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Quantitative Analysis of the Relationship between Different Physico-Chemical Parameters and Fish Yield in Some Selected Fish Ponds in South- East, Nigeria

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Abstract:
Study was conducted to determine the relationship between the different physico-chemical parameters and fish yield in some selected fish ponds in south- east, Nigeria. Water samples were collected from different fish farms for 6 months for analysis. The physico-chemical parameters analyzed were transparency, temperature, pH, dissolved oxygen (DO), carbon dioxide (CO_2), chloride (Cl^-), alkalinity, and hardness. Simple scatter plots were used to determine the quantitative values of each parameter and their effects on the yield of fish. The result showed that Temperature (r=0.025), pH (r=0.000) and DO (0.017) correlated negatively with fish yield in concrete fish farms but transparency (r=0.002), CO_2 (0.006), alkalinity (r=0.543), and hardness (r=0.451) showed positive correlation with fish yield in the same concrete fish farms. Chloride (r=0.006) indicates a near nil effect on fish yield in concrete fish farms. A different scenarios (opposite) were observed in earthen fish farms in the cases of temperature (r = 0.044) and DO (r =0.711) which showed positive correlation with fish yield while the effects of transparency (r = 0.17), pH (r = 0.008), alkalinity (r = 0.022) and hardness (r = 0.188) on fish yield in earthen fish farms were negative. pH (r =0.008) had a mild positive correlation with fish yield in earthen fish farms. Although the mean values of DO in concrete and earthen fish farms were almost equal in concentration but its effects were more felt in concrete fish farms than earthen fish farms which are more or less like open system. The effect of chloride (r = 0.000) on fish yield was nil in earthen fish farms but negligibly mild (r = 0.006) in the concrete fish farms. Also, CO_2 (r = 0.017) in earthen fish farms has similar negligible effects on fish yield as in concrete fish farms (r=0.006). The study therefore recommends strategic management of water quality especially in concrete ponds to ameliorate the negative effects of those parameters such as temperature, pH and DO that have direct bearing on fish yield.

1. Introduction
Pond-raised fish production is an emerging phenomenon in Nigeria. It is an attempt to bridge the huge demand – supply gap of fish products in the country. Analysis of FAO fisheries statistics indicated that the African fish production especially from aquaculture, which stood at 6,600,000 metric tons in 1979 and 7,600,000 metric tons in 2003, is low (FAO, 2003). Fish yield is of paramount important to Aqua-culturist as the main objective of fish rearing is to get good return on investment. There is the need to critically look at factors which affect fish yield. One of such factors is water quality. According to Wikipedia, water quality refers to the chemical, physical, biological and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. However, our concern here is those characteristics of water that affects the survival, reproduction, growth, production, or management of fish. These include temperature, oxygen content, pH, transparency, hardness, and alkalinity. Fishes respond differently to different environmental variables (Yong-Su et al, (2012). The goals of this study were to identify the most important variables affecting the fish yield as well as to determine the correlation (strength and direction) of the various phyisco-chemical parameters with fish yield.

2. Materials and Methods
Water samples from fifteen randomly selected farms in Anambra, Enugu, and Imo states were collected for six months for analysis. Five farms each were selected from three senatorial zone of the state to reflect the geographical spread using purposive sampling. Water samples were collected from Concrete and Earthen fish ponds to compare the physico-chemical parameters. All the samples

were analyzed following Colorimetric and Titrimetric procedures for physico-chemical parameters at the site of collection using LaMotte fresh water aquaculture Test-Kit (Model AQ-2, Code-3633-03). The parameters analyzed were temperature, pH, carbon dioxide, chloride, alkalinity, hardness and dissolved oxygen. Transparency was measured with Secchi disc in (cm).

2.1. Statistical Analysis

Simple Scatter plots were used to determine the quantitative values and effect of different water quality variables on the yield of fish. The strength (numerical values) and the direction (whether positive or negative) of the parameters in relation to fish yield were established through this analysis

3. Results

Figures 1 – 4 show simple regression graphs of the effects of different parameters on fish yield in concrete and earthen fish ponds. Inspection of the scatter graph plots revealed that parameters exhibited different patterns of relationship with fish yield in the two set of ponds.

