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QUALITATIVE RELATIONSHIPS BETWEEN AN AQUIFER AND THE SURFACE WATER FLOWS

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ABSTRACT

In the alluvial aquifers, closely related to the superficial water-flow, the quality of the pumped water is more or less influenced by the river water quality. This influence is specially remarkable in the mineralization.

An analytical comparison of ground-water and river-water shows the reactions of the aquifer to an impulsion given by the latter. If often acts as a "fad" or a "stopper" and provokes the slackening of the variations created by the river.

It is hence possible to deduce the changes in the aquifers caused by an accidental pollution of a river, the zones susceptible to be affected by the phenomenon and the time necessary for its eventual disappearence.

INTRODUCTION

In an alluvial aquifer, the lenticular structure is the general rule. This medium can be assimilated to anything of isotropic and homogeneous to the pressure transmission. On the contrary, this assimilation is impossible about the water quality.

The permeability variation, in horizontal plane like in vertical plane brings about mixtures which are more important than the alone analysis of isopieze maps could show it.

ANALYSIS OF THE PHENOMENON

If we consider a point of the water table where the water comes from the river, without interruption, the comparison of the resistivity variation in the water-table and in the river shows great difference. The river resistivity variation are absorbed, for a great part, in the water-table (Fig. I).

But this absorption is very different of the absorption of the waves inducted in the water-table by the variation of the river level.

It is not a true absorption but only a large mixture.

In a similar situation, in case of great pumping out, the water pumped shows the same difference with the river water (fig. 2). The mixture affects a large volume and can be supplied.

All these results of the mixture of water proceeding of the same source but which was injected in the water-table at different times (ref. 1). The question is to know what is the mechanism of this mixture.

An alluvial aquifer is made of pebble, gravel, sand and clay lentils. Those ones cut again themselves. Every lentil can be assimilable to stream-tube, characterised by their permeability and their section. In this stream tubes water flows submitted to a field pressure varied with the gradient of the water-table in the considered aera.

In the connection of two lentils waters of the two stream tubes are mixted and this mixture will be divided after to flow in other lentils.

If we consider the phenomenon in an horizontal plane, each lentil can be assimilated to a vector caracterised by its permeability and its section.

It is possible to establish a system where these vertors are the boundaries of mails and where the knots are the points of mixture (Fig. 3).

In a part of the water-table where the supply proceeds in totality from the same source, the river for example, the water arrives at the point of pumping out by different ways at the same time.

Each way implies a different time of transit. The water pumped out at a certain time, is constitued by elementary masses of water injected in the water-table at different time and having covered different distances, according to different ways. In two neigbouring stream tubes, speed of flow can be very different, from one or two power of ten, in connection with permeability.

In fact, it seems that the multitude of ways possible for elementary masses come to an average for transit time ; this average time represents the renewal time, that is to say the time to renew all the water of the area concerned by the pumping out.

Therefore the pumped out water represents a mixture of elementary masses of water injected at different times. Each of this elementary masses has a specific mineralization function of the mineralization of the river water just as the injection in the water-table.

The longer average transit time is, the more important the mixture will be and the variation of mineralization absorbed in the water-table too. If this transit time is last more than a year, the mineralization of the water pumped out will be almost constant.

If the system of stream tubes can explian clearly the mixture observed at the pumping out point, it is also possible to understand the dispersion of a mineralization wave inducted in the water-table.

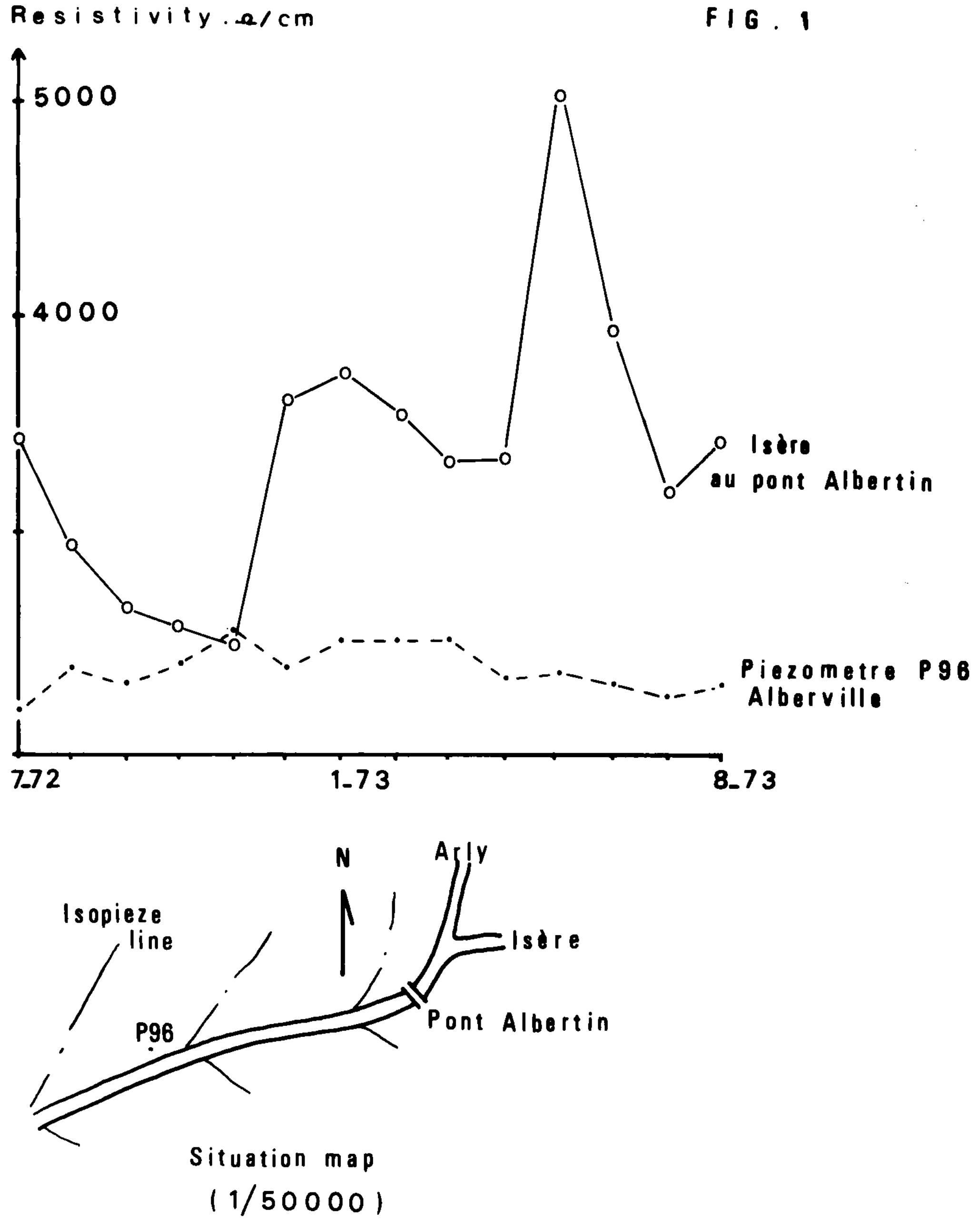

Fig. 1. Comparison of the water resistivity in the river and in the water-table, in a point where the supply is comming from only the river (near Albertville - Isère valley - France).

Dynamic limits are different of chemical limits (ref. 2). It is easy to imagine, according to the system, that a part of injected water and of ions inclued can be found on a surface much more expanded like it would be possible to see it according to isopieze maps.

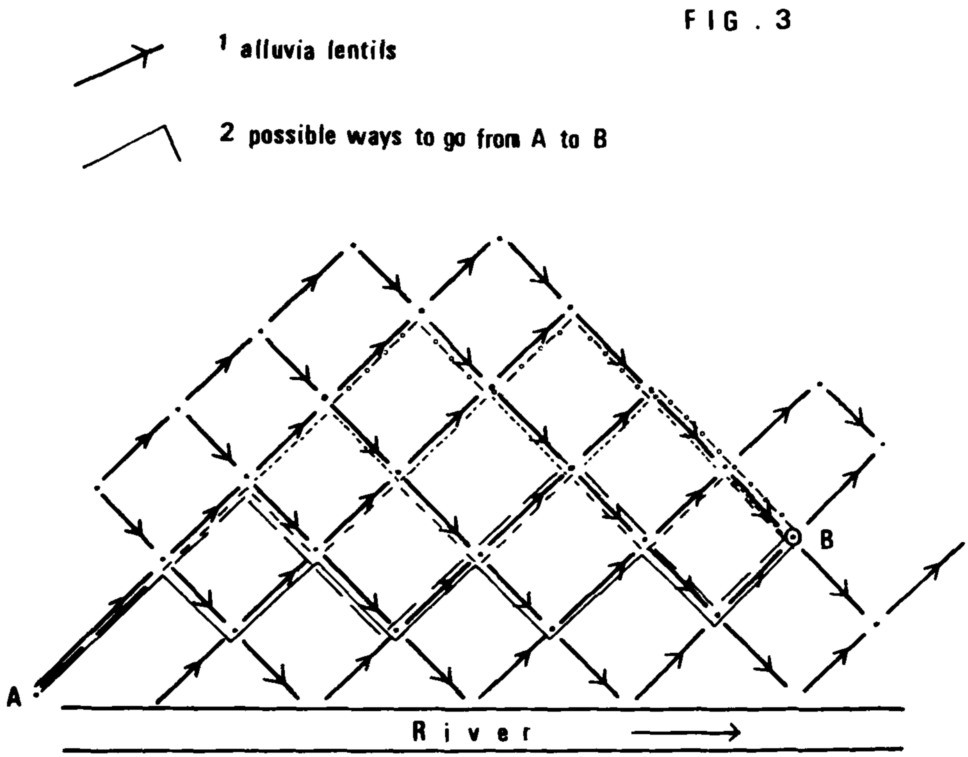

Fig. 3. Diagram of a mailed system with the different possible ways for an elementary mass of water to go from the infiltration zone to the point of measure. The mail limits represent the alluvial lentils.

