Quality of Groundwater, Proceedings of an International Symposium, Noordwijkerhout, The Netherlands, 23—27 March 1981, W. van Duijvenbooden, P. Glasbergen and H. van Lelyveld (Eds.), *Studies in Environmental Science*, Volume 17

SOME EXAMPLES OF GROUNDWATERS POLLUTION IN ITALY

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1. - FOREWORD

The intense social and economic development which occurred in Italy during the years 1950-1980, caused widespread urbanization and a transformation of the production sources with a considerable growth of industrial activity and with the passage from an agricultural to an agricultural-industrial economy trough the creation of specialized transformation industry. In the meanwhile, adeguate planning of the territory in relation to these new demands , has often been neglected.

The aim of this paper is not to give a general framework of the qualitative state of groundwaters in Italy, because it is difficult to synthesize such a complex subject in a few pages due to the heterogeneity of the hydrogeological situation of the Italian peninsula. Instