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INTER-RELATIONSHIP BETWEEN MAJOR IONS, TOTAL DISSOLVED SOLIDS AND CONDUCTIVITY IN SOME TROPICAL FISH PONDS

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ABSTRACT

Major ions, total dissolved solids (T.D.S), conductivity and their inter-relationships were investigated in eight fish ponds located in Ile-Ife, Nigeria. Chloride concentrations were the least of all the ions measured. Sulphate and magnesium concentrations were highest in station 7 while other parameters (potassium, chloride, calcium, alkalinity, conductivity and total dissolved solids (T.D.S) were highest in Station 6. The ponds belong to class 1 of the African waters since they all have electrical conductance of less than 600μs cm^{-1}. Highest conductivity values were recorded between March and May and thereafter, values dropped gradually till the end of the investigation in August. Very high positive correlations existed between the summation of the total cations and anions, suggesting a direct relationship between the measured ions. Similarly, high and positive correlations existed between the total ions and electrical conductance and between total dissolved solids (T.D.S) and conductivity of the pond waters, also suggesting that increase in total ions still results in the increasing level of total dissolved solids (T.D.S) and electrical conductance. These interrelationships are used to explain the contributive role of each ion to the total dissolved solids (T.D.S) and conductivity levels of a tropical fish pond.

Key Words: Major ions, Conductivity, Tropical Fish Ponds.

INTRODUCTION

In Nigeria, Osun State is one of the leading states in aquaculture production, the major aim being the production of fish for either commercial purpose or house-hold consumption. However, pond fish culture requires reliable and accurate data for use in water quality management. The knowledge of the interrelationship between water quality parameters can act as a useful tool in predicting the productivity vis a vis the total fish yield in ponds. For instance, Boyd and Walley (1975) found that hardness and total alkalinity of pond waters in Alabama were closely related to the geologic and edaphic characteristics of watersheds.

In Nigeria, not much attention has been paid to the study of the water chemistry of fish ponds. Among the available records are those of Asuquo (1990) and Ekpenyong (1991). The present study was therefore initiated to provide data on the water chemistry of some fish ponds in Ile-Ife, Nigeria, with emphasis on the major anions (HCO_3^-, SO_4^{2-} and Cl^-), major cations (Ca^{2+}, K^+, Na^+, Mg^{2+}), total dissolved solids (TDS), conductivity, and to assess the interrelationship between the measured parameters in the studied fish ponds.

AREA OF STUDY

The study ponds are located in Ile-Ife (latitude 7°29'N and longitude 4°34'E) in Osun State of Nigeria. The climate of Ife is governed by the two dominant seasons, the wet season (April to October) and the dry season (November to March). The rainfall regime is characterized by two peaks-the major one occurring in June/July and the minor one occurring in September or October. There is abundant sunshine all throughout the year while temperatures are more or less equal, with very low levels of variation.

Following the classification of Keay 1959 (cited Omolekulo, 1981), the vegetation of Ile-Ife consists mainly of lowland rain forest and some areas of derived grasslands while the rock types found in the area include gneisis, pegmatite, schist and undifferentiated schists (Adepoiu, 1981).

MATERIALS AND METHODS

Surface water samples were collected at fortnightly intervals between 30th March and 14th August 1981, in clean 1-litre plastic containers, from eight fish ponds located at different parts of Ile-Ife, Nigeria.

Sodium, potassium and chloride concentrations were determined according to Golterman (1979) while calcium and magnesium concentrations were determined titrimetrically using E.D.T.A. with Calcon and Erichrome Black indicators respectively. Sulphate and alkalinity concentrations were determined according to A.P.H.A. (1980). Conductivity was measured with the aid of conductivity meter in μS cm^{-1} at 25°C.

Total anions and total cations were obtained by the summation (meq l^{-1}) of the major anions and cations while the total ion was determined from the summation of all the total anions and cations. The concentration of total dissolved solids (T.D.S) was determined by filtering the samples under pressure through a millipore filter paper (size, 0.15μ) and dried to a constant weight at 105°C (APHA, 1980).

