TRACING EXPERIMENTS PERFORMED AT SHALLOW AQUIFER - REGION S^{t} GEORGEN-GRAZ-AUSTRIA

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RESUMO--Os experimentos com traçadores colocados em prática na região de S^{t} Georgen, na Áustria, por ocasião do Postgraduate Course on Groundwater Tracing Technique, em 1985, foram feitos sobre os Terraços Pleistocênicos constituidos por uma variedade litológica com predominância de areias e cascalhos, de espessura não superior a 20 metros. Os experimentos objetivaram determinar, com precisão, a direção e a velocidade de fluxo da água subterrânea, a porosidade real do aquífero, além de fornecer subsídios para procedimentos que pudessem restringir a contaminação do aquífero, por usos dos pesticidas aplicados nas culturas da região. Como traçadores foram usados Uranina (fluorescente) e Au^{198} (radiativo).

ABSTRACT--Included in the Post-graduate Training Course Program was carried out an excursion to S^{t} Georgen Region, Austria, where a dyeing and radioactives isotopes experiment in Shallow Aquifer. This experiment was performed having as main objectives evaluation of flow characteristics (velocity and flow direction and porosity) and procedures to control groundwater pollution from agricultural activities in the vicinity. It was used as tracers "Uranime" and "Radioactive Isotope, Au^{198}".

INTRODUCTION

Included in the Postgraduate Training Course Program was carried out an excursion to the Quaternary Basin South of Graz near S^{t} Georgen City (fig. 1), where a dyeing and radioactives isotopes experiment in Shallow Aquifer was performed having as main objetives the evaluation of flow characteristics (velocity and flow direction and porosity) and procedures to control groundwater pollution from agricultural activities in the vicinity.

To achieve these objetives several observation boreholes (13) were drilled as an injection borehole. It was used as tracers "Uranine" and "Radioactive Isotope, Au^{198}. The results were

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suficients to characterize the aquifer according to the objective drawn prior to the experiment.

These experiments proved the feasibility of using fluorescent dyes as an indirect mean of analising qualitatively and quantitatively the intrinsic parameters which characterize shallow aquifer.

GEOLOGICAL BACKGROUND

The working area which is inserted in a Quaternary Basin, can be characterized in the geological point of view by Pleistocenic Terraces surrounded by Terciary Formation (Neogene sediments and Limestones). The productive layers in the region as was shown by the geological profiles of the boreholes are composed by well sorted gravel with a relatively high permeability (10^{-4} to 10^{-2} m/s). One may draw from the well-logs the existence of a layer of "Tegel" which is located underneath the productive zone, (and) with presumably less permeability than the productive gravel strata. Besides those stratigraphy and litological characteristics, from the geometry of the isopiezes one could conclude that the boreholes 6 and 7 present better hydraulic conditions (high transmissibility, high permeability) than the others boreholes.

Still from the well-logs one may conclude that there is an increasing thickness of the gravel sand strata towards the south. One may expect different degrees of sorting and compaction of productive layers which account for the slight fluctuation of the permeability value (10^{-4} to 10^{-2} m/s). Looking at the hydrological situation at high water level and low water level our conclusions were in the first situation, borehole nº 6 could be recharged by the river flow as well as in Bx; on the other hand at low water level the recharge to boreholes 6 is practically inexistent from the river.

METHODOLOGY

Regarding the methodology used one draw the following categories.

Well Set-Up

From the previous Knowledge on the geological and hydrological conditions of the regime pumping tests (sediment sample) a well set-up was specially designed to allow the implementation of experiment. The set-up was composed of an injection well drilled to a total depth of 10 meter as 13 observation wells located in a circunference of a radius 3 meters from the injection well (fig. 2). These observation wells were drilled to a depth of 10 m having a diameter of 2.1/2".

The injection well as the observation well were completed with perforated PVC casing throught the total lenghts, to allow free flowing of the injected tracer. The observation wells were located around the injection well spaced whithin 1 meter from the next well.

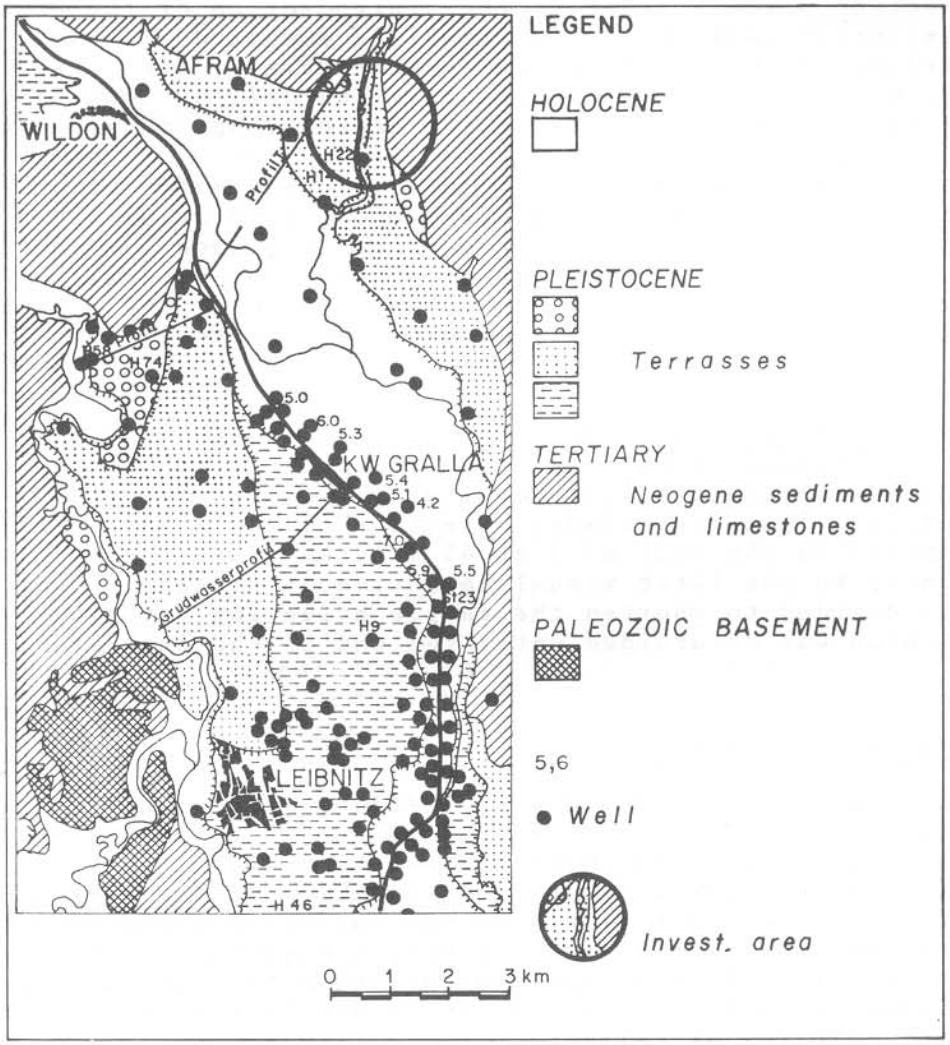
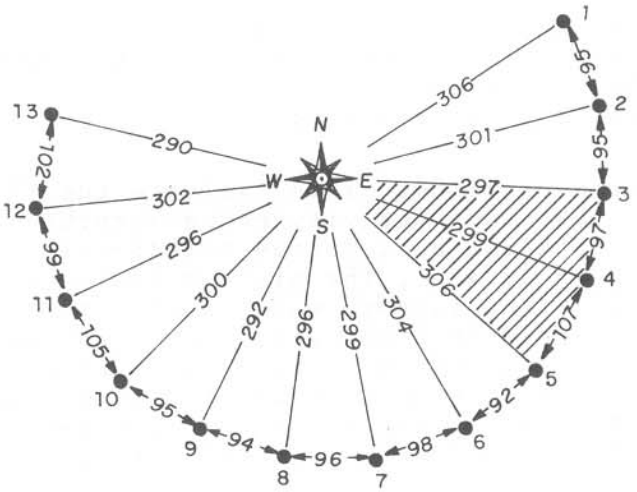


Fig. 1 - Localization map
Quaternary Basin South of Graz



●-BOREHOLES OBSERVATION
⊙-BOREHOLE INJECTION
290-DISTANCE BETWEEN BOREHOLES
▨-GROUNDWATER FLOW DIRECTION

Fig. 2 - Test Circle - St. Georgen

Injection Set-Up--Prior as the introduction of the tracer in the injection well, to avoid immediate downward flow of the liquid tracer to the injection hole which delay the expected radial flow, was introduced in the injected well by means of plastic road, a rubber stopper at the depth of one meter below the water level.

The injection was performed at the upper first part of the injection well. The tracer, "uranine", was used aqueous solution (30 g of Uranine/1 liter of water) after the injection, made through a plastic hole an additional amount of 5 liters of natural water was introduced in the well, which would wash out the remaing solution inside the tube and allow a better spreading of the tracer.