INFLUENCE ON WATER QUALITIES

This idea of mixture in connection with lenticular structure of aquifer presents three aspects concerning the water qualities.

Waters pumped out in a point of the water-table are not depending of the instantaneous qualities of the water which supplies this sector of the water-table but of their average qualities. Pumped out waters have a mineralization which changes much less than these of the river-water. Mineralization of the pumped out waters does not deviate much of the average of water-river mineralization (ref. 1), all the more as the area of mixture is larger.

The pumped out water qualities depend on the aquifer structure. The more numerous and the shorter the lentils are, the more numerous the points of mixture are.

Existence of ancient meanders can permit the diffusion of supplies in all the water-table, if these ancient meanders go through the valley from one side to the other (ref. 3).

But in general rull, horizontal permeability is higher than the vertical permeability. This can explain the presence, on the same vertical, of waters with very different qualities whereas the mixture is doing well in an horizontal plane, on a large area.

The second aspect is in relationships with the mineralization of the water during its underground passage. River waters are often far of the saturation and they can react on the midle, that is to said on the mineral elements composing the aquifer. The mineral charge of the waters increases with the length of the underground passage (ref. 1). This increase of mineralization affects all the area of mixture all the more as the points of mixtures are more numerous.

The third aspect concerns risks of pollution. In case of pollution of the river-water the wave of pollution willbe absorbed in the water-table like the wave of mineralization, but the polluant will stay in the water-table a longuer time which is function of the average transit time.

Furthermore, the pollution diffuses on all the area of mixture. It is, in such a case, necessary to know the limits of this area, that is to say the chemical limits which are different of the dynamic limits.

This will be easier as the supplies coming from the river have a mineralization different from those of the other supplies (ref. 1).

But it is very difficult to forecast the absorption of the wave of pollution, particulary near the river. In some lentils with high permeability, the concentration of the polluant can be very high on a long distance (ref. 3) when it is almost null in neighbouring lentil.

CONCLUSIONS

The lenticular structure of alluvial aquifers favors the mixture of the water in the water-table. This comes to an absorption of the waves inducted in the water-table, but also by the dispersion of the elements injected in the water-table on areas very expanded, much more expanded like it would be possible to see it according to hydrodynamic analysis.

The limit susceptible to be reached by the pollution wave can be determined only by the chemical analysis of the underground water, which permits to settle the limit of influence of each supply of the water-table, if their mineralization are enough different.

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FIG. 2

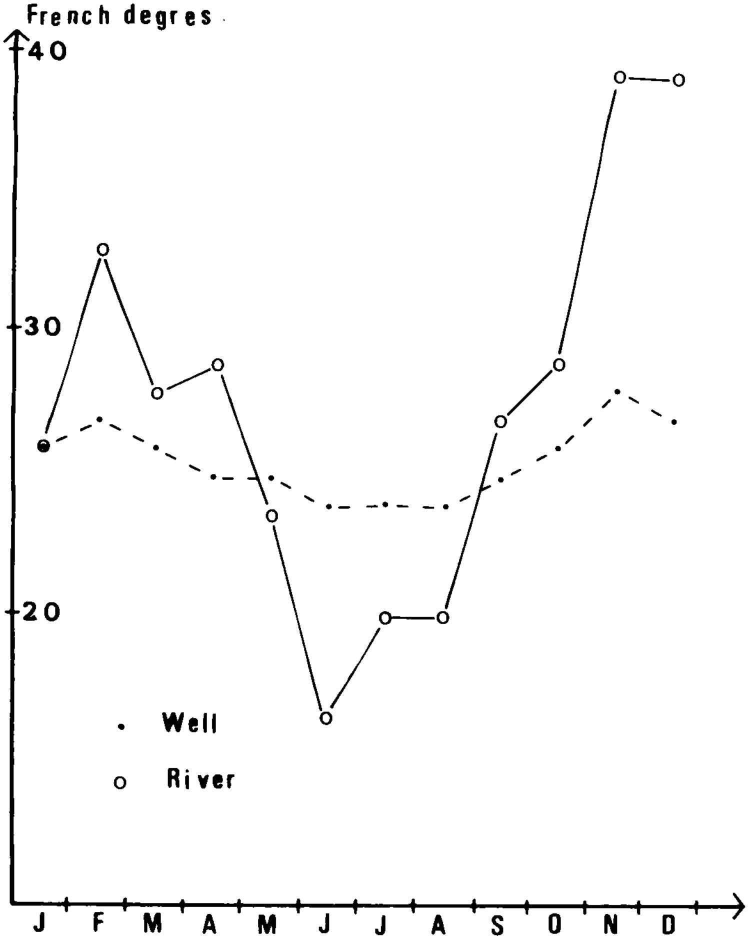

Fig. 2. In a well 30 m distant of the river, to a pumping out of 350 m3/h the french degrees changes from 24 to 28 in the well, when it changes from 14 to 39 in the river water (near Grenoble - Isère valley - France).