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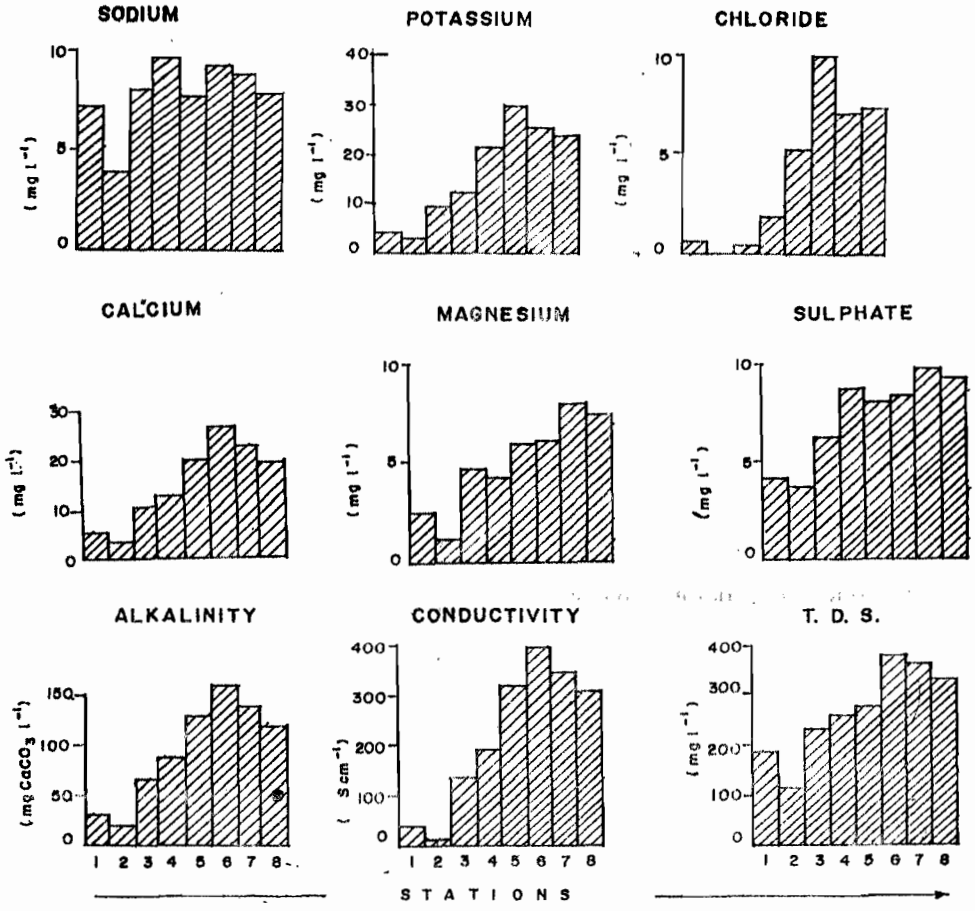

Fig. 1
Levels of investigated parameters in the study ponds.

RESULTS AND DISCUSSION

Frequency distribution histograms (Fig. 1) were prepared to give a visual comparison across the study ponds in terms of the investigated parameters. Except for sodium, all the parameters maintained a similar pattern of distribution. Chloride was undetectable in station 2 and maintained a relatively low level between

Table 1: Correlation Matrix Showing the Relationship Between the Investigated Parameters

	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	SO_4^-	Cl^-	Cond.	TDS
Ca^{2+}	1.000								
Mg^{2+}	0.685	1.000							
Na^{+}	0.411	0.485	1.000						
K^{+}	0.829	0.708	0.458	1.000					
HCO_3^-	0.719	0.752	0.517	0.880	1.000				
SO_4^-	0.266	0.070	0.069	0.367	0.334	1.000			
Cl^-	0.717	0.552	0.407	0.894	0.793	0.446	1.000		
Cond.	0.555	0.537	0.418	0.691	0.935	0.065	0.536	1.000	
TDS	0.490	0.583	0.543	0.658	0.656	0.083	0.611	0.503	1.000

$P \leq 0.05$ ($r = 0.25$) $P \leq 0.01$ ($r = 0.354$) $P \leq 0.001$ ($r = 0.443$)

Key: Cond = Conductivity; TDS = Total dissolved solids

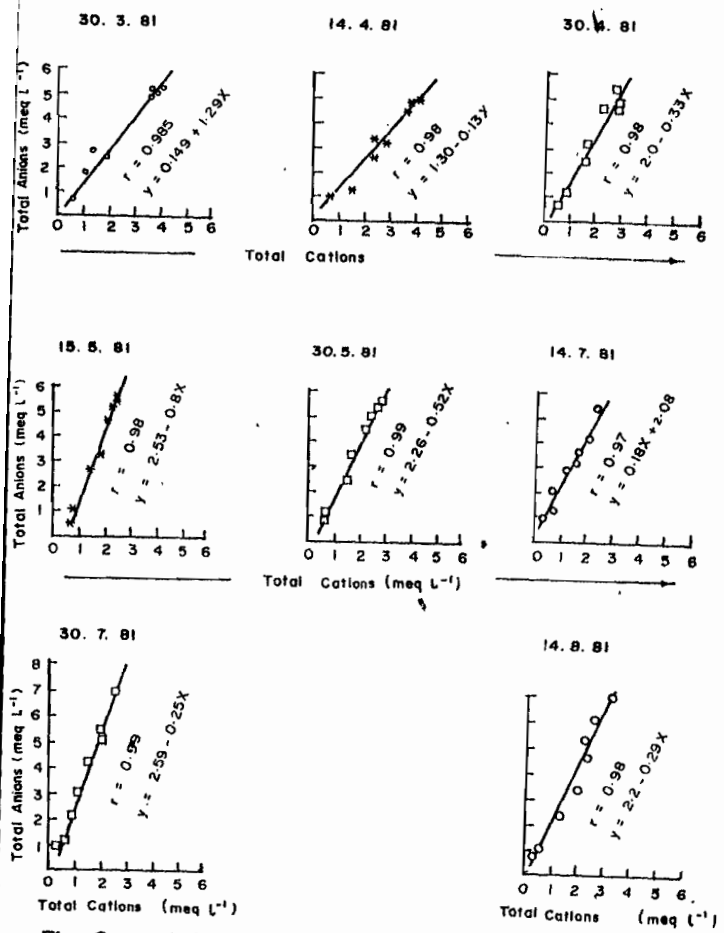

Fig. 2 Relationship between the total anions and the total cations of the pond waters.

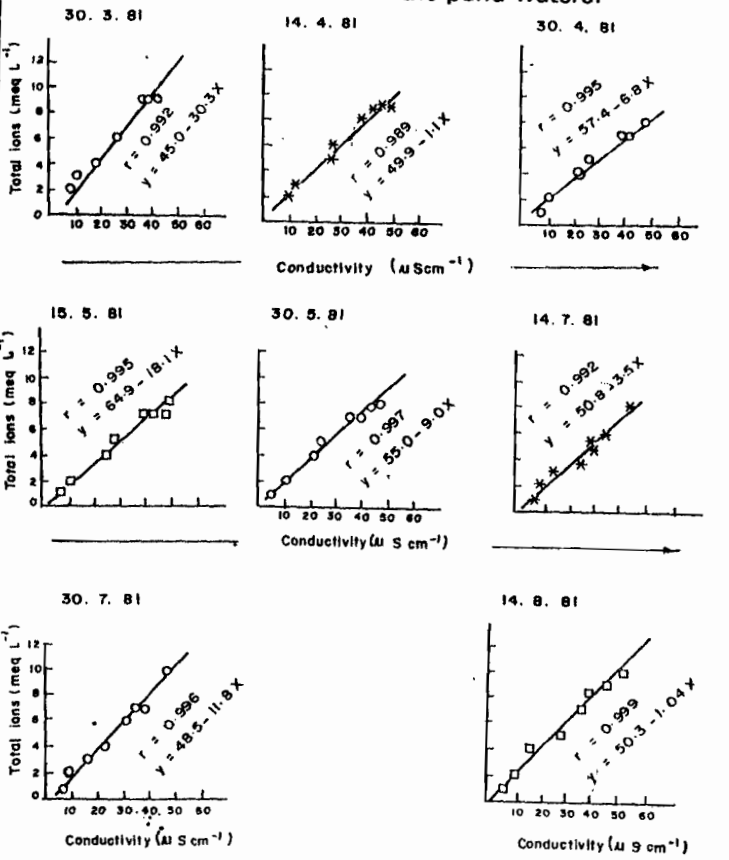

Fig. 3 Relationship between the total ions and electrical conductivity of the pond waters.

stations 1 and 5. Station 7 recorded the highest concentration of sulphate and magnesium while station 6 had the highest concentration of all other parameters, except sodium at station 4. The constancy of sodium indicates that it is the most abundant ion in fresh water fish ponds.

Conductivity (ranging from 74.4 to 467.8 μS cm^{-1}) were low as compared to existing conductivity record on African waters according to Talling and Talling, 1965 (cited Ayodele, 1979). Based on the above results, the study ponds all belong to class 1 of the African waters since they all have electrical conductance of less than 600 μS cm^{-1}. Similarly, low conductivity values were obtained by Egborge (1977), and Ayodele (1979) for Lake Asejire and some other lakes in the Osun River Basin respectively. The low values may be due to the fact that the ponds are low in total dissolved solids (T.D.S), values of which were relatively higher between March and May, after which there was a gradual decrease till the end of the sampling period in August. This trend seems normal because the period between March and May, marks the beginning of the rains which normally dissolve the bulk of both inorganic and organic materials that had been deposited during the dry season in the ponds.

