AQUAPONICS SYSTEM FOR TREAT A CATFISH WASTEWATER

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ABSTRACT

The combination of fish and plant production in an integrated recirculation system is called Aquaponics system. In natural waters, ammonium is converted rather rapidly to nitrite and further to nitrate by aerobic bacteria from the genera Nitrosomonas and Nitrobacter, through a process called nitrification. Ammonia (NH3) is the waste products of the fish and extremely toxic to fish. First nitrifying process is by Nitrosomonas bacteria. Nitrosomonas bacteria is cultured in the grow beds (gravel). This bacteria feed on both oxygen and ammonia and with their biological activities. Reaction of Nitrosomonas bacteria produces excretes a chemical called nitrite (NO2). Nitrite is toxic to fish but not toxic as ammonia. Second of nitrifying process is by Nitrobacter bacteria. Nitrobacter bacteria also cultured in the grow beds (gravel). These bacteria utilize oxygen in its respiration, acts in similar way as Nitrosomonas bacteria. Reaction of Nitrobacter bacteria have changes the nitrite into a relatively harmless chemical called nitrate (NO3). Nitrate is primary source of plant nutrition. Plants take in the converted nirates as nutrients. The nutrients are a fertilizer, feeding the plants. This system produces the clean water to fish tank and ready for next cycle. The aims of this research are to determine the characteristics of water quality from the cultured catfish (Siluriforme) tank, to determine effect of vegetable (Ipomoea aquatic) distribution on the wastewater quality and effect of the vegetable (Ipomoea aquatic) growth. The results found the ideal range of temperature 27.92°C to 29.14°C and ideal range of pH 6.50- 6.94. The temperature and pH in fish tank in controlled conditions. Besides that, the results of BOD5, COD, TSS and NH4 – N concentration have decrease responding to retention time. It is because of nitrifying process and the growing root of plants and increasing the plants in Aquaponics. Besides that, Ipomoea aquatic grow rapidly and seemed healthy.

ABSTRAK

Gabungan ikan dan pengeluaran tanaman dalam sistem peredaran semula bersepadu dipanggil sistem Aquaponics. Di perairan, ammonium ditukar agak pesat kepada nitrit dan seterusnya kepada nitrat oleh bakteria aerobik dari genus Nitrosomonas dan Nitrobacte melalui proses yang dipanggil penitritan. Ammonia (NH_3) adalah bahan buangan ikan dan sangat merbahaya kepada ikan. Proses nitrifying pertama adalah oleh bakteria Nitrosomonas. Bakteria Nitrosomonas hidup di dalam grow beds (kerikil). Bakteria ini memakan kedua-dua oksigen dan ammonia dan dengan aktiviti-aktiviti biologi mereka. Reaksi bakteria Nitrosomonas menghasilkan bahan kumuhan kimia yang dipanggil nitrit (NO_2). Nitrit adalah toksik kepada ikan tetapi tidak bertoksik seperti ammonia. Proses kedua nitrifying adalah dengan bakteria Nitrobacter . Bakteria Nitrobacter juga hidup di dalam grow beds (kerikil). Bakteria ini menggunakan oksigen dalam respirasi ia, bertindak dengan cara yang sama seperti bakteria Nitrosomonas. Reaksi bakteria Nitrobacter akan mengubah nitrit ke dalam bahan kimia yang dipanggil nitrat yang agak tidak berbahaya (NO_3). Nitrat adalah sumber utama pemakanan tumbuhan. Tumbuhan mengambil dalam nirates yang ditukar sebagai nutrien. Nutrien adalah baja kepada tumbuh-tumbuhan. Sistem ini menghasilkan air yang bersih untuk tangki ikan dan bersedia untuk kitaran seterusnya . Tujuan kajian ini adalah untuk menentukan ciri-ciri kualiti air daripada ikan keli (Siluriforme) yang diternak di dalam tangki , untuk menentukan kesan sayur-sayuran (Ipomoea akuatik) kepada kualiti air sisa dan kesan sayur-sayuran (Ipomoea akuatik) pertumbuhan. Keputusan menunjukkan julat ideal suhu 27.92 ° C - 29.14 ° C dan nilai pH 6,50-6,94 . berdasarkan keputusan, suhu dan pH dalam tangki ikan dalam keadaan terkawal . Selain itu , keputusan BOD5, COD, TSS dan NH4 - N menunjukkan penurunan kepekatan menanggapi masa penahanan . Ia adalah kerana proses nitrifying dan akar Ipomoea akuatik yang semakin membesar dan pertambahan pokok pada Aquaponics. Di samping itu, Ipomoea akuatik cepat membesar dalam keadaan sihat.

