DETECTION OF WATER LEAKS IN FOUM EL-GHERZA DAM (ALGERIA)

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ABSTRACT

The main objective of this work was to detect water leakage origin combining conventional, tracing and isotope techniques. The investigation was performed by a research team from the 'Algiers Nuclear Research Centre' in collaboration with engineers from the 'National Agency for Dams'. The chemical and isotopic results have shown no influence of dam water on the surrounding aquifers. Dye tracing has shown a faster water circulation through complex pathways for the right bank as compared to the left one.

INTRODUCTION

This work was carried out within the framework of a Regional Co-operation AFRA programme supported by IAEA (RAF/8/028). This programme consists of the strengthening and development of scientific knowledge in African countries, mainly in the detection of a dam leakage and safety. The main objective of this work was to detect the origin of water leakage combining conventional, tracing and isotope techniques. Classical methods concerned the monitoring of changes in physico-chemical parameters (conductivity, temperature and chemical composition). Isotopic and tracing techniques concerned the determination of the isotopic composition of on-site available different water bodies (oxygen-18 and tritium) and the labelling of the reservoir (Rhodamine-Wt fluorescent tracer) respectively.

DESCRIPTION OF THE STUDY AREA

Foum-El-Gherza dam is located at 18 km east of Biskra province in south-eastern part of Algeria (Fig. 1). Its water is collected mainly for irrigation purposes.

The dam model project was designed in 1946 by the Algerian Hydraulics Laboratory (Neyrpic). The completion of the construction phase was in 1952 and first operation immediately showed leaks at the downstream part of the dam. Since then, leakage continued and the maximum water loss (20.7 Mm^3) was recorded from 1981 to 1982.

The dam regulates about 13 Mm^3 of water conveyed by Wadi El-Abiod (Fig. 2) ephemeral river and tributaries during a whole hydrological cycle for a catchment of ~1300 km^2.

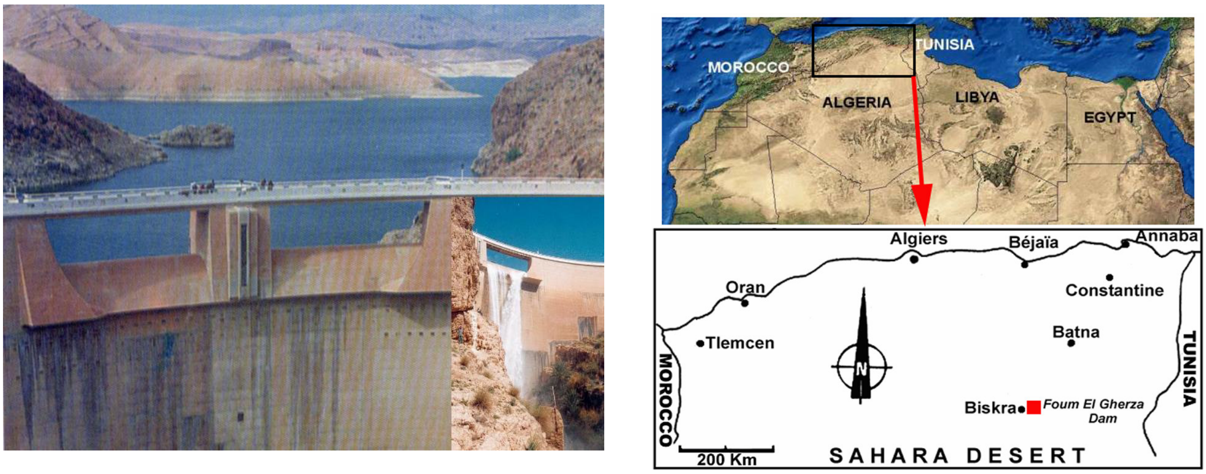

Figure 1: Map showing location of dam site

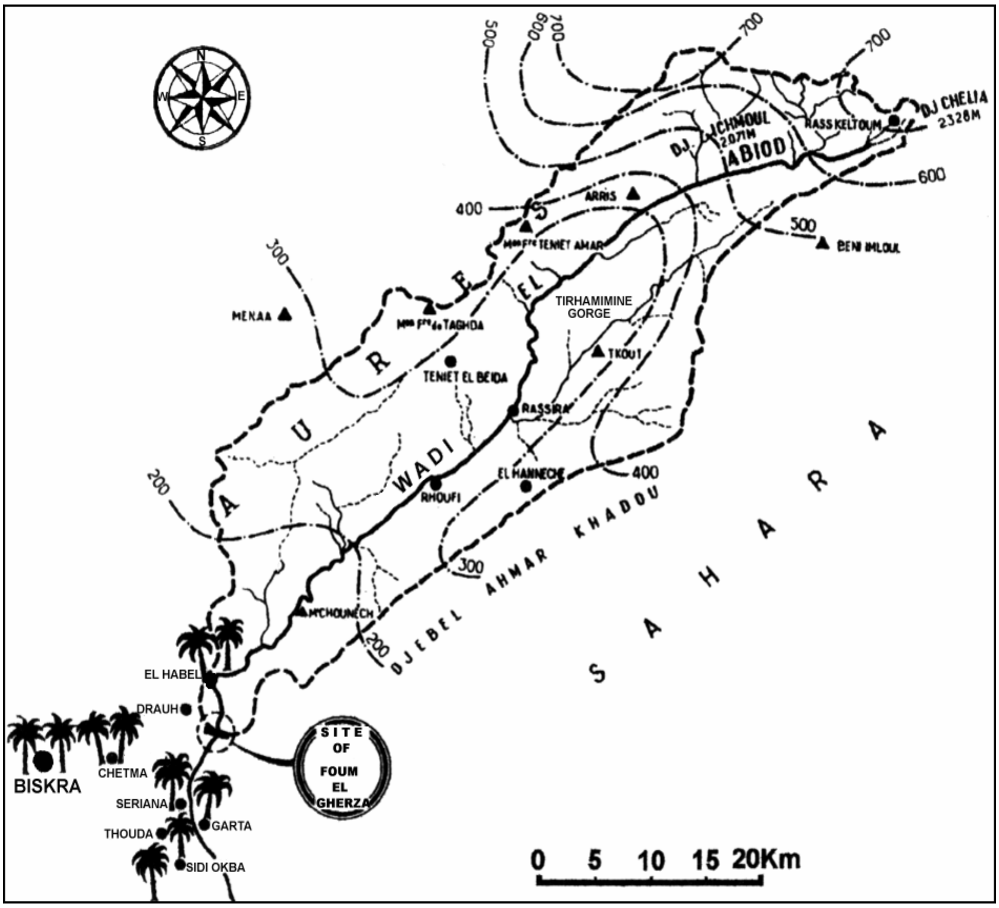

Figure 2. The catchment area of Foum El-Gherza dam

1. Geological and hydrogeological settings

The massif where the dam is founded is composed of a relatively thick fissured karstic Maestrichtian limestone laying over a Campanian marl stratum (Fig. 3).

Three main aquifers are present in the investigated region. These are from the shallowest to the deepest the following:

- The alluvial phreatic aquifer: it is contained in the alluvial deposits and is recharged by precipitation and infiltration from the riverbed and from irrigation channels.
- The Miopliocene sands and the Senonian-Eocene carbonates aquifers. They are deeper and are both still artesian at some locations.

