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FACTOR ANALYSIS AND INTERPRETATION OF THE HYDROCHEMISTRY OF A ROCKFILL DAM

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1. INTRODUCTION

Water quality is a multivariate concept. It is not defined by any single constituent or summary value. Furthermore, because of the occurrence of related mineral species among flow path water chemistry variables typically are correlated among each other. Thus a variable by variable analysis ignore relevant information[3].

The purpose of this study is to demonstrates the usefulness of factor analysis as a tool for simultaneous analysis of a great number of variables and observations.

In this research, factor analysis was applied to the hydrochemical study of a rockfill dam.

2. OUTLINE OF THE DAM AND SAMPLES

The rock fill dam is located in Kyushu Island, West of Japan. Fig 1 illustrates plan of the dam including sampling points. This research has been started from the year 1989 and the authors have reported the primary results previously[2]. In this article, the results of water quality analysis of last year is used to find out about the source of the ions in the water and to gain further understanding of groundwater movement in the right and left abutments.

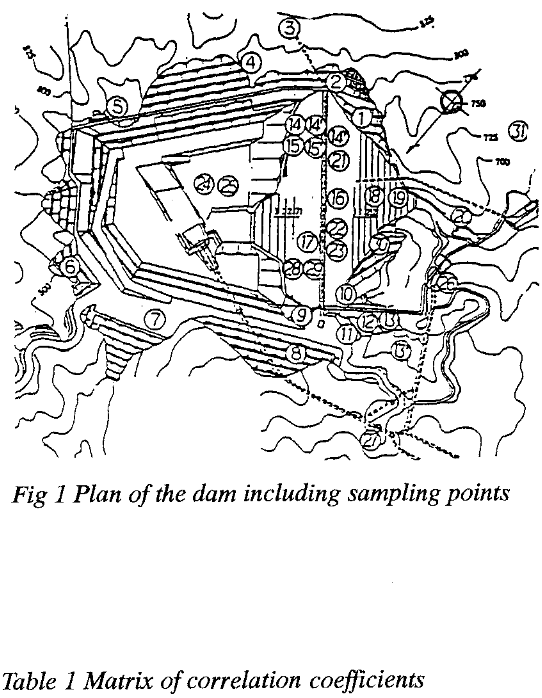

Fig 1 Plan of the dam including sampling points

3. METHODS

The R–mode factor analysis was applied for interpreting commonly collected water quality data and relating them to the specific hydrogeologic processes. The method used for the initial factor extraction was principal component analysis and for the factor rotation the Varmix method. The variables were standardized to a mean of zero and a variance of one in order to give equal weight to all variables.

4. RESULTS AND DISCUSSION

Table 1 presents matrix of correlation coefficients between the chemical variables and Table 2 shows the results of the factor analysis. 81.13% of the total variability is accounted for by the first two factors (factor 1: 53.53%; factor 2:. 27.6%). Table 3 indicates that the comunalities of all the ions are > 75%, indicating that the two factors explain well the variance of almost all of the variables. Cntributions of the variables show that

Table 1 Matrix of correlation coefficients

	EC	Na^+	K^+	Mg^{2+}	Ca^{2+}	SO_4^{2-}
EC	1.000					
Na^+	0.698	1.000				
K^+	0.324	0.374	1.000			
Mg^{2+}	0.340	−0.010	−0.478	1.000		
Ca^{2+}	0.694	0.701	−0.105	0.374	1.000	
SO_4^{2-}	0.762	0.596	−0.084	0.400	0.672	1.000

EC, Na^+, Ca^{2+}, and SO_4^{2-} contribute to factor 1 and Mg^{2+} and K^+ contribute to factor 2.

Factor 1 can be associated with the dissolution of gypsum ($CaSO_4$) or anhydrite ($CaSO_4 . 2H_2O$) and theardite (Na_2SO_4) or mirabilite ($Na_2SO_4 . 10H_2O$) minerals of the soils in the core part.

Factor 2 indicates dissolution of rock mass in the area.

Fig 2 illustrates the first two factor scores for sampling points. The sampling points coordinates in regard to factor 1 and 2 are obtained by using factor scores coefficients and standardization of raw data. The results show that seepage points have high scores for F1 and groundwater points have low scores. There are not much difference among the second factor scores (F2) of the sampling points except for sampling point 22 that due to its depth and location dissolve green rock.

Table 2 Weights of the factor analysis and eigen values

Factor	Eigen value	Percentage of variation	Cumulative Percentage of Variation
1	3.212	53.53	53.53
2	1.656	27.60	81.13
3	0.543	9.05	90.15
4	0.341	5.69	95.87
5	0.175	2.92	98.79
6	0.073	1.21	100.00

Table 3 Factor loading after Varmix rotation, communalities for each ion

Variables	Mean	Standard deviation	Factor 1	Factor 2	Communality
EC	97.34	29.24	0.922	−0.089	0.86
Na^+	6.12	1.26	0.845	−0.347	0.83
K^+	1.48	1.70	0.177	−0.901	0.84
Mg^{2+}	1.80	0.30	0.358	0.795	0.76
Ca^{2+}	10.12	4.11	0.862	0.204	0.78
SO_4^{2-}	30.62	22.80	0.856	0.229	0.79

5. CONCLUDING REMARKS

The study clarified that the statistical approach of factor analysis facilitates determination of assemblages of water quality results. The research also proved that: Groundwater points are recharged mainly by rainfall and water quality is affected by lithologies through which the water percolates and flows.

There is a flow from rock mass in the left abutment to points 14 and 14' (these points are known as seepage points), so the water appeared in these points are mixture of seepage and groundwater.

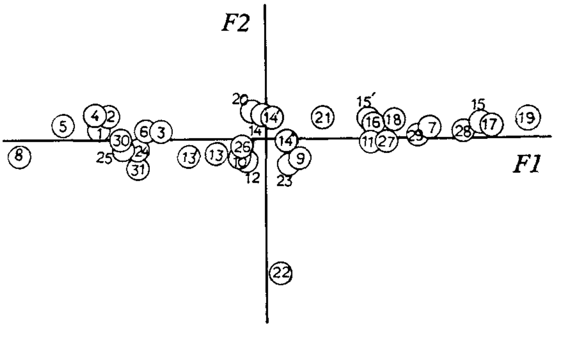

Fig 2 Factor score for sampling points

REFERENCES

Afifi, A.A. (1979) Statistical analysis. A computer oriented approach. Second edition. Academ ic press.

Nakajima, S. et al. (1992) Classification and estimation of seepage path through a rock fill dam using multivariate analysis. Proc. of Mediterranean Conf. on Environmental Geotechnology. Turkey. 93–99.

Riley, R. et al. (1990) Statistical analysis of the hydrochemistry of groundwaters in Columbia river basalt. Journal of Hydrology. 119: 245–262.