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Physical-chemical research of a mountain reservoir in filling phase

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Introduction

Riaño Reservoir is a system in the initial working phases (the beginning of its filling date: 1/1/1988) so the results give the first information about it. Main aim has been the characterization of Riaño Reservoir and it is revealed to be particularly interesting because of the lack of similar researches on the subject that have been carried out in Spain (Vidal 1976).

Description of the study area

Riaño Reservoir is located in the north-eastern part of the León Province, in the southern slope of the Cantabrian Mountain Range. This reservoir regulates the Esla River and is mainly used for irrigation and power generation (Table 1).

The Basin has the general characteristic of the alternating different sedimentary materials: Limestone, shale, sandstone, quartzite and conglomerates (Alonso 1987).

The climate in the area is continental, the average annual precipitation is 1324 mm and the mean annual temperature 8 °C.

Methodology

A sampling station was placed 250 m from the dam. Water samples were collected from this station with a Niskin bottle (capacity: 5 l) in 0, 2, 5, 10, 15, 20, 30, ... m. There were analysed: Temperature, pH, conductivity, alkalinity, oxygen, ammonia, nitrites, nitrates, orthophosphates, silica, sulphates, chlorine, sodium, potassium, calcium and magnesium. The analytic procedures used are described in Margalef et al. (1976), Rodier (1981), Grasshoff et al. (1983) and Standard Methods (1985).

To the statistical treatment of the data, a Principal Components Analysis (85 cases and 15 variables) was used by the statistical set SPSS. Previously, it was used the Kolmogorov and Smirnov' Test to verify the normality of data, then, those variables which did not fit into this kind of distribution were transformed.

Table 1. Morphometric characteristica of Riaño Reservoir.

Maximum capacity (Hm^3)	664
Surface (ha)	2,263.418
Average width (m)	1,800
Average length (m)	19.800
Height of the dam (m)	102.50
Line of the overflow channel (m)	1,097
Maximum line (m)	1,103
Minimum line (m)	1,012

Results and discussion

Table 2 shows the relation of the physical-chemical parameters and the mean and typical deviations that allow a first approach to the characteristics of the Riaño Reservoir. Likewise, the logarithmic and exponential transformations (where appropriate) that were applied to the variables are shown. The orthophosphate has not been considered in the Principal Components Analysis because of its low concentration.

The first three components resulting from the analysis explain 61.8 % total variance (Fig. 1).

The first component (28.9 %) is positively correlated to conductivity, calcium, nitrite, alkalinity, and negatively correlated to pH and oxygen.

Table 2. Variables, units and transformations used.

Variables	Units	Transformations
Temperature	(°C)	Log (x + 1)
pH		Not transformed
Conductivity	$\mu S \cdot cm^{-1}$	Log (x + 0.001)
Alkalinity	$meq \cdot l^{-1}$	Log (x + 0.001)
Oxygen	$mg \cdot l^{-1}$	Not transformed
Calcium	$mg \cdot l^{-1}$	Log (x + 0.001)
Magnesium	$mg \cdot l^{-1}$	Not transformed
Sodium	$mg \cdot l^{-1}$	$-1/(10\times)^{1/2}$
Potasium	$mg \cdot l^{-1}$	Log (x + 0.001)
Chlorine	$mg \cdot l^{-1}$	Log (x + 0.001)
Sulphate	$\mu M\ SO_4^{-2}$	Not transformed
Silicate	$\mu M\ SiO_3^{-2}$	Log (x + 0.001)
Ortophosphate	$\mu M\ P\text{-}PO_4^{-3}$	Not included in the PCA
Nitrite	$\mu M\ N\text{-}NO_2^-$	$x^{1/3}$
Nitrate	$\mu M\ N\text{-}NO_3^-$	$x^{1/5}$
Ammonium	$\mu M\ N\text{-}NH_4^+$	$x^{1/3}$

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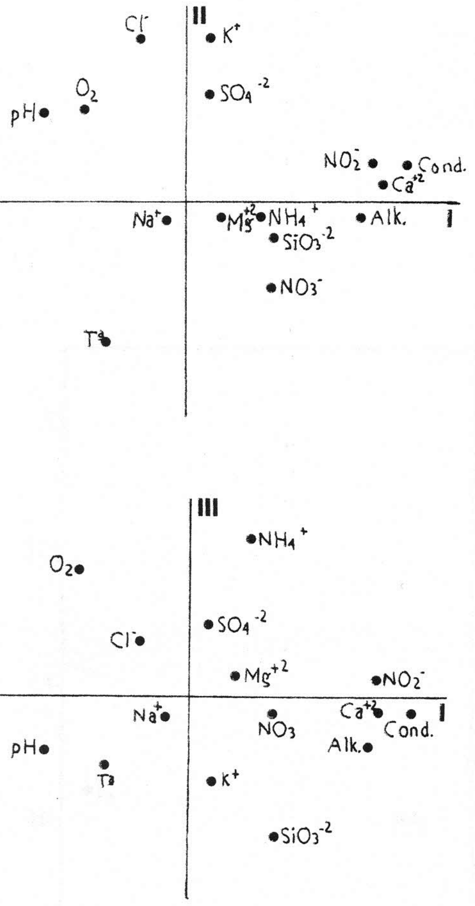

Fig. 1. Distribution of the studied variables in the spaces determined by: A) Principal Components I and II, B) I and II. The variable graph is obtained from the rotated factor matrix.

This distribution of the variables allows for the definition associated with this axis, of a gradient of mainly alkaline mineralization because of the high correlation between conductivity and alkalinity ($r = 0.712$). This has been observed by other authors (Toja 1984). The calcium make up the main cation in this water. The nitrite position close to this group of variables can be explained by its increase at the bottom of the reservoir, where it coincides with the high values of conductivity. The correlation between pH and oxygen is explained by the phytoplankton's primary production.

The variables most closely associated with second factor (20.1 %) are: In the positive sense, potassium and chlorine; in the negative sense, temperature. The opposition between these variables does not give a significant information to the physical-chemical dynamics of the reservoir and they may be associated to punctual measurements in certain seasons. These ions have a tiny contribution to the whole of the ionic balance.

The third axis (12.8 %) sets up a clear polarity between silicate and oxygen. This is closely related to the diatoms' activity: They incorporate silica out of the environment and increase the concentration of dissolved oxygen. But the most important variable is the ammonia. It has not been found and explanation is according to the tendency indicated by this axis.

From the order of the samplings in the plane the first of the two axis define (Fig. 2), it may be set up as main characteristic that the most remarkable tendency of variation is related to the first component and, then, according to the gradient of mineralization. The samples with highest values of conductivity are those from September to November (the seasons of top contribution of ions from the basin towards the reservoir) in contrast with the less mineralized samples from June 1988, and June–July 1989. In each month there is also a variation that is imposed by this axis in vertical direction with tendency to an increase of conductivity and alkalinity.

The second component indicates the distribution of the samples in February because of the temperature conditions (extremely low) of the water that caused the freezing of the surface in the large part of the reservoir. At the same time, the highest values of chlorine and potassium were recorded. Because of all this, the variability of the order samples remains eclipsed and they are not put in order in a defined sequence along this axis.

As was expected for axis 3, winter months (with less production of diatoms) set up the extreme with most silicate in the water in contrast with the spring, particularly May, when the lowest values of this parameter were observed.

Taking all the results obtained into account and the immature state of the system and the irregularity of the filling process a dynamics in the physical-chemical composition into the temporal variation that could be comparable to the dynamic obtained in other reservoirs with a more regular working, cannot be established.