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APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
$Ca(OH)_2$	Calcium Hydroxide
COD	Chemical Oxygen Demand
H2PO4/HPO4	Phosphate Hydrate
KOH	Potassium Hydroxide
NH_3	Ammonia
NH_4- N	Ammonia Nitrogen
NO_2	Nitrite
NO_3	Nitrate
PO_4-P	Phosphorus
TSS	Total Suspended Solids

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF PROPOSED STUDY

The combined culture of fish and plants in re-circulating systems is called aquaponics (Graber & Junge, 2009, p.148). Nutrients flow from wastewater generated by the fish, either by direct excretion or the microbial breakdown of organic wastes are absorbed by plants cultured hydroponically. Aquaponics also known as the integration of hydroponics with aquaculture is gaining increased attention as bio- integrated food production. Nutrient-rich effluent from fish tanks in aquaponics is used to fertigate hydroponic production beds. This is good for the fish because plant roots and rhizobacteria remove nutrients from the water. Fish mature, algae and decomposing fish feed are generated the nutrients. These nutrients are contaminants that would otherwise build up to toxic level in the fish tank, but instead serve as liquid fertilizer to hydroponically grown plants. The hydroponic beds function as a biofilter where ammonia, nitrates, nitrites and phosphorus are stripping off. So, the freshly cleansed water can then be re-circulated back into the fish tank. The plant roots in association with the nitrifying bacteria living in the gravel play a critical role in nutrient cycling without these microorganisms the whole system would stop functioning. Thus, aquaponics sytem can enable the production of fresh

vegetables and fish protein since it is water re-uses system. Nutrient removal is essential for aquaculture wastewater treatment to protect receiving water from eutrophication and for potential reuse of the treated water. The integration of aquaculture with agriculture appears to be an excellent way of saving water, disposing aquaculture wastewater and providing fertilizer to the agriculture crop.

1.2 STATEMENT OF PROBLEM

The intensive development of the aquaculture industry has been accompanied by an increase in environmental impact. Discharges from aquaculture into the aquatic environment generate substantial amounts of polluted effluent, containing uneaten feed and feces. Wastewater from aquaculture contains nutrients, various organic and inorganic compounds such as ammonium, phosphorus, dissolved organic carbon and organic matter. The high levels of nutrients cause environmental deterioration of the receiving water sources. Wastewater treatment of aquaculture is important because in many areas, water is a limited resource and depending on the receiving water source. The total nutrients form effluents can contribute to significant environmental degradation. The concept of aquaponics involves integrating aquaculture and hydroponics is gaining increased attention as a bio- integrated food production systems (Fox, Howerton & Tamatu, 2010). Reuse the nutrient released by fish to grow crop plants is the primary goal of aquaponics. Aquaponics systems are more environmentally sustainable than most traditional farming practices, which have resulted in widespread soil erosion, desertification and pollution in Asia (A. Endut, A. Jusoh, N. Ali, & W.B. Wan Nik, 2011). Thus, aquaponics system efficient use of resources, reduction in risk of total crop failure, additional sources of food, extra income and reduction of operation costs for farmers than fish culture alone.

1.3 RESEARCH OBJECTIVES

The objectives of this research are:

i. To determine the characteristics of water quality from the cultured fish tank.
ii. To determine effect of vegetable distribution on the wastewater quality
iii. Effect of the vegetable growth

1.4 SCOPE OF PROPOSED STUDY

In the proposed study, an aquaponics system is my conducted research. I will determine the water quality characteristics from culture fish tank. Besides, I will determine effect of vegetable distribution on the wastewater quality and effect of the vegetable growth. Fish species is an important material in my research besides vegetables. I used catfish (Siluriformes) as fish species and water spinach (Ipomoea aquatic) as vegetable to run my experiment. The catfish I get from Agro Bazaar, Sungai Pekan and brought back to my lab in University Malaysia Pahang (UMP). In my experimental design, I will build a mini aquaponics system. The waste discharge from catfish will treat by Ipomoea aquatic roots and bacteria's and return to fish tank as a clean water. The parameters that will be observed are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Ammonia Nitrogen (NH) and pH. During the experiment, the heights of plant were observed and record every day.

1.5 EXPECTED OUTCOME

Aquaponics is a working model of sustainable food production wherein plant and animal agriculture are integrated and recycling of nutrients and water filtration are linked. As a model of sustainable food production, the science of aquaponics helps agricultural production through the implementation of certain principles. First, the waste products of

one biological system serve as nutrients for a second biological system. Second, the integration of fish and plants results in a polyculture that increases diversity and yields multiple products. Third, water is re-used through biological filtration and recirculation. And the lastly, local food production provides access to healthy foods and enhances the local economy (Lennard, 2012). The expected outcome from our research based on research objectives are Ipomoea aquatic have the ability to reduce the pollution potential of aquaculture wastewater, the vegetable distribution does not effect on the wastewater quality and the vegetable and catfish growing well.

1.6 SIGNIFICANCE OF STUDY

Aquaponics is a refined branch of aquaculture. Aquaponic system is a promising technology in the integration of fish and hydroponic plant production. The wastewaters from fish water are rich in nutrients. These nutrients are used for plant growth, while the plants are used as biofilters for water regeneration (Azizah Endut, A. Jusoh, N. Ali, W.B. Wan Nik, A. Hassan, 2010). Aquaponic system offer several advantages especially to greenhouse growers and farmers. Aquaponics is a working model of sustainable food production wherein plant and animal agriculture are integrated and recycling of nutrients and water filtration are linked. Economically, vegetables and flowering plants can utilize the major nutrients (NO3-N, NH4-N and H2PO4/HPO4- P) for their growth from the nutrient- rich wastewater upon proper management or suitable amendments (Rana, Bag, Golder, Mukherjee (Roy), Pradhan & Jana, 2011). Hydroponics viewed to fish farmer as a biofi ltration method to facilitate intensive recirculating aquaculture and aquaponics viewed to Greenhouse growers as a way to introduce organic hydroponic produce into the marketplace; since the only fertility input is fish feed and all of the nutrients pass through a biological process. Besides, enable the production of fresh vegetables and fish protein in arid regions and on water limited farms, since it is water re-use system by aquaponics system. In addition to commercial application, aquaponics has become a popular training aid on integrated bio-systems with vocational agriculture programs and high school biology classes.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is about searched the related and relevant literature to a research project that had been chosen. It is also, summarize the literature and find the evidences which can answer the research objectives and research questions. Based on the literature that had been found, further research is made on Aquaponic systems: treat the catfish wastewater by vegetable (spinach).

According to Lennard (July, 2012) aquaponic systems contain fish and fish release solid wastes. In aquaponics, I wish to treat these fish waste solids by vegetable and reuse the nutrients for plants growth. The literature review was discus on an aquaponics cycle, biofiltration and suspended solids and fish species and plants adapted to aquaponics.