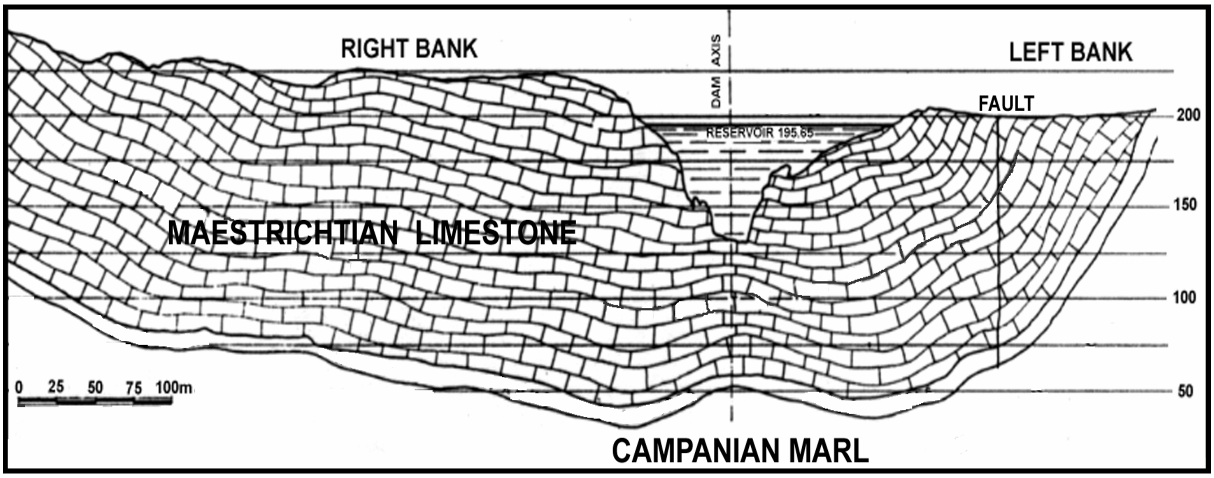

Figure 3. Geological cross-section of the dam site and geology of site surroundings

2. History of the leakage phenomenon

The first filling and operation of the reservoir started in 1952 upon completion of the construction which was then resumed between 1954 and 1957 by the reinforcement of the hydraulic works and the injection of a grouting curtain. Just after dam filling, leaks started to appear at the immediate downstream of the dam (1.6 Mm^3 in 1952/53, ~2.0 Mm^3 for the next two years,…). The maximum value was observed for season 1981/82 during which not less than 20.7 Mm^3 were recorded (Fig. 4). Due to lack of precipitation, the leakage rate started to fall down and during summer 1994 (June 24th) no more water was present in the reservoir.

Seepage takes place both at the left and the right banks. The leaks at the left bank are visible and their flow rate is rather low. They are collected within a small irrigation channel which follows the riverbed towards the irrigated areas. On the contrary, right bank leaks flow via a two-row network of drains and are directly collected within the irrigation gallery.

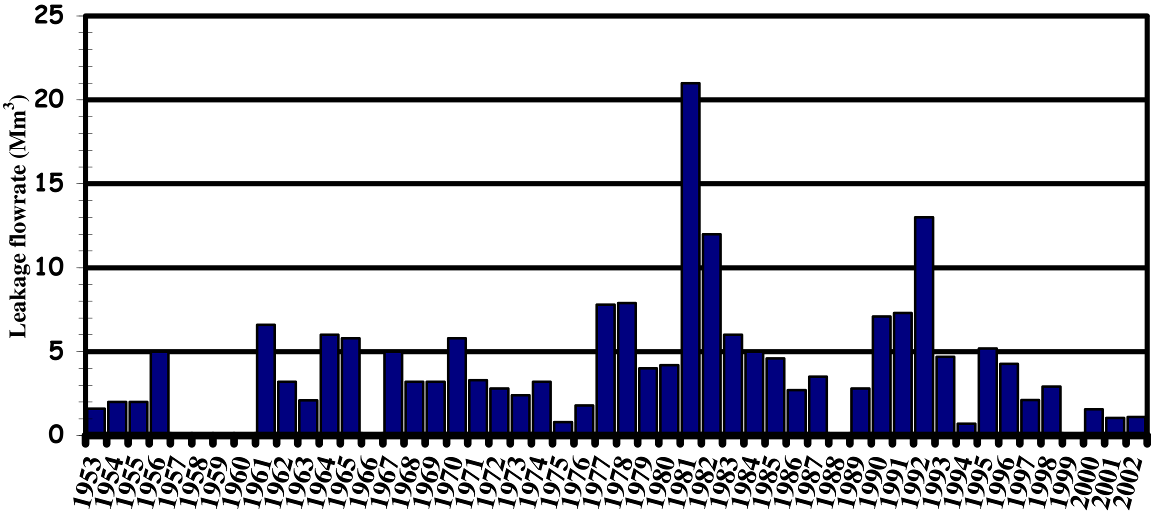

Figure 4. History of the leakage at Foum El-Gherza since first filling of the reservoir

EXPERIMENTAL WORK

One evaluation mission and two field trips were carried out (Fig. 5). During the first field campaign, samplings for all water bodies that are present within the immediate vicinity of the dam were effected. In addition, conductivity and temperature profiles were recorded for the accessible piezometers on both banks and for some points in the lake itself.

