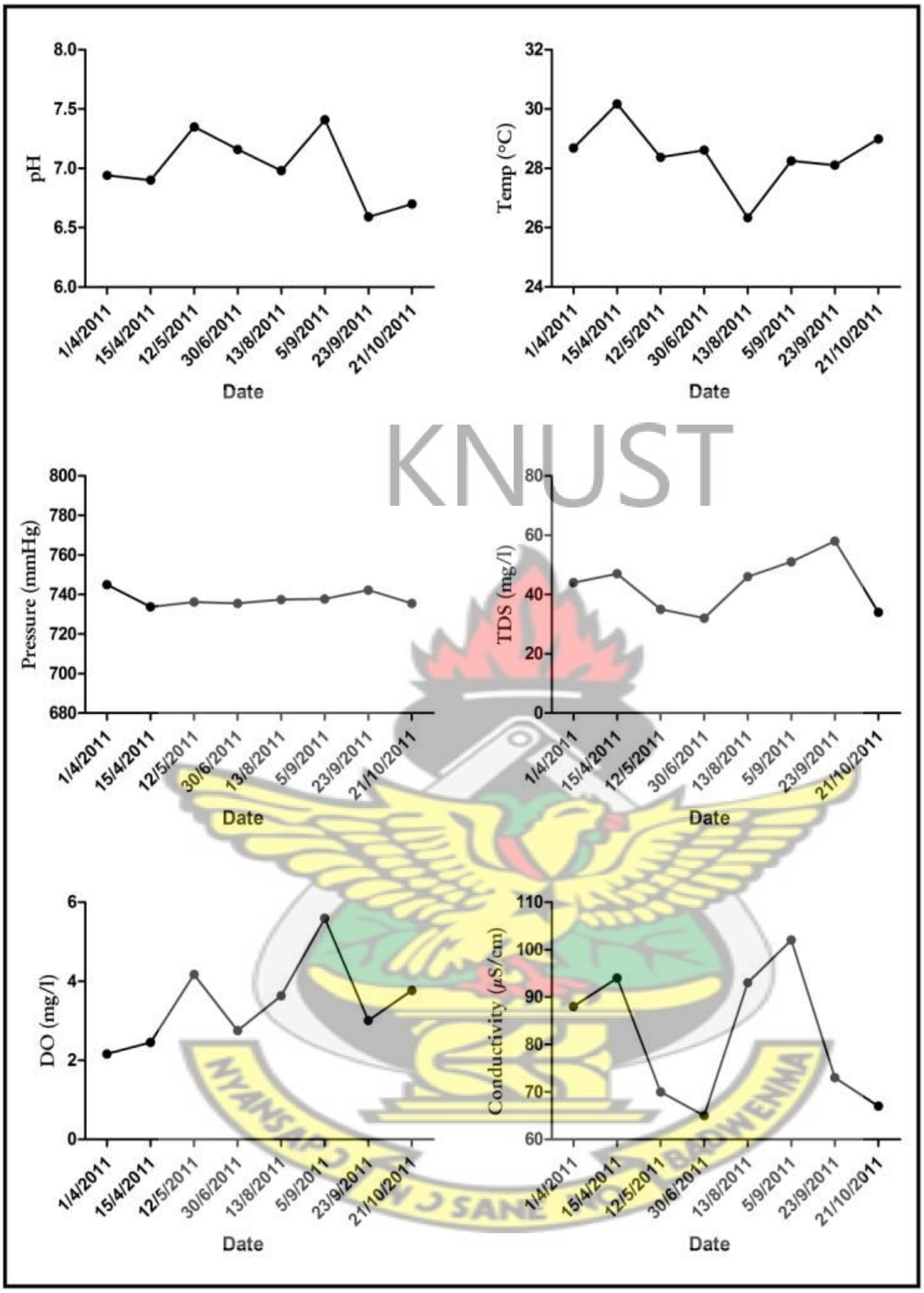
Appendix 14: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing re-use water and subjected to farm-made feed (OWL)at study site one .



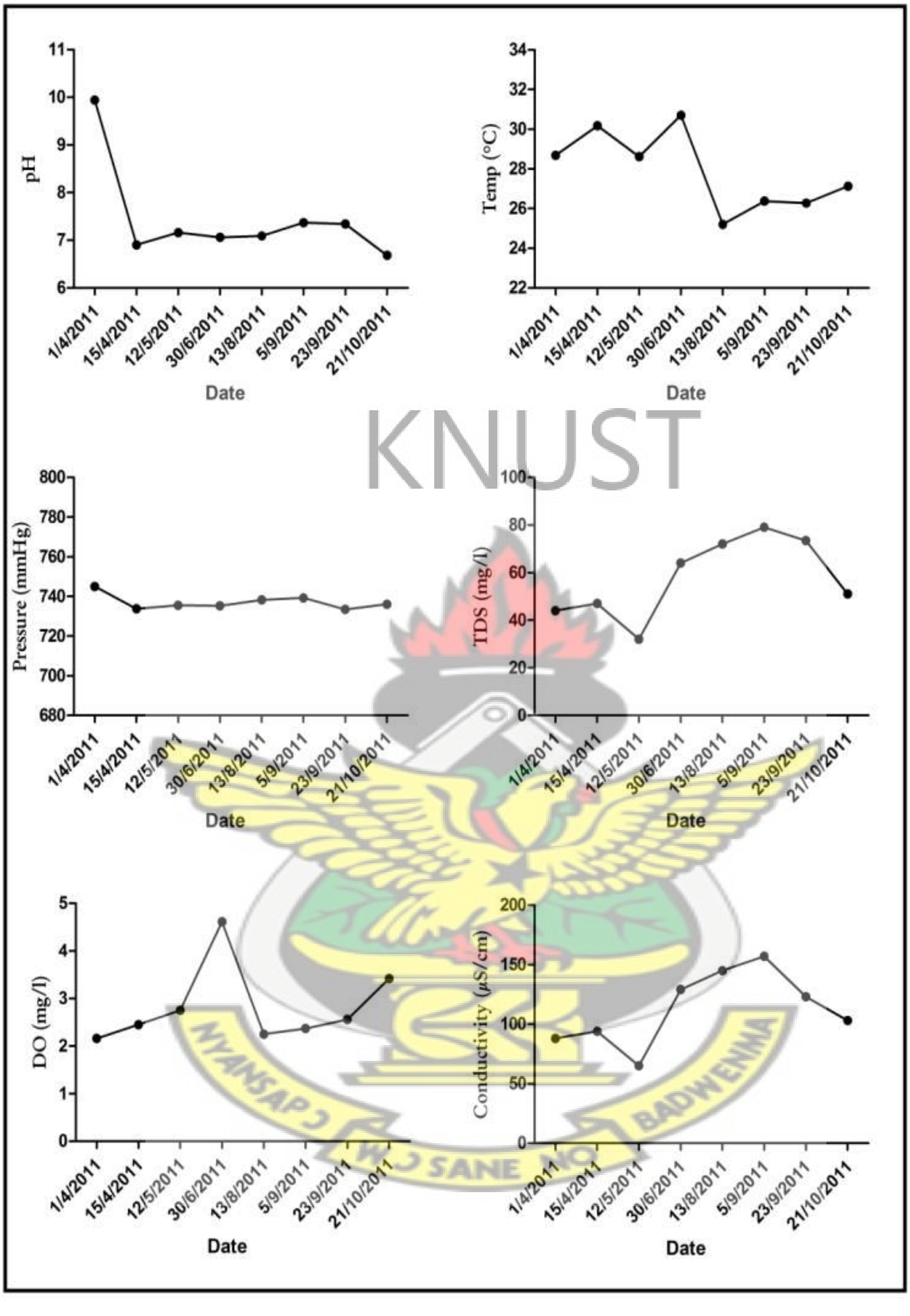
Appendix 15: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing re-use water and subjected to formulated feed (OWR) at study site one