2.2 AQUAPONICS CYCLE

Aquaponics is the production of vegetables and fish which live in a symbiotic relationship. How aquaponics works? Firstly, fish are raised in a tank. Fish are fed food and produce ammonia rich waste. Too much waste substance is toxic for the fish but they can't withstand high levels of nitrates. Second, water from the fish tank is pumped to the plants. The Plants take in the converted nitrates as nutrients fertilizer, feeding the plants. Also, the plants roots help filter the water for the fish. Third, the bacteria, which is culture in the grow beds as well as the fish tank, breaks down this ammonia into nitrites and the nitrates. Fourth, plants absorb the nutrient rich water. Fifth, filtered water as clean water is returned to the fish tank and ready for the next cycle. Water in the system is filtered through grow medium in the grow beds. The water also contains all the nutrients for the fish. Oxygen enters the system through an air pump and during dry periods. This oxygen is essential for plant growth and fish survival. Figure 2.1 show the Aquaponics cycle by Affnan's Aquaponics (December 01, 2010).

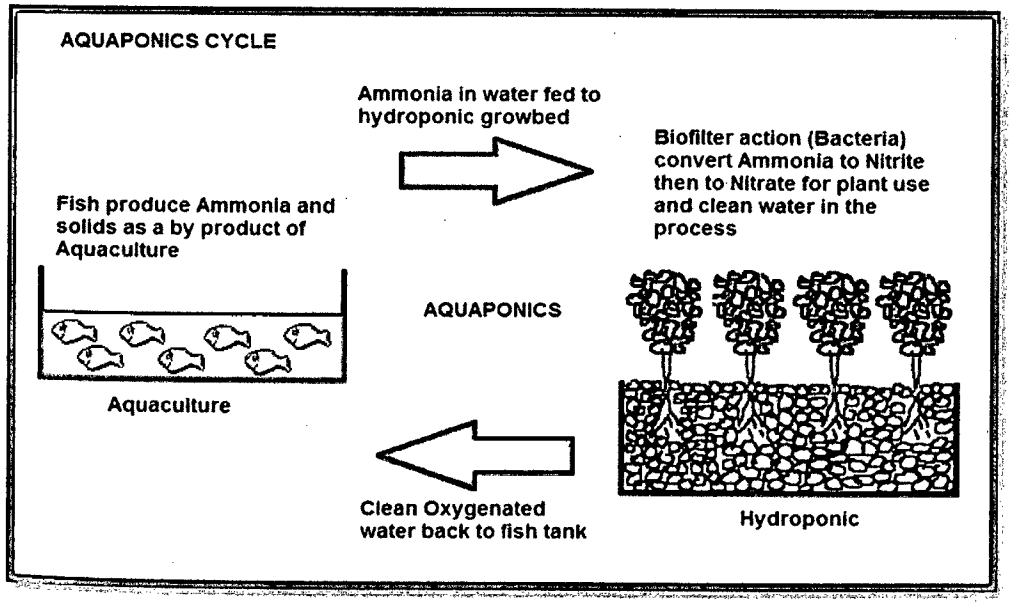

Figure 2.1: Aquaponics cycle

2.3 BIOFILTRATION AND SUSPENDED SOLIDS

Dissolved and suspended organic materials accumulate rapidly in aquaculture systems and must be removed for efficient fish production. Some aquaponic systems are designed with intermediate filters and cartridge to collect suspended solids in fish effluent and to facilitate conversion of ammonia and other waste products to forms more available to plants prior to delivery to hydroponic vegetable beds. Gravel functions as a "fluidized bed bioreactor". This becomes very important in aquaponic systems because the presence of a media that plant roots are grown in can possibly eliminate the need for a separate settling tank and biofilter. Sludge and solid from the fish tank get caught in the media and are processed by bacterial communities that develop in the media, thereby acting as a biofilter and eliminating the need to remove the solids in a separate system. Besides, the water from the fish tank runs through this gravel where the ammonia will be efficiently converted to nitrite and then to nitrate. Furthermore, Rinehart, L. (2010) said, the nitrifying bacteria living in the gravel and in association with the plant roots play a critical role in nutrient cycling; without these microorganisms the whole system would stop functioning. Gravel is heavy enough to provide secure support for the plant's root systems and was used in indoor and outdoor hydroponic systems.