In figure 1, Temperature (r=0.025) correlated negatively with fish yield in concrete fish ponds but in earthen ponds temperature (r = 0.044), showed weak positive correlation. Transparency (r=0.002) showed weak positive correlation in concrete ponds it effects on fish yield in earthen fish farms were negative.

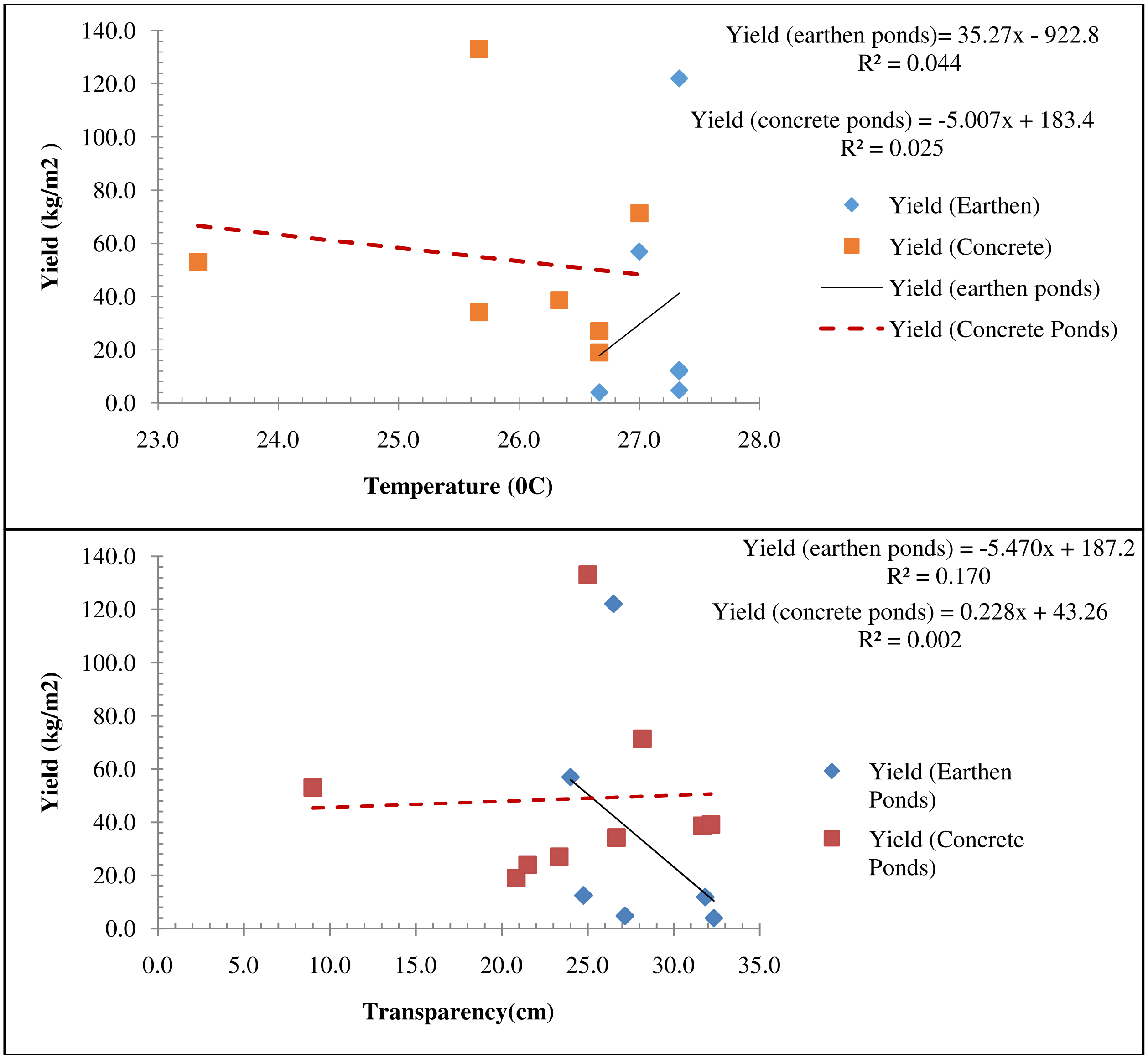

Figure 1: Effect of temperature and transparency on fish yield in concrete and earthen fish ponds

Figure 2 shows the relationship of pH and DO with fish yield. While pH (r=0.000) showed negative correlation both in concrete and earthen ponds, DO (0.017) correlated negatively with fish yield in concrete fish ponds, but demonstrated strong positive correlation (r =0.711) with fish yield in earthen ponds. Although the mean values of DO in concrete and earthen fish farms were almost equal in concentration but its effects were more felt in concrete fish ponds than in earthen fish ponds which are more or less like open system.

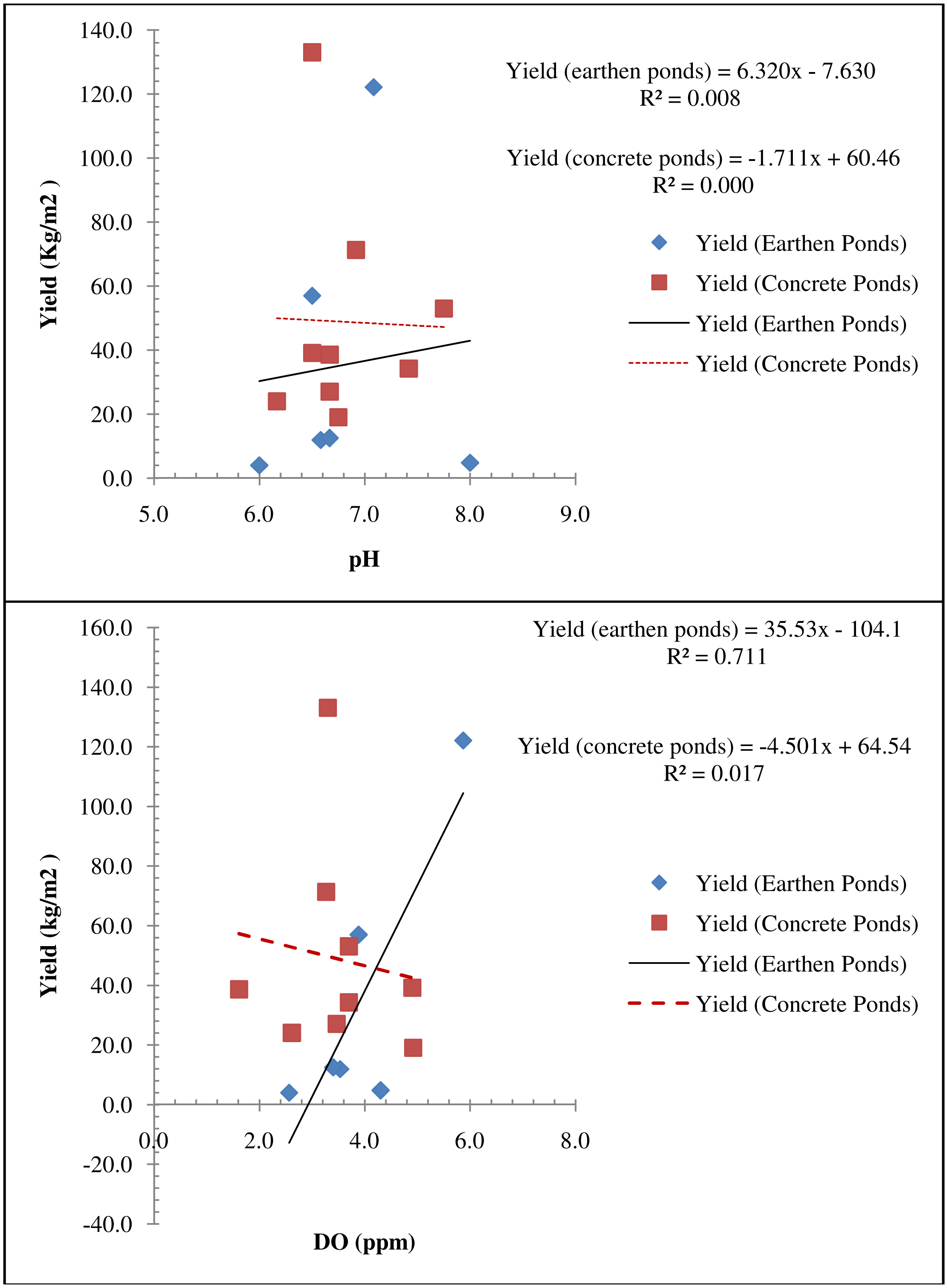

Figure 2: Effect of pH and dissolved oxygen on fish yield in concrete and earthen fish ponds

In figure 3, CO_2 (0.006) and Chloride (r=0.006) showed weak positive and near nil effect correlations respectively on fish yield in concrete fish ponds. Also, in earthen fish ponds the effects of CO_2 (r = 0.017) and chloride (r = 0.000) on fish yield were negligibly mild and nil respectively in earthen fish ponds.

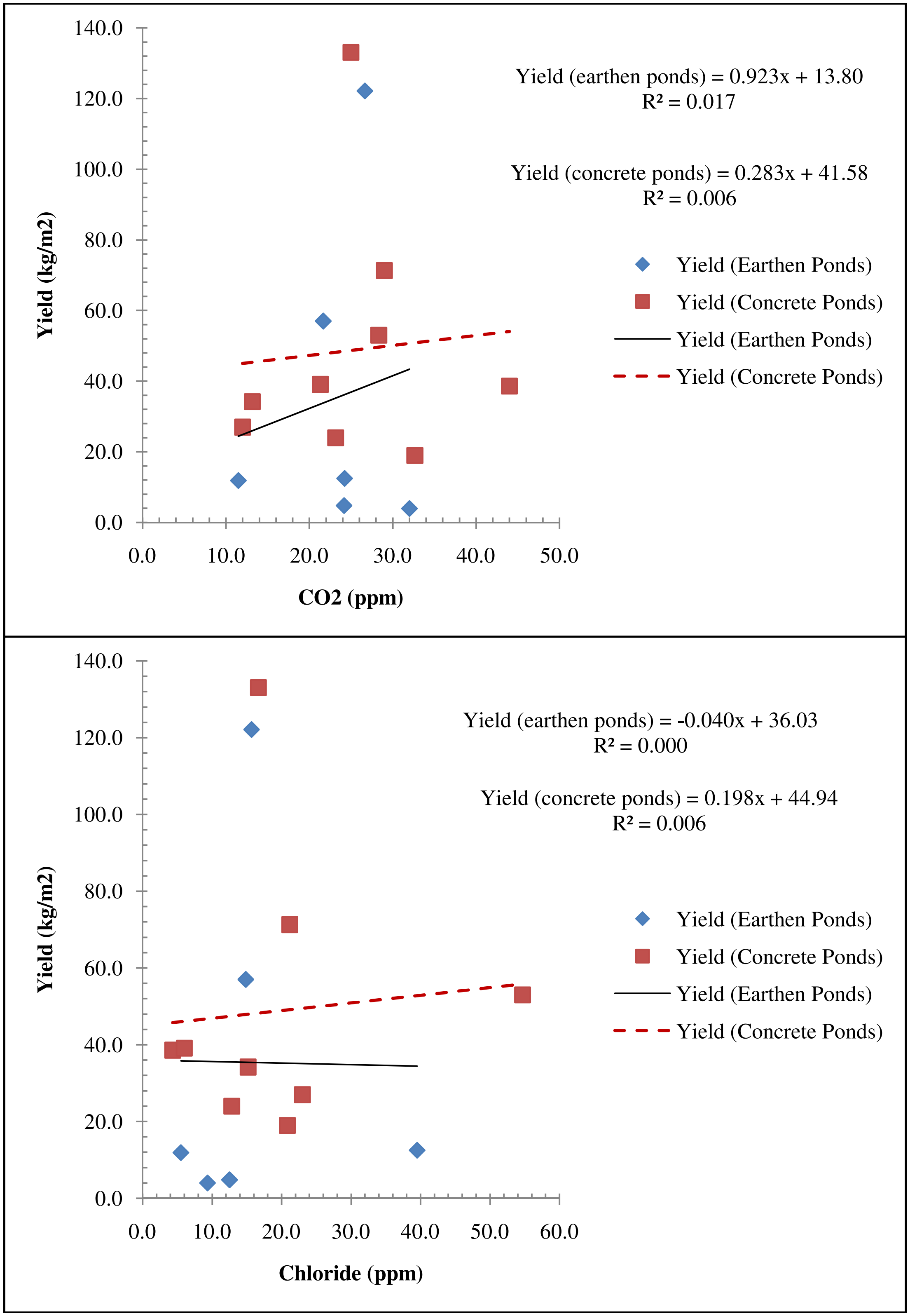

Figure 3: Effect of carbon dioxide and chloride on fish yield in concrete and earthen fish ponds

In figure 4, alkalinity (r=0.543), and hardness (r=0.451) showed strong positive correlation with fish yield in concrete fish ponds but their effects [alkalinity (r = 0.022) and hardness (r = 0.188)] on fish yield in earthen fish farms were negatively correlated.

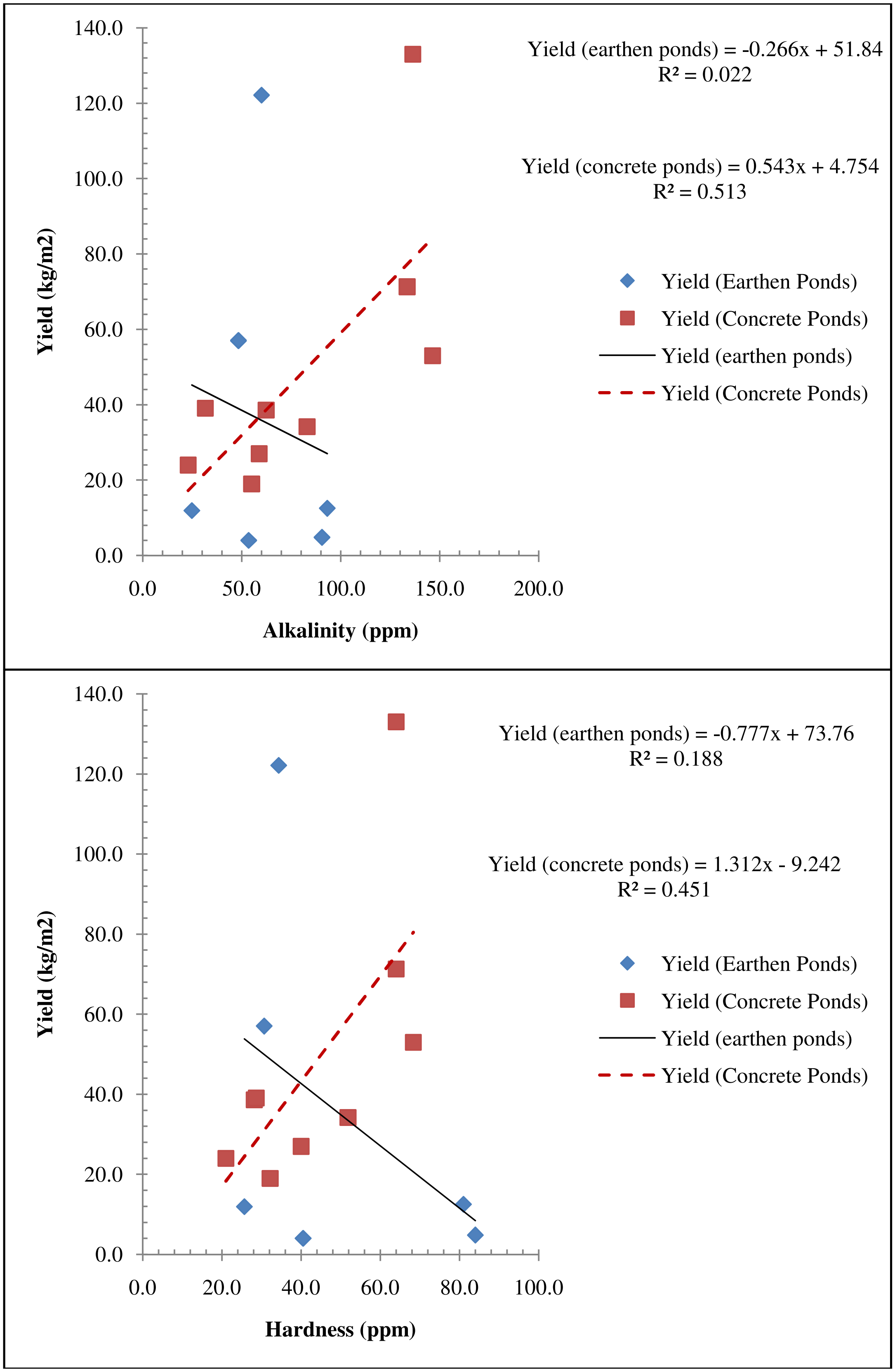

Figure 4: Effect of alkalinity and hardness on fish yield in concrete and earthen fish ponds

Figure5 shows the mean differences between the values of fish yield in concrete farms and the fish yield in earthen fish farms. The figure indicates that the fish yields in both concrete and earthen ponds were not significantly different.

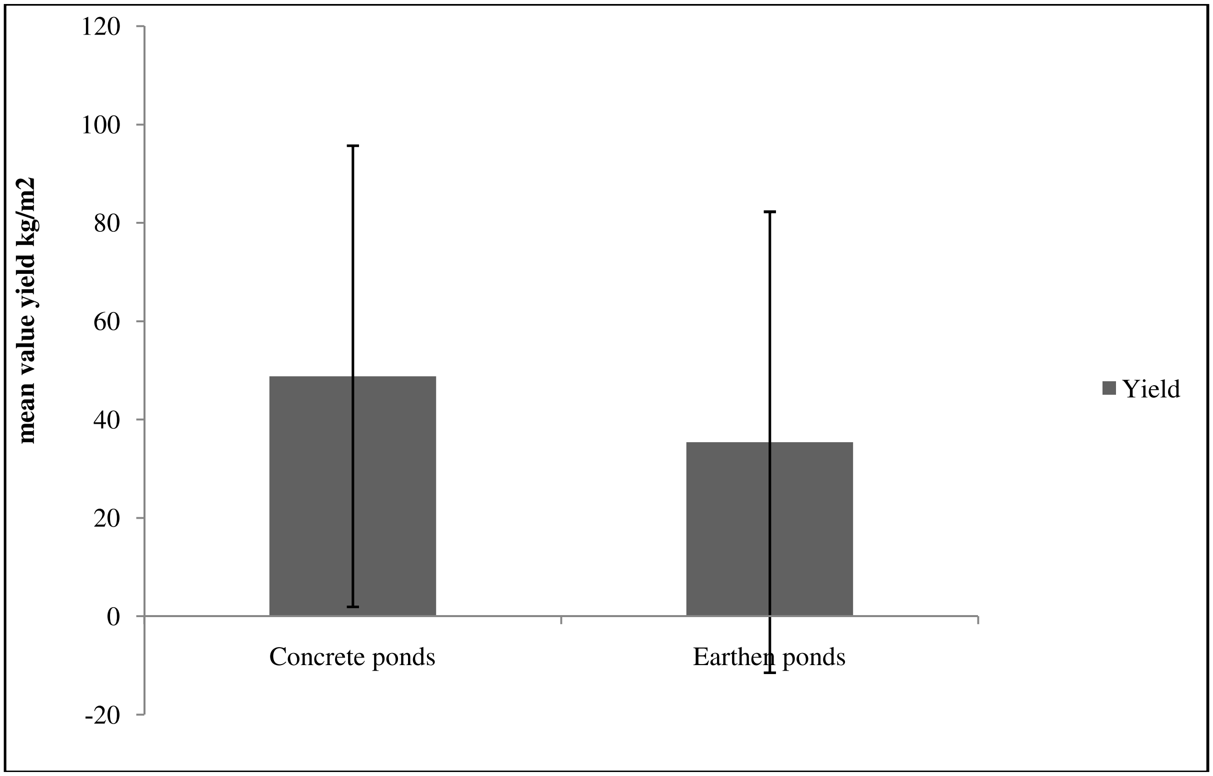

Figure 5: Mean value of fish yield in concrete and earthen fish ponds

4. Discussion

Water quality variables have been known to impact greatly on the yield of fish. Fei (1989) pointed out that water quality variables such as temperature, transparency, oxygen content, pH, hardness, alkalinity and nutrient availability could affect the health, survival, growth, reproduction, production or management of fish. Survival of aquatic biota including fishes depends largely on good quality water. Physico-chemical parameters such as temperature, total suspended solid (TSS) or transparency, pH, CO_2, DO, and chloride have been used as reliable indicators of the quality of natural waters and for providing indirect correlations to a number of different environmental impairments. The values or concentrations attributed to such parameters have equally been used to describe the pollution status of an environment. The resulting data can as well provide baseline information for future reference. The specific effects and quantitative values of different physico-chemical parameters on fish yield as presented in Figures 1 – 4. The result of this study shows that physico- parameters exhibit different pattern of correlations with fish yield. As shown in the above figures, temperature, pH, and DO, correlated negatively with fish yield in concrete fish farms while transparency, CO_2, alkalinity and hardness correlated positively with fish yield also in concrete fish farms. Chloride had nil effect on fish yield. In earthen fish farms, a different scenario (opposite) was observed with regard to temperature, transparency, pH, DO, alkalinity and hardness. In other words, temperature, pH, DO correlated positively with fish yield in concrete ponds while transparency, alkalinity and hardness correlated negatively. This finding highlights an important fact that physico-chemical parameters could have varying effects on fish yield in different environments. Temperature has a profound influence upon the aquatic life because of its influence on water chemistry. Fish cannot maintain their internal body temperature as humans. Temperature affects feeding, growth and reproduction of all fish. Chemical and biological processes are affected by temperature. The rates of chemical and biological reaction double for every $10^{o}C$ increase in temperature. This means that aquatic organisms will use twice as much dissolved oxygen as at $30^{o}C$ than as at $20^{o}C$. It is known that temperature changes of even one to two degree Celsius can cause significant changes in metabolism and other adverse cellular biology effects (Newcombe and Jensen, 1996).

The effect of temperature on the physiology of many fishes has been studied. Landau (1992) reported that reduced temperature slowed down growth of some species whereas higher temperature led to thermal death and increased the outbreak of diseases. Tilapia species also have different temperature requirements. *Tilapia aurea, T. mossambica*, and *O. nilotica* (which are collectively called mouth brooders) spawn and reproduce best at the optimum temperature of $25^{o}C$ to $30^{o}C$, while the substrate spawners *T.rendalli,* and *T. zilli* reproduce at the optimum temperature of $28^{o}C$ (Anonymous, 1990). The most important external factor being ambient water temperature which rises and falls in mean temperature of only a few degrees could cause marked increases or decreases in weight gain.

Evidence that changes in temperature could influence the distribution of some plankton was long ago presented some workers and supported by recent findings of Anthony (2008) who indicated that zooplankton exhibit range shift in response to global warming. The correlation between the temperature and fish yield in concrete fish farms was negative but positive in earthen fish farms. The range of temperature obtained in this study ($25^{o}C$ – $27^{o}C$) was within the optimal levels and could sustain the growth of most fish specifics in the tropic. Therefore, the above finding suggests that other factors rather than temperature might have contributed to the disparity in fish yield between concrete fish farms and earthen fish farms. There was no correlation between temperature and fish yield in this study.

Strong correlation was demonstrated between fish yield and transparency Newcombe and Jensen (1996). Effects of transparency on the aquaculture organisms have been discussed by many workers

EPA (2012) observed some important effects of transparency on growth rate of certain fishes and pointed that suspended materials can clog fish gill, reducing resistance to diseases in fish, lowering growth rates and affecting egg and larval development. At the end of two growing seasons the average total weight of fish in "clear" pond (average turbidities less than 25 mg/l) was about 1.7 times that of fish in ponds with "intermediate" turbidities (ranging from 25 – 100mg/l) and approximately 5.5 times greater than that of fish in "muddy" ponds (turbidities exceeding 100mg/l). Van de *et al* (2005) also reported that transparency affects predator-prey interactions. Other studies indicate that mud transparency could lower fish yield 2-4 times of the normal net yield of a fish pond by modifying the temperature structure of the ponds (Gordon, 2011 and McELwee*et al;* 2000). In this study, transparency correlated positively with fish yield in concrete ponds but correlated negatively with fish yield in earthen fish ponds. The significance of excess turbidity (low transparency) in water on fish and other aquatic life begins by modifying the temperature structure of the ponds thereby lowering the primary productivity and reduction in fish yield.

No effect was manifested between pH and fish yield in earthen fish farms but pH correlated with fish yield in concrete fish farms. Effects of pH in the aquatic culture systems have been reported by several workers. As the pH rises the equilibrium between NH_4^+ and NH_3 in water shifts toward the NH_3 form. The NH_3 form is highly toxic to most fish. Water at pH 6.5 may be entirely safe for fish, whereas the same water at pH 8.0 may be highly toxic to the same fish. However, the most serious chronic effects of increased acidity in surface waters appear to be the interference with fish's reproductive cycle. Calcium levels in the female fish may be lowered to the point where she cannot produce eggs or the eggs fail to pass from ovaries or if fertilized, the eggs and/or larvae develop abnormally (EPA, 1980).

DO correlate positively with fish yield in concrete fish farms but negatively in earthen fish farms. The importance of dissolved oxygen in fish culture demands that the fish culturist should be familiar with the dynamics of dissolved oxygen concentration in ponds. Breth *et al.* (2005) observed that if a sufficient level of dissolved oxygen is not maintained, animals will be stressed, becoming vulnerable to diseases and parasites outbreaks, and might refuse to eat for a period during and after oxygen depletion. Thus growth rate and food conversion efficiency will suffer and feed will be wasted if prepared diets are provided. They therefore argued that if DO falls to a concentration that placed stress on animals or threatened their lives, other water quality parameters tended to become insignificant until DO is reestablished at a safe concentration.

Carbon dioxide is essential for plant growth and in usually present as a free gas or bound with other elements to form bicarbonates, carbonate and other organic compounds. High levels of free CO_2 can cause problems at pH levels (pH < 7.0) (Breth *et al;* 2005). It has been reported that high levels of CO_2 (20 – 39mg/l) higher than the recommended 15mg/l has caused problem in RAS growing Murray Cod. Symptoms of fish exposed to excess CO_2 include dyspnoea and chronic inflammation and calcium carbonate deposition in the kidney and epaxial muscles (Breth *et al;* 2005).

In this study, the correlation of CO_2 with fish yield in concrete fish farms (r = 0.006) and earthen fish farms was very negligible (r = 0.007), but with the mean range of CO_2 in earthen fish farms and concrete fish above the recommended limit of 15mg/l, continuous exposure was likely to have adverse effect on the fish.

Chloride ion is widely distributed in nature and due to its high solubility and mobility in the groundwater it can impact water quality in some distance away (Regina, 2007). Chloride levels above 250mg/l, as stated by Regina are sufficient to reduce agricultural yield. In this investigation however, the level of chloride found were not significant to affect fish yield. As a matter of fact, chloride correlated neutrally (r = 0.00) with fish yield in earthen fish farms and negligibly in concrete (r = 0.006) fish farms.

Alkalinity and hardness correlated positively with fish yield in concrete fish farms but correlated negatively with fish yield in earthen fish farms.

Alkalinity is a reflection of the carbonate and bicarbonate content of the water while hardness refers to the concentration of divalent cations (primarily calcium and magnesium) present in water expressed in terms of milligram per liter of calcium carbonate. Alkalinity protects or buffers against pH change.

The import of this finding is that having established the quantitative value of each of the parameter and their effect on fish yield, strategic management of water quality is required to ameliorate the negative effects of these parameters that have direct bearing on fish yield.

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