The first in situ observations have shown the existence of lateral infiltrations through the massif. Land collapse and rockfall were also noticed. Excavations and large cracks were brought to sight by the decrease of water level in the lake (6.5 Mm^3 at that time). It was even possible to hear water flowing through the carbonate fractures on the left bank.

During the second field mission and besides recording profiles similarly as during the first field trip, tracer experiments using Rhodamine-WT were achieved. Making use of such a tool, an estimation of the total flowrate at the outlet of the irrigation gallery was performed.

Moreover, the reservoir water was also labelled in the vicinity of the banks for the sake of interconnection experiment purposes. The volume of water in the lake was about 5.9 Mm^3.

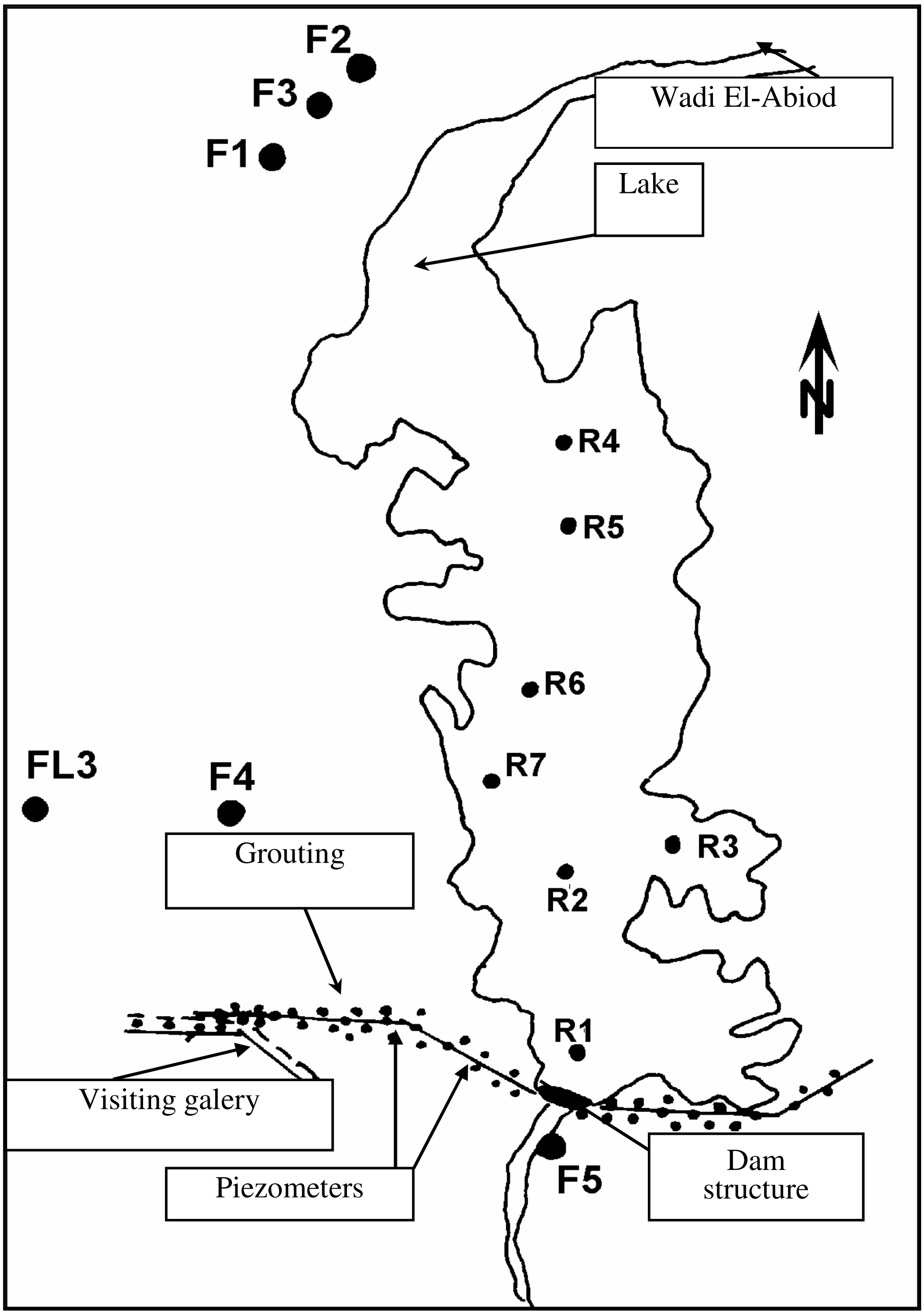

Figure 5. Schematic location of sampling sites during field campaigns

RESULTS AND CONCLUSIONS

The achievements and the results gathered from the field campaigns that has been effected allowed us to identify the problems affecting this dam through the overall observation of the features of the physical medium (geology) where it has been built.