2.4 FISH SPECIES ADAPTED TO AQUAPONICS

Aquarium fish, tilapia, yellow perch, trout, catfish, bass, bluegill, carp, koi, goldfish and freshwater prawns are include as several warm- water fish and cold- water fish species are adapted to aquaponics system. However, I use catfish (Siluriformes) in my research. Catfish species can be grows well in re- circulating system and like temperature around 80° C. But, catfish is more sensitive to temperature, pH and water quality. So, I must checked water quality and add water or do partial water changes if necessary. Have few factors that we must consider to keeping fish healthy. Most fish like pH between 6- 8. In Aquaponic

fish tank, a water pH of 6.5 to 7.0 is maintained (Nelson, 2008). We must maintain the water pH in fish tank to keep fish survival. Potassium hydroxide (KOH) and calcium hydroxide ($Ca(OH)_2$) are often used in the system in order to maintain a pH of 7. Besides that, ammonia and nitrites are very toxic to fish but nitrates are fairly safe for fish and great for plants. So, Aquaponics system will remove this ammonia to produces clean water for fish. Furthermore, fish are sensitive to light. We must avoid direct sunlight on fish tank, cover the top to avoid algae and make fish happy. We need to add water or do partial water changes if necessary.

2.5 PLANTS ADAPTED TO AQUAPONICS

Why do plants like Aquaponics? It is because nutrients constantly provided as fertilizer for plants. The roots plants will absorb this nutrient to growth health. Besides, warm water from fish tank bathing the roots plants and we no need to search for water and food for plants. All plants may have different nutritional requirements; for instance leafy green vegetable require more nitrates than fruiting plants. Lettuce, herbs, and specialty greens (spinach, chives, basil, and watercress) have low to medium nutritional requirements and are well adapted to aquaponic systems. Plants yielding fruit (tomatoes, bell peppers, and cucumbers) have a higher nutritional demand and perform better in a heavily stocked, well established aquaponic system. The selection of plant species adapted to hydroponic culture in aquaponic greenhouses is related to stocking density of fish tanks and subsequent nutrient concentration of aquacultural effluent. Greenhouse varieties of tomatoes are better adapted to low light, high humidity conditions in greenhouses than field varieties. However, I choose water spinach (Ipomoea aquatic) as my plant in my research because it is really to grow.

2.6 NITRIFICATION PROCESS

In natural waters, ammonium is converted rather rapidly to nitrite and further to nitrate by aerobic bacteria from the genera Nitrosomonas and Nitrobacter, through a process called nitrification (A. Endut, A. Jusoh, N. Ali, & W.B. Wan Nik., August, 2011). Ammonia (NH_3) is the waste products of the fish and extremely toxic to fish. First nitrification process is by Nitrosomonas bacteria. Nitrosomonas bacteria is cultured in the grow beds (gravel). This bacteria feed on both oxygen and ammonia and with their biological activities. Reaction of Nitrosomonas bacteria produces excretes a chemical called nitrite (NO_2). Nitrite is toxic to fish but not toxic as ammonia. Second of nitrification process is by Nitrobacter bacteria. Nitrobacter bacteria also cultured in the grow beds (gravel). This bacteria utilize oxygen in it's respiration, acts in similar way as Nitrosomonas bacteria. Reaction of Nitrobacter bacteria have changes the nitrite into a relatively harmless chemical called nitrate (NO_3). Nitrate is primary source of plant nutrition. Plants take in the converted nirates as nutrients. The nutrients are a fertilizer, feeding the plants.

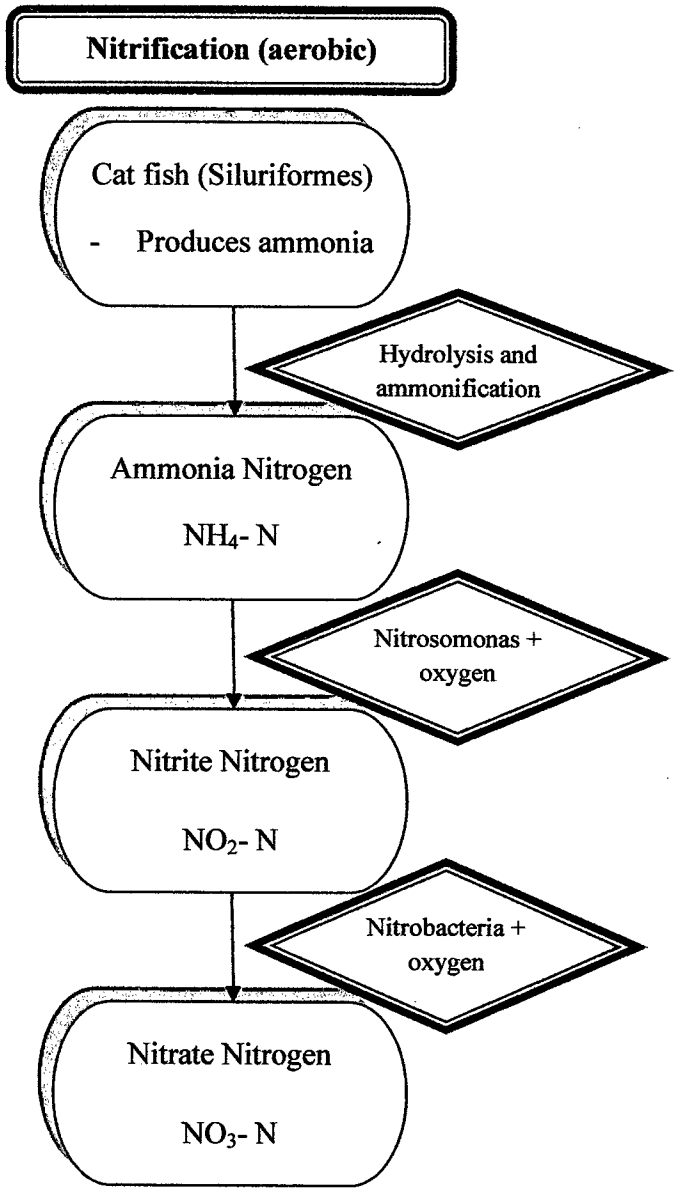

Figure 2.2: Nitrification Process

CHAPTER 3

METHODOLOGY

3.1 EXPERIMENTAL PROGRAM

The methodology process flow for an evaluation of the Aquaponic systems for treat the catfish wastewater by vegetables (Ipomoea aquatic) as illustrated in figure 3.1