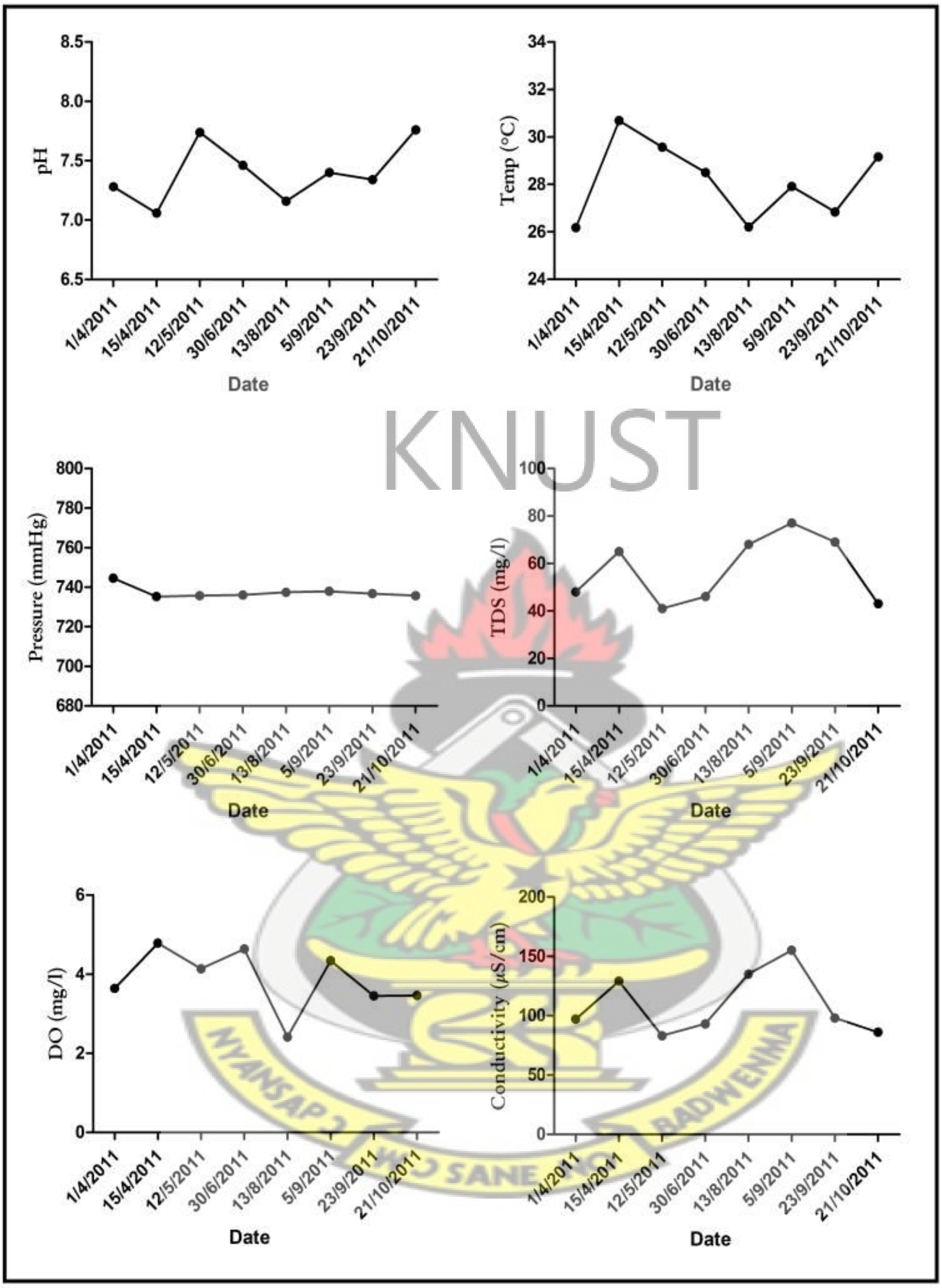
Appendix 16: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing fresh water and subjected to formulated feed (NWR) at study site one.