Acknowledgements

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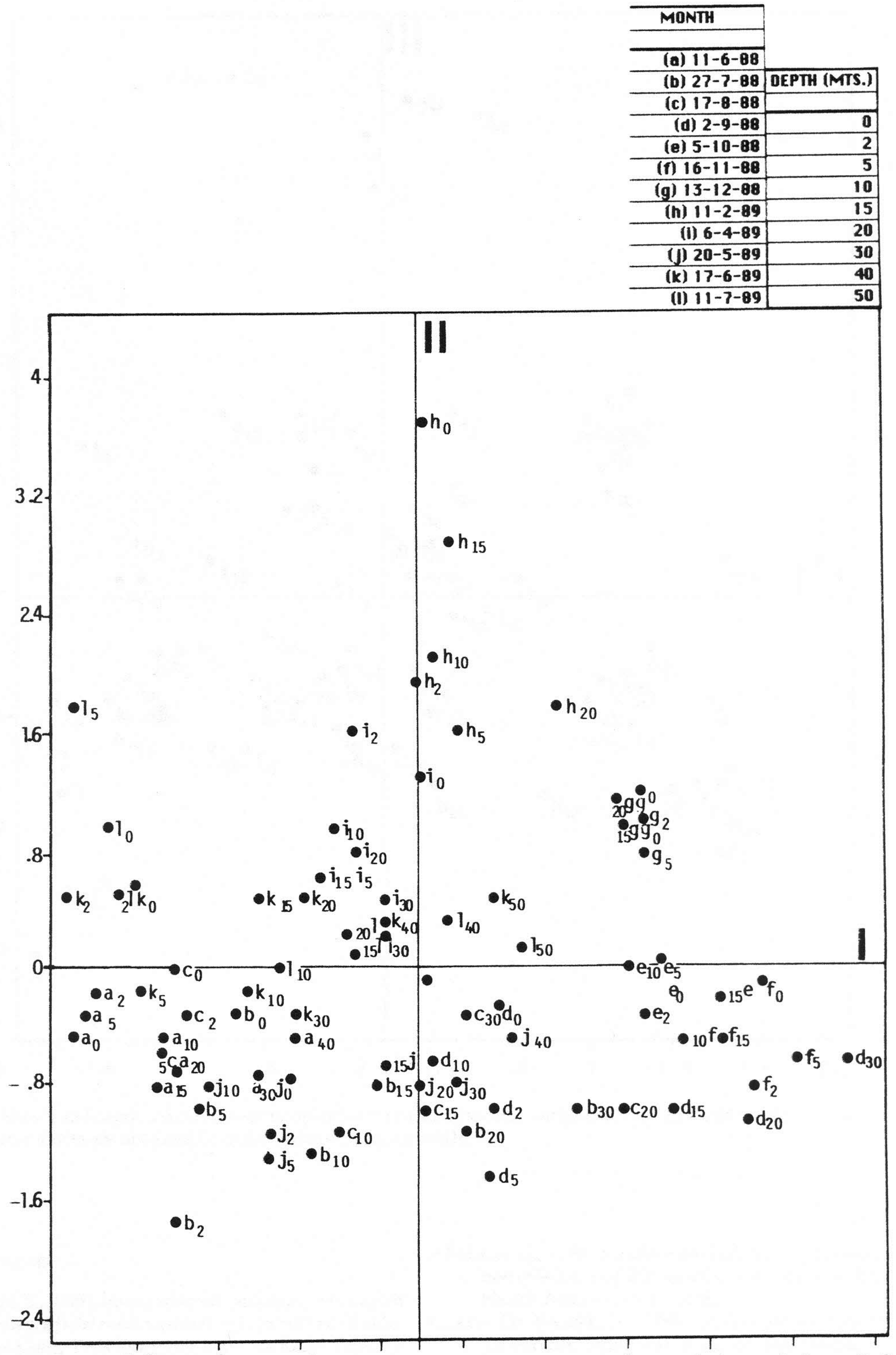
MONTH
(a) 11-6-88
(b) 27-7-88
(c) 17-8-88
(d) 2-9-88
(e) 5-10-88
(f) 16-11-88
(g) 13-12-88
(h) 11-2-89
(i) 6-4-89
(j) 20-5-89
(k) 17-6-89
(l) 11-7-89
DEPTH (MTS.)
0
2
5
10
15
20
30
40
50
II
I
4
3.2
2.4
1.6
.8
0
-.8
-1.6
-2.4
-1.1
-1
-.6
-.2
0
.2
.6
1
1.4
1.8
2.2
h0
h15
h10
h2
h20
l5
i2
h5
i0
g0
g2
g5
l0
i10
i20
i15
i5
k2
k0
k15
k20
i30
k40
k50
l40
l50
l30
l20
l15
c0
l10
e10
e5
e0
f0
e15
a2
k5
k10
a5
c2
b0
k30
c30
d0
e2
a0
a10
a40
j40
f10
f15
a20
j15
d10
f5
d30
a15
j10
a30
j0
b15
j20
j30
f2
b5
c15
d2
b30
c20
d15
d20
j2
c10
b20
j5
b10
d5
b2