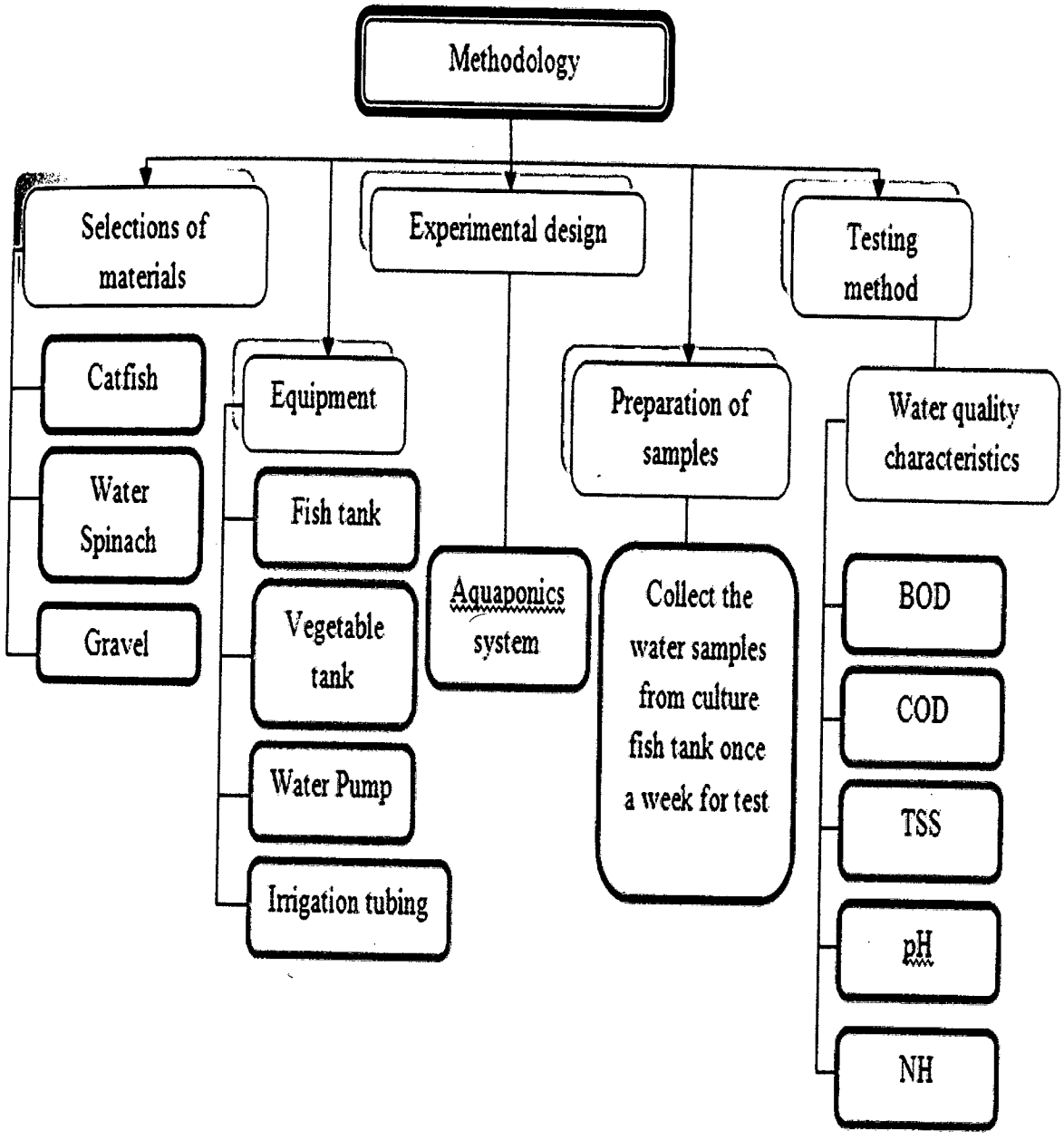

Figure 3.1: The methodology process flow

3.2 SELECTIONS OF MATERIALS

In this experiment, I have prepared three materials to run the Aquaponics system. It is fish, plant and grows bed.

3.2.1 Fish

I have chosen catfish in my research. The scientific name of catfish is Siluriformes. I put 5 tails of catfish in my aquarium and the average size in 18 cm. catfish will products the ammonia and then the Aquaponics system will remove this ammonia for fish health.

Figure 3.2: Catfish (Siluriforme)

3.2.2 Plant

Water spinach as plant I have used in experiment. Ipomoea aquatic is scientific name of water spinach. This water spinach I get from market and then I cut and take the roots. I plant 3 clumps per week on grow beds. I were recorded the effect of water spinach to wastewater quality 3 times in every week and collected the effect of water spinach growth in term of plant height. The

Figure 3.3: Water Spinach (Ipomoea aquatic)