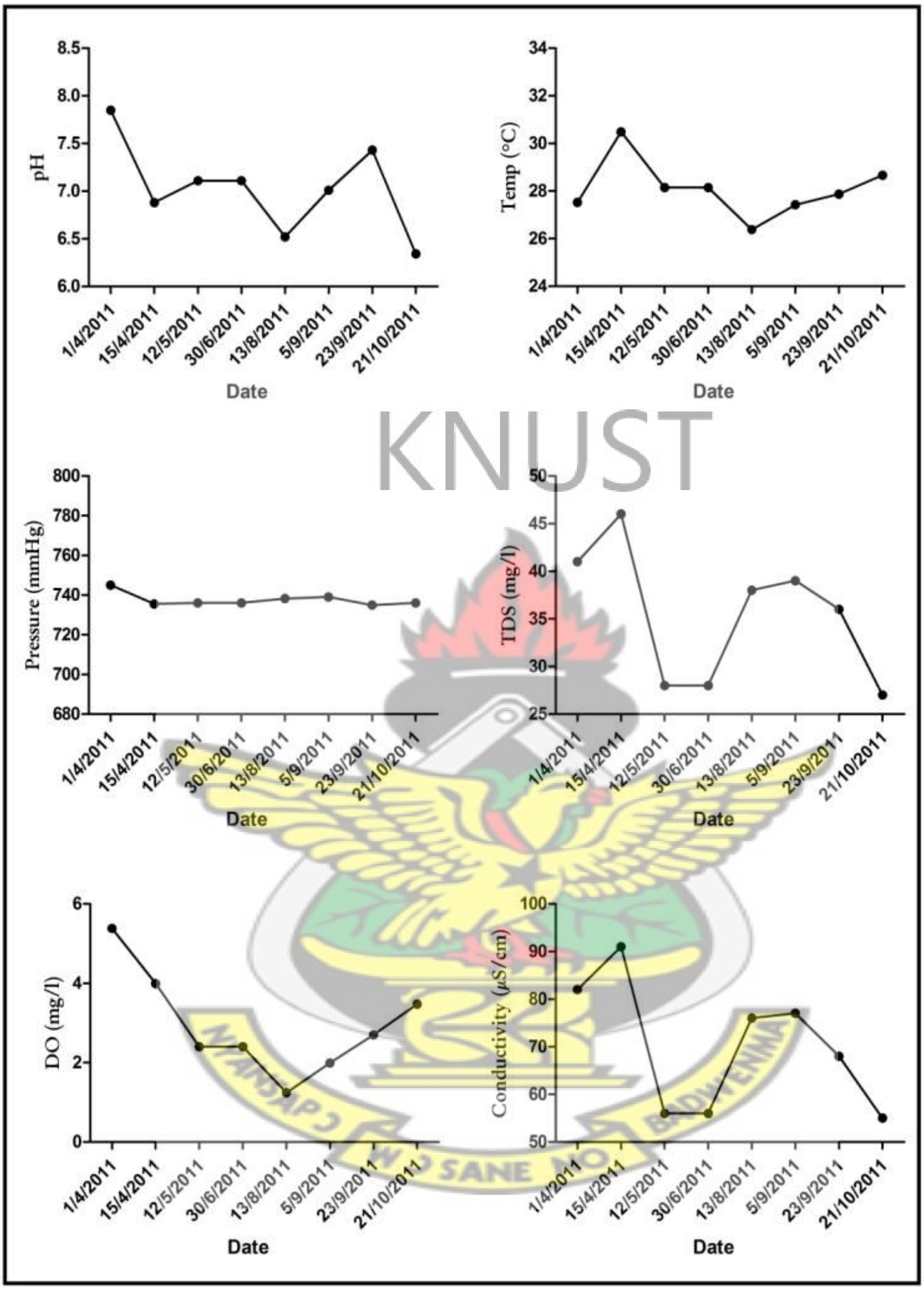
Appendix 17: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing fresh water and subjected to farm-made feed (NWR) at study site two.



Appendix 18: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing re-use water and subjected to farm-made feed (OWL) at study site two.



Appendix 19: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity ($°\mu/cm$)), and atmospheric pressure (mmHg) in earthen pond containing fresh water and subjected to formulated feed (NWR) at study site two.



Appendix 20: Variations in water temperature (℃), pH, dissolved oxygen (mg/l), total dissolved solid (mg/l), conductivity (μ/cm)), and atmospheric pressure (mmHg) in earthen pond containing re-use water and subjected to formulated feed (OWR) at study site two.

Appendix 21: Tilapia cultured in re-use water and fed with farm-made feed

Appendix 22: Tilapia cultured in fresh water and fed with farm-made feed

Appendix 23: Tilapia cultured in re-use water and fed with formulated feed

Appendix 24: Tilapia cultured in re-use and fed with farm-made feed