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PROTECTION AND IMPROVEMENT OF GROUNDWATER QUALITY BY OXIDATION PROCESSES IN THE AQUIFER

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ABSTRACT

Oxidation processes in an aquifer caused by injection of oxygen containing water can improve the groundwater quality and protect the groundwater against pollutions. The so called subterranean groundwater treatment is applied in several european countries for some years. Stream and transport mechanisms and chemical and biological reactions as well are described. The recharge system in an most practical manner uses the pumping well for injection of oxygenated water into the soil.

INTRODUCTION

The quality of groundwater depends on its content of soluble and insoluble substances. The concentration of several substances in groundwater varies with oxydation and reduction reactions. A solution containing substances with different oxidation grade is described by its redoxpotential. As oxidation is defined as delivery of electrons a change in the solution in oxidative direction is measured by raising redoxpotential.

By biological decomposition of organic matter or pollutions the oxygen content of perculating water is consumed and the redoxpotential decreases. Hem (ref. 1) shows in stability field diagrams that the concentration of important substances in groundwater e.g. iron or manganese can raise considerably with decreasing redoxpotential. A change of redoxpotential from 22o mV causes a change of concentration of iron by factor $1o^4$. In this paper a method is described by which a change of redoxpotential can improve groundwater quality.

INFLUENCE OF REDOXPOTENTIAL

The redoxpotential of groundwater can be influenced by adding an oxidizing agent into the soil, usually oxygen from the air. Transport and spreading of oxygenated water is described mathematically by a diffusion-convection equation under consideration of a sorption term. Fig. 1 shows the spreading of oxygenated water injected into a well computed for a radial symmetrical stream field.

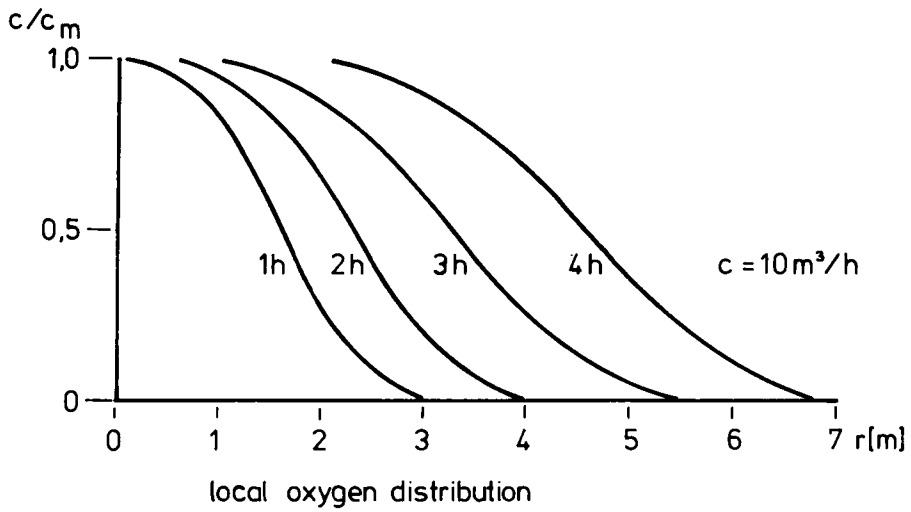

Fig. 1. Oxygen concentration in different distances from injection well, parameter: time after injection

After recharging oxygenated water into a well iron and manganese containing water will be pumped out with remarcably lower contents of iron and manganese. Repeated recharge of oxygenated water causes a treatment of groundwater as well as in water works facilities. Polluted groundwater may be treated by recharge of oxygenated water too. The following explanation for oxidation mechanisms in the soil shows that subterranean treatment of groundwater is not the same as in water works plants (fig. 2):

After some starting injections of oxygenated water the soil is covered by a layer of iron-III-hydroxides. During pumping iron

containing water out of the well the iron-III-hydroxide layer adsorbes iron-II until the surface of the layer is completely covered. The oxygen injected into the aquifer by the next recharge with oxygenated water oxidises the layer of iron-II to iron-III-hydroxides again and thus creates new adsorption space. The reaction velocity is high enough caused by autocatalytic acceleration though pH may be low. A similar explanation is given by van Beek (ref. 2) for removal of iron from groundwater in the aquifer.

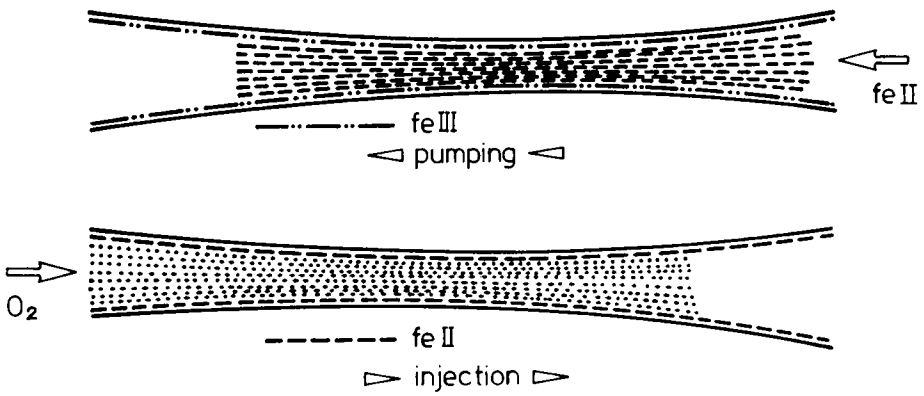

Fig. 2. Adsorption and oxidation of iron on the surface of grains shown in a pore of an aquifer

The growth of iron and manganese bacteria can support the adsorption and oxidation of iron and manganese caused by the alcaline cell surface of the bacteria. Therefore the subterranean groundwater treatment may be caused by chemical and biological reactions too.

TECHNICS OF RECHARGE

The oxygen from the air used as oxidizing agent in an most practical manner is transported into the aquifer soluted in water. The oxygenated water should be injected in the same well used for pumping of groundwater. The injection capacity should be at least

the same as the pumping capacity, to be sure that all layers of the aquifer will be treated. Some appliers prefer recharging by means of special injection wells. This method may cause trouble if it is used in aquifers containing different layers with different permeabilities.

If a groundwater flow is to be treated in some special direction, may be to avoid spreeding out of a pollution, injection wells are necessary. Usually a plant of subterranean groundwater treatment is based on at least three wells. Two of them are ready to supply clean water, the third may be enriched with oxygenated water and so on.

EXAMPLES

A lot of plants of subterranean groundwater treatment in several european countries shows that this method can replace conventionel water works facilities. Groundwater with iron contents up to 18 mg Fe/l and manganese contents of 2 mg Mn/l are conditioned. If the method is applied in a correct manner according to the hydrogeological situation and the plant is correctly dimensioned no modification of aquifer characteristics is caused, service life of wells is prolonged and ferric encrustations in wells, pumps and pipes are avoided too. The method can be performed economically with vertical as well as horizontal water supply wells.

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