The results obtained from temperature and conductivity profiles that were drawn for the probe accessible piezometers have shown the presence of very complex vertical and horizontal flows as depicted in Figure 6a and 6b. This could be due to the geological characteristics of the site.

With regard to the chemical composition, a Piper diagram (Fig. 7) showed that there is no relationship between lake water and groundwater that is occurring in the immediate vicinity of the reservoir. This was further confirmed by the isotopic results through oxygen-18 and tritium contents as summarized in Table 1.

An interconnection experiment using Rhodamine-WT fluorescent tracer was performed afterwards. It consisted of labelling the reservoir water at a distance of 2 m from the shores. The monitoring of tracer arrival at the downstream springs showed that Rhodamine was detected respectively after two days at the right bank and after one week at the left bank, since injection started (Fig. 8).

The investigation described in this paper leaded us to the conclusion that the implementation of such a pilot study and its associated preliminary findings seems to be satisfactory. However, according to the complexity of the geological site, more experiments need to be performed in order to better understand and better address the leakage phenomena.

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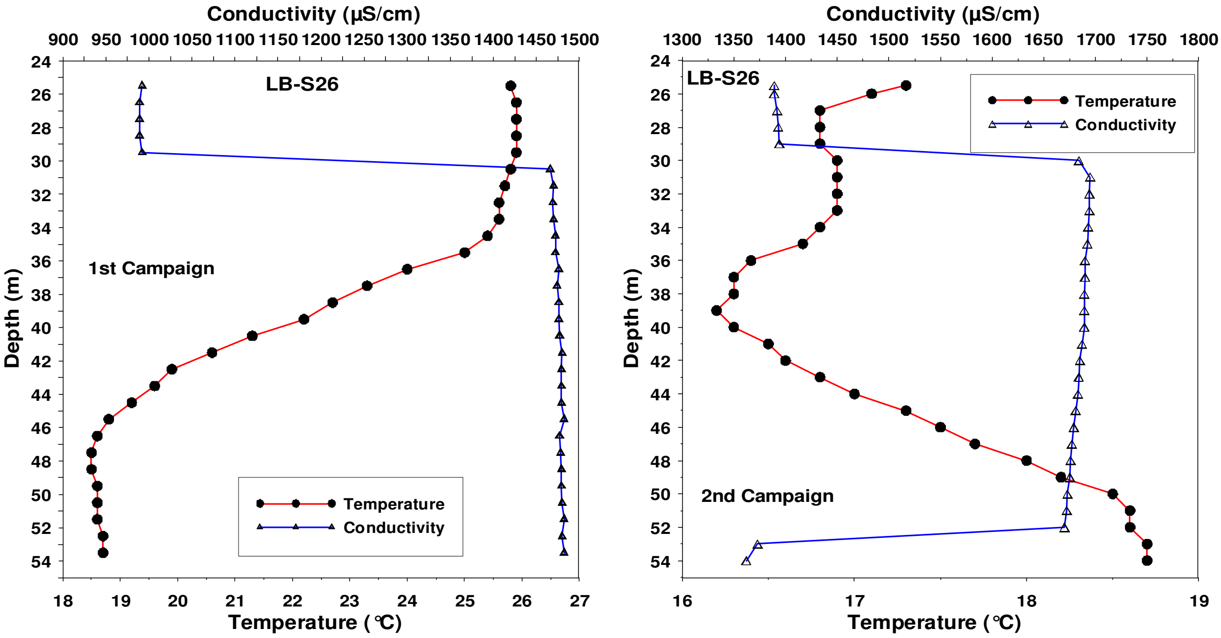

