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Impact of some water quality parameters of Nile Tilapia (*Oreochromis niloticus*) farm cultured in different pond systems, Gezira State, Sudan

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Abstract

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Sudan, but little is known about the nutritional value of the Nile fish that are normally utilized either fresh or preserved dried, salted or smoked. The current study was conducted to evaluate the similarities and differences of water quality parameters which are; Total Dissolved Solids “TDS“, pH, Ammonia as and Temperature “C°“ of Cultured Nile tilapia (*Oreochromis niloticus*) fish Ponds in Gezira State, Sudan. A total of 36 samples of water were collected from earthen and concrete ponds of nile tilapia (*Oreochromis niloticus*) around Gezira State and the samples were subjected to analysis for (Ammonia, TDS, Temperature, and pH). The data was subjected to SPSS by using RCD. The findings of this study revealed that,. There was a highly significant difference ($P \leq 0.01$) in all water quality parameters, between earthen and concrete ponds water. The study is recommended that, Measurements of water quality parameters should be taken regularly in order to decide whether to change ponds water or not.

Keywords: *Oreochromis niloticus*, food security, Nile Tilapia

Introduction

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Sudan. However, a little is known about the nutritional value of the Nile fish that are normally utilized either fresh or preserved dried, salted or smoked. Better knowledge of their nutritional value, which is expected to be closely associated with fish species, could contribute to the understanding of variability in meat quality of different species of the Nile fish. Moreover, the measurement of some proximate profiles such as protein contents, lipids and moisture contents is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Waterman, 2000) [18].

Most developing countries are located in tropical or sub-tropical areas, and fish is a vital component of food security for these countries. Rivers and lakes in these countries are more accessible and kinder sources of fish, and also carry over 40% of the world's known fish species (Zenebe *et al*., 1998a) [20]. Moreover, the production and consumption of freshwater fish has increased during recent years. Therefore effort is needed to improve the output performances and quality of the most important tropical freshwater fish.

The production of Tilapia worldwide is being intensified, mainly due to the decline in marine fisheries and to the quality of its meat. Tilapia is suitable for intensive farming and trade. It has characteristics preferred by the market, such as white meat, firm texture, delicate taste, easy filleting, no “Y” -shaped bones, in addition to productive characteristics suitable for breeding: high growth rate and adaptability to different conditions (Jory *et al*., 2000) [11].

The intensive farming of tilapia, *Oreochromis sp*. is rapidly expanding and tilapias (including all species) are the second most widely farmed fish in the world with annual production exceeding two million tons in 2005 (FAO, 2007) [8]. China produces almost half of the worlds' tilapia, usually sold in the form of frozen products (FAO, 2007) [9].

Several species of tilapia are cultured commercially, but Nile tilapia (*Oreochromis niloticus*) is the predominant cultured species worldwide. Nile tilapia is a tropical species native to Africa. It is more tolerant to lower temperatures than most of other tilapia species. The lower and upper lethal temperatures for Nile tilapia are 11 - 12 °C and 42 °C, respectively, while the preferred temperature ranges from 31 to 36 °C (FAO, 2007) [8].

Water is the culture environment for fish and other aquatic organisms. It is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson, 2005) [2]. Based on this, access to adequate, regular and constant supply of good quality water is vital in any aquaculture project. According to Sikoki and Veen (2004) [15], any water body is a potential medium for the production of aquatic organisms. Water quality parameters can be divided into three main categories: physical (density, temperature); chemical (pH, conductivity, nutrients) and biological (bacteria, plankton and parasites) (Delince, 1992) [4]. All living organisms have tolerable limits of water quality parameters in which they perform optimally. A sharp drop or an increase within these limits has adverse effects on their body functions (Davenport, 1993) [3]. Fishes are reared in different culture media that can retain water and these are earthen ponds, concrete, plastic, wooden, metal, glass and fibre glass tanks. The recent increase in intensive aquaculture production in Nigeria will require effective water quality management for its success (Ezenwa, 2006) [7].