Fig. 2 a

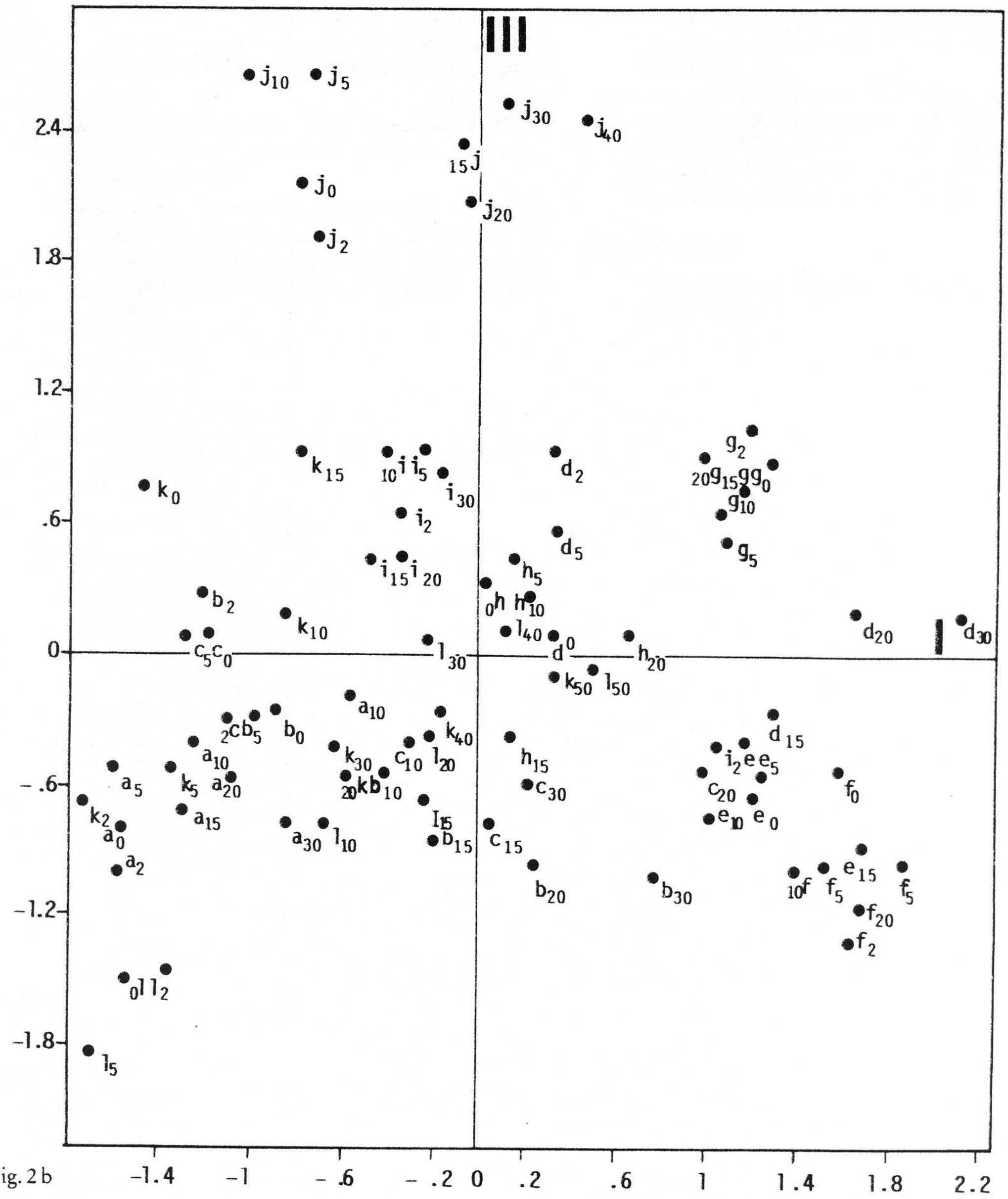

Fig. 2b

Fig. 2. Month and depth distribution of samples for the first and second components and first and third components. The factor scores are obtained from the minimum square method.

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