Figure 6a. Comparison of left bank S-26 piezometer EC& T profiles of the two campaigns

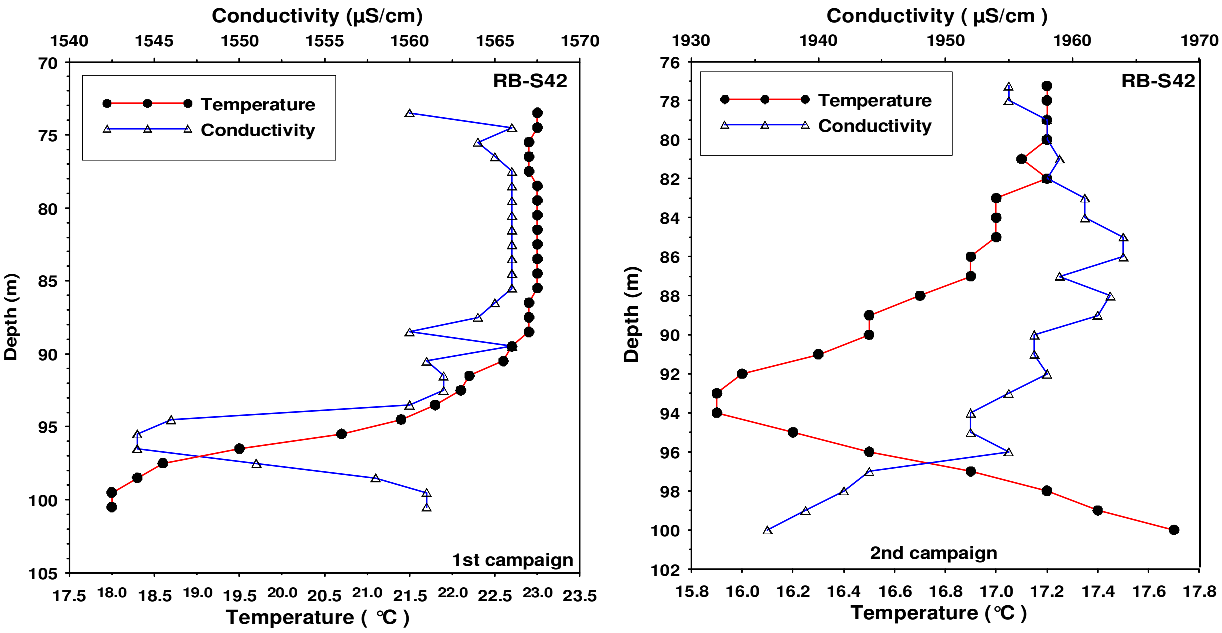

Figure 6b. Comparison of right bank S-42 piezometer EC & T profiles of the two campaigns

Table 1. Isotopic composition of some samples

Sample	Tritium (T.U.)	$\delta^{18}O$ (‰)
Borehole F1	2.1	-7.3
Borehole F2	1.3	-7.5
Borehole F3	< 0.4	-7.5
Borehole FL3	1.4	-7.9
Borehole F4	2.0	-7.4
Borehole F4 bis	1.7	-7.5
Borehole F5	< 0.4	-7.4
Reservoir	9.7	-0.2

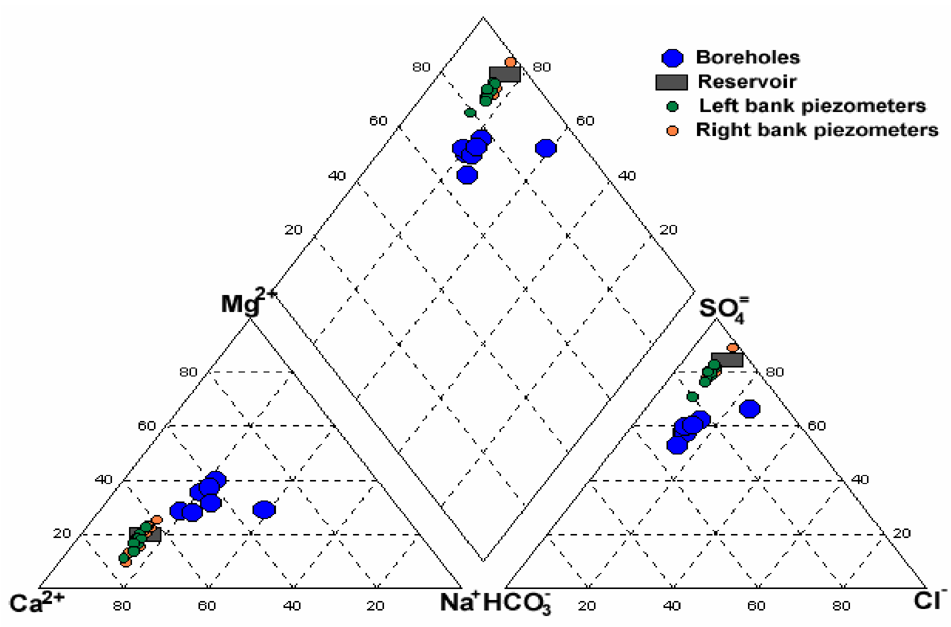

Figure 7. Chemical classification of samples according to Piper diagram

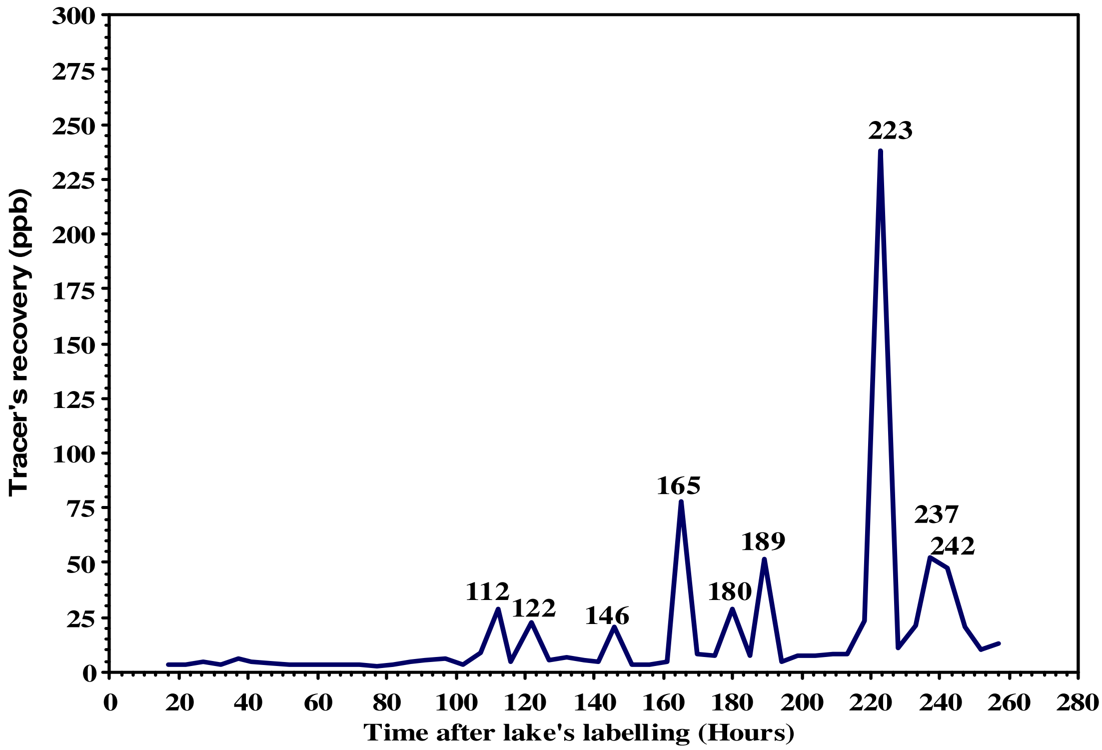

Figure 8. Tracer recovery as a function of time

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