Sampling Procedure--Immediately to the tracer injection , samples were collected every 15 minutes from the observation wells which were equiped individual water samples to avoid potencial contamination. The first visual detection of the injected tracer was registred in the well nº 4 at 45 minutes after the injection; subsequently to the first visual detection of Uranine in well nº 4, it was decided to shorten the sample colecting interval to 10 minutes which was maintained until the end of the experiment.

One Point Dilution Method

The methodology utilized was as follow: injected, by means of special probe, a radioactive isotope Au^{198} in the water column and subsequently measured through a Geiger Muller Counter the evoluation of the radioactivity concentration at the site of the injection as the current displacer the radioactive isotop. The faster the reduction of the radioactive concentration the higher the flow velocity. By plotting concentration vs time and using an empirical formula one can evaluate (quantitatively) the filtration velocity as follow:

$$vf = \frac{d}{4.£1.£2.t} - \ln \frac{\varepsilon}{\varepsilon o}, \text{ being}$$

d = diameter of section of boreholes;
£1 and £2 = correction factors depending upon borehole screen characteristic;
$\varepsilon/\varepsilon o$ = radioactive concentration;
t = time.

This experiment allows us to evaluate the flow direction using the foot that radioactivity being absorbed by the screen and the gravel-pack can be detected immediately after the displacement of the tracer. The highest radioaction is detected at this angle were the isotope was pushed through the water flow. This information used in a special program can be plotted by the computer as a flow direction diagram. Summarizing, this experiment gives us enough information to evaluate the filtration velocity and flow direction at a certain point which does not necessary correspond to the ground water flow direction.

RESULTS

From the dyeing experiment using Uranine the results were as

follow:

On The Flow Direction--The tracer was detected at boreholes 4, 2, 3, 6 and 5. The order given corresponds to the decreasing order of magnitude of the highest concentration of tracer detected in their samples by a simple orientation of the observation boreholes 4, 2, 3, 6, 5 one could easily conclude that the flow direction happens towards well 4 which corresponds to the Direction South 72º E. These 5 boreholes where located in a range between S 30º E and N 73º E. This range correspond to the overall flow direction of the tracer front.

The velocity of the water flow--These experiments also allows us to draw some considerations about the aparent velocity of the water flow, "va", the filtration velocity measured from the one point dilution method, "vf", duel the porosity, "P*", the main equation utilized is: $p^* = \frac{vf}{va}$, by plugging in the different "va" values (velocity at first occurence, velocity at maximum concentration and background velocity) and the value of vf = 17,2 m/d; one get three values of porosity which can be compared for further conclusions.

As the exercise that follows:

Well nº 4

velocity of first occurence = $1{,}662 \times 10^{-3}$ m/s

va velocity of maximum concentration = $5{,}245 \times 10^{-4}$ m/s

velocity of background = $2{,}314 \times 10^{-4}$ m/s

vf = filtration velocity = 17,2 m/d

$$p^* = \frac{17{,}2 \text{ m/d}}{1{,}662 \times 10^{-4} \text{ m/s}} = 12\%$$

$$p^* = \frac{17{,}2 \text{ m/d}}{5{,}245 \times 10^{-4} \text{ m/s}} = 38\%$$

$$p^* = \frac{17{,}2 \text{ m/d}}{2{,}314 \times 10^{-4} \text{ m/s}} = 86\%$$

One readily discards the last for being irrealistic (We are not dealing with fractured type of aquifer or "tube flow" which may reach such value of porosity).

In fact the realistic value of "P*" is "P2" because the parameter "va" (maximum concetration) reflects the most relible apparent velocity value which is not very affected by dispersive phenomena as in case P*1. So, we accept this value of P* = 38% as representative.

The one Point Dilution Method also gives some positive resuls

Regarding the flow direction the Computer Diagram showed a range of movement of the isotope between S 50º W and S90º E. The furthers points of the tracer front reveled an orientation of S 70º W.

CONCLUSIONS

The conclusions obtained in this experiment are the following:

a) Both methods produce similar results.

b) The One Point Dilution Method envolves two parameters (£1 and £2) to evaluate "vf". It is easy only using standard filters and diameter.

c) The One Point Dilution produce field results, the flow direction needs the use of laboratory measurements.

d) We obtain high values of intensity in the samples, so we can use lower quantities of tracers.

e) We need for the two methods complete filter.

f) We detected high flow velocity in this shallow aquifer.

g) We can replace the tracers by others chemicals solution (for example salt) and evaluate their decrease.

h) Through the fact that we obtained high concentration values in the well number 2, 3, 5, and 6 we concluded that there high natural dispersion of the water.

i) The Flow Direction Methods is restricted only to shallow aquifer, the One Point Dilution method has not restrictions.

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