Water is the home of the fish and its quality is one of the most over looked aspect of pond management until it affects fish production. Water quality generally means the component of water which must be present for optimum growth of aquatic organisms (Ehiagbonare and Ogundiran, 2010) [5]. Water quality is made up of physical, chemical and biological factors which influence the use of water for fish culture purposes. These factors include dissolved oxygen, pH, hardness, turbidity, alkalinity, ammonia and temperature. Other parameters such as biological oxygen demand and chemical oxygen demand indicate the pollution level of a given water body (Ehiagbonare and Ogundiran, 2010) [5]. Productivity depends on the Physico-chemical characteristics of the water body (Huct, 1986) [10].

Water quality is one of the most critical factors besides good feed/feeding in fish production. For a successful aquaculture venture, the dynamics and management of water quality in culture media must be taken into consideration. Tilapia can survive at pH ranging from 5 to 10 but they do best at a pH range from 6 to 9. Mohamed *et al*., (2009) [13] pointed-out that, Ammonia and Nitrite are a concern in aquaculture systems and should be monitored regularly. Ammonia production is directly related to feeding and depends on the quality of feed, feeding rate, fish size and temperature (Riche and Garling, 2003) [14].

Minerals are required for normal life processes in all animals, including fish. Fish obtain these minerals in their diet (trophic chain) and also directly from water. Minerals are responsible for skeletal formation, colloidal systems maintenance, regulation of acid-base equilibrium and to make a part of important physiological compounds such as hormones and enzymes. Mineral deficiencies can provoke structural and functional pathologies which depend on several factors, including the duration and degree of mineral deprivation (Watanabe *et al*., 1997) [17].

Global aquaculture production has increased over the past fifty years, from less than 1 million t in the early 50's, to 59.4 million t in 2004. According to FAO (2007) [9] estimates, an additional 40 million t of fish will be required by 2030 just to meet the current levels of consumption.

Fish lipid is regarded as quality lipid being rich in cholesterol and triglyceride. The changes in habitat and nutrition may have a significant impact on the quantity of different components of lipid profile.

Justifications

1. The importance of Nile tilapia (*Oreochromis niloticus*) as a source of Protein and unsaturated fats which is low in cholesterol and triglycerides.
2. The noticeable attention that has been paid at Tilapias culture in Sudan so that there is need for characterization of water quality for Nile and Fish farms, special Earthen and Concrete Ponds.

The general objective

The general objective is to standardize the water quality parameters for adequate environment of aquaculture in Gezira State.

The specific objectives

To estimate some parameters of water quality Total Dissolved Solids "TDS", pH and Ammonia as well as Temperature "C°" of Cultured fish Ponds.

Materials and Methods

Area of study

In the present investigation, two sampling sites (Earthen and Concrete Pond Fish Farms) were selected at Gezira State, Sudan. For easy interpretation of results, samples were analyzed depending on general experimental strategy as follows:

- The similarities and differences of water Physico-chemical characteristics of Nile tilapia (*Oreochromis niloticus*) farm were investigated between: earthen fish ponds and concrete fish ponds via laboratory analysis through this study.

Experimental design

The study was carried out in two areas identified as treatments at Gezira State:

Treatment (1) earthen ponds culture tilapia fish was carried out using six ponds for sampling.

Treatment (2) concrete ponds culture tilapia fish was carried out using six ponds for sampling.

Water Samples

A total of 36 samples of water were collected from earthen and concrete fish farm ponds, 18 representative samples were randomly collected from each treatment. 3 representative samples were taken from water depth (Shallow, Middle and Deep) in sterilized water containers (300 ml) and transferred immediately to the laboratory.

Water quality analysis

Water Quality Parameters (Physic-chemical parameters of water) were investigated and analysed include:

Temperature

Temperature (C°) was measured using digital thermo-meter which was taken directly in the fish farms or fields Nile fish farm ponds where Nile Tilapia cultured.

pH determination

The pH value was determined using digital pH-meter which was taken directly in the fish farms or fields where Nile fish farm ponds where Nile Tilapia cultured.

Dissolved oxygen (DO)

Dissolved Oxygen (mg/L) was measured using digital Oxygen-meter which was taken directly in the fish farms or fields where Nile fish farm ponds where Nile Tilapia cultured.

Determinations of TDS

Total Dissolved Solids (mg/L) were measured using digital TDS-meter which was taken directly in the fish farms or fields where Nile fish farm ponds where Nile Tilapia cultured.

Determinations of Ammonia

Ammonia (mg/L) was measured using digital Ammonia-meter which was taken directly in the fish farms or fields where fish samples were taken.

Statistical analysis

The data was analysed by using statistical package for Social Studies (SPSS version 20.0). A CRD was curried-out for means separation of water samples. A P-value of ≤ 0.05 was considered indicative of a statistically significant difference.

Results

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Sudan, but little is known about the nutritional value of the Nile fish that are normally utilized either fresh or preserved dried, salted or smoked. Better knowledge of their nutritional value, which is expected to be closely associated with fish species, could contribute to the understanding of variability in meat quality of different species of the Nile fish. Moreover, the measurement of some proximate profiles such as protein contents, lipids and moisture contents is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000) [18].

This study was conducted to evaluate the similarities and differences in Water Physic-chemical characteristics of Nile tilapia (*Oreochromis niloticus*) farm cultured in different pond systems: earthen and concrete ponds at Gezira State:

Table 1: Profile of Water Quality Parameters according to Pond Types

	Pond		
Parameter	**Earthen Ponds**	**Concrete Ponds**	**Sig.**
Ammonia (mg/L)	$0.25^a \pm 0.09$	$0.84^b \pm 0.09$	**
TDS (mg/L)	$417.00^b \pm 15$	$354.78^a \pm 15$	**
Temperature (C°)	$29.29^a \pm 0.63$	$26.23^b \pm 0.63$	**
pH	$6.68^a \pm 0.05$	$6.12^b \pm 0.05$	**

ab ≡ Means with similar superscripts within the same row are not significant different.
**≡ significant at ($P \leq 0.01$).
Sig. ≡ Significant Level.
TDS ≡ Total Dissolved Solids.

Discussion

Profile of Water Quality Parameters according to Pond Types

Because water is an essential requirement for fish farming, any properly prepared business plan for aquaculture must describes the quality and quantity of water available for the proposed enterprise or feasibility. An experienced aquaculturist can judge whether the water is adequate for the proposed fish farm. The physic-chemical parameters analyzed during study period at different chosen type of Ponds are presented into tables as bellow:

Ammonia

The major source of ammonia in a water of a heavily stocked culture pond or in the effluent of a raceway is from excretion of fish, mostly via their gills. Ammonia is produced by animals as a byproduct of protein metabolism (Boyd, 1990) [1].

Table 1, showed that, ammonia (mg/L) of water from Earthen ponds and Concrete ponds were 0.25 and 0.84 mg/L, respectively. There was a highly significant difference ($P \leq 0.01$) in ammonia between water from earthen ponds and concrete ponds. The higher Ammonia was found in concrete ponds water and the lower was found in earthen ponds water. The earthen ponds were recorded the best value of ammonia than concrete ponds, However, this difference in ammonia whether probably might be due to the nature of pond type, because in the earthen pond we found blue green agley may grow in pond as food and the fish eat this food and clean the pond bottom from residues, so the clean pond bottom the less in Ammonia. Also, perhaps return to the difference in fish density, water change duration and quantity of supplementary feed in fish farms. Hence, the more dense ponds the more waste, also when water spend more time (+20 day for instance) without change this leads to more feces, as it is known that fish feces generate ammonia which is toxic to fish. Moreover, feed residues accumulate in ponds and this also generates ammonia. In addition, there was a strong correlation between temperature and pH with ammonia, the increase in temperature and pH leads to increase in ammonia, as mentioned by Boyd (1990) [1] when temperature fall in 15 ºC and pH 7.0 the ammonia is 0.273, but when temperature increase to 30 ºC and pH 8.0 the ammonia increase to 7.45 accordingly. Ammonia production is directly related to feeding and depends on the quality of feed, feeding rate, fish size and temperature (Riche and Garling, 2003) [14]. However, the findings of this study in less than (Lloyd, 1992) [12] who was figured out that, the recommended levels of ammonia for tilapia aquaculture is >1.00 mg/l.

Total Dissolved Solids TDS

Total Dissolved Solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions. Total Dissolved Solids (TDS) is a measure of all constituents dissolved in water. The inorganic anions dissolved in water include carbonates, chlorides, sulfates and nitrates. The inorganic cations include sodium, potassium, calcium and magnesium. Thus, sulfate is a constituent of TDS and may form salts with sodium, potassium, magnesium and other cations (WHO, 2003).

The fluctuations in the recorded mean TDS levels in the Pond Types are presented in Table (1), showed that, TDS (mg/L) of water from earthen ponds and concrete ponds was 417 and 354.78 mg/L, respectively. There was a highly significant difference (P≤0.01) in TDS between Earthen and concrete ponds. The higher TDS was found in earthen ponds water and the lower was found in concrete ponds water. The concrete ponds were recorded the best value of TDS than earthen ponds,

However, these differences probably might be due to the difference in pond ground, because the nutritional habits for fish reared in earthen ponds are differ from fish reared in concrete ponds, the justification is; in the earthen ponds, fish fed natural food plus supplemented feed, so the residues of food well go to mix with soil, this is why the TDS in Earthen ponds is less than Concrete ponds. Hence, Earthen ponds water was recorded the higher number of TDS than Concrete ponds. However, the findings of this study fall in the optimal limits. The acceptable range of TDS for aquaculture is 20 – 450 mg/L (Environmental Policy and Planning, 2013) [6]. And in the acceptable range which mentioned by WHO, (2003) is 500 mg/L.

Temperature (C°)

Table (1), showed that, temperature (ºC) of water from Earthen and concrete Ponds was 29.29 and 26.23 ºC, respectively. There was a highly significant difference (P≤0.01) in temperature from Earthen and concrete ponds. Water temperature is an important parameter in this study. The measured water temperature in Earthen and Concrete ponds this study is considered normal for Nile tilapia life in Gezira state. The temperature observed in this study corroborates the report of (Lloyd, 1992) [12] whom was pointed out that, the recommended level of temperature for tilapia aquaculture 21 – 32 ºC. Moreover, the recorded temperature is in the ranges of FEPA, (1991) and WHO, (1986) whom were figured out that, the desirable ranges of temperature for Aquaculture are 20 – 30 C°.

pH values

Water pH affects metabolism and physiological processes of fish and exerts considerable influence on toxicity of ammonia. Table (1), showed that, pH value of water from Earthen and concrete Ponds is 6.68 and 6.12, respectively. There was a highly significant difference (P≤0.01) in pH value between earthen and concrete ponds. pH in ponds in this study is normal for nile tilapia rearing. The pH observed in this study less than the report of (Lloyd, 1992) [12] who was figured out that, the recommended level of pH for tilapia aquaculture 6.8 – 9.5 ºC.

Unfortunately, the majority of information available on water quality in aquaculture deals with salmon species. The values represent quality for the optimal growth of the freshwater species rather than absolute limits for specific species (Environmental Policy and Planning, 2013) [6].

Conclusion

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Sudan, but little is known about the nutritional value of the Nile fish that are normally utilized either fresh or preserved dried, salted or smoked. The current study was conducted to evaluate the similarities and differences of water Physico-chemical characteristics of Nile tilapia (*Oreochromis niloticus*) farm in Gezira State, Sudan. A total of 36 samples of water were collected from earthen and concrete ponds of nile tilapia (*Oreochromis niloticus*) around Gezira State and the samples were subjected to analysis for (Ammonia, TDS, Temperature, and pH). The data was subjected to SPSS by using RCD. The findings of this study revealed that,. There was a highly significant difference (P≤0.01) in all water quality parameters, between earthen and concrete ponds water.

Recommendations

According to the findings, we recommended that:

- Aquaculture is so recent in Sudan and only few farmers are aware about water quality parameters, hence the facilities and equipment for physic-chemical parameters measurements should be facilitated to aquaculturists.
- Measurements of water quality parameters should be taken regularly in order to decide whether to change ponds water or not.
- Encouragements and attention should be paid to aquaculture sector in order to shift fish production gradually from fisheries sector to aquaculture systems.
- Monitoring should be focused on unionized ammonia in fish farms because it is toxic to fish even in small amount.

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