Similarly, the total dissolved solids (T.D.S) should have been expected to drop as the rainy season progressed. The increase is attributed to the addition of the K, Ca, and Cl ions by surface run off in the pond. The relationship between the individual parameters considered in pairs is shown in table 1. Positive correlations were observed for all the parameters. Except for the relationship between SO_4 and Na^+ (r = 0.07); between SO_4 and T.D.S. (r = 0.08), and SO_4 and Mg^{2+} (r = 0.07) which were very low, most of the relationships gave r values above average, thus depicting that there is a close relationship between the various parameters.

Plots of the summation of the major anions (HCO_3^- + SO_4^- + Cl^-) against the summation of the major cations (Ca^{2+} + K^+ Na^+) for each of the sampling dates is given in Fig. 2. The major ions account for almost all of the total ions in natural waters and the summation of anions and cations must be comparable because of the principle of electrical neutrality (Hutchinson, 1957; Livingstone, 1963; Sawyer and McCarty, 1967; Stumm and Morgan, 1970 and Wetzel, 1975). Throughout the sampling period, there were high and positive correlations between these two factors and values ranged between r = 0.97 and r = 0.99, n = 64. While working on the water chemistry of some Alabama ponds, Arce and Boyd, (1980) achieved a good agreement between the summation of major anions and major cations, and according to Hem (1970), this suggests a high degree of accuracy in analytical work and this is also true of the present study.

The major cations and anions also account for essentially all the electrical conductance of a water sample. The observed strong and positive correlations existing between the total ions and electrical conductivity (r = 0.99) of the pond waters (Fig. 3) also suggests a high degree of accuracy in the analytical

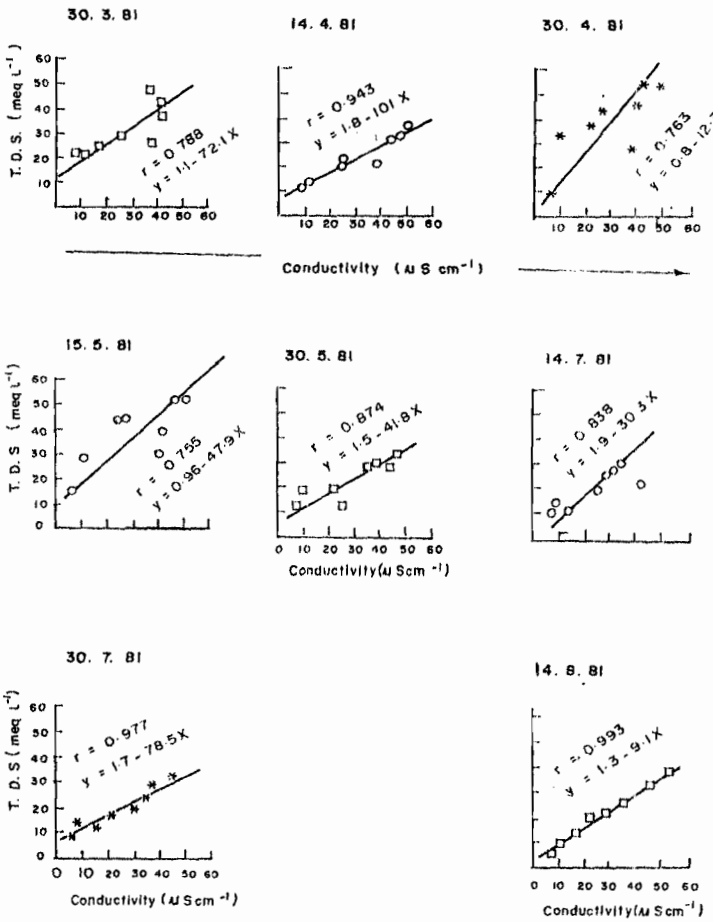

Fig. 4 Relationship between the total dissolved solids (T.D.S) and the conductivity of the pond waters.

procedures as earlier pointed out by Arce and Boyd (1980).

Also, highly significant and positive correlations ranging from r = 0.76 to r = 0.99) have been found to exist between the total dissolved solids (T.D.S) and the conductivity of the ponds (Fig. 4). This is probably due to the fact that the ability of a solution to conduct electricity is directly proportional to the ionic concentration and it is therefore, not surprising that high and significant correlations should exist between the two factors.

CONCLUSION

From the above findings, the following conclusions are reached:

Chloride levels have been observed to be low in the study ponds possibly due to the absence of salt deposits in the vicinity of the ponds and the fact that they are entirely freshwater ecosystems. The high levels of magnesium and sulphate suggest the occurrence of gypsum and carbonate rocks while the observed high positive correlations between the measured parameters is indicative of a direct relationship between them. It can also be concluded that the major determinants of total dissolved solids (T.D.S) and conductivity in the studied fish ponds are sodium (Na), Potassium (K) Chloride (Cl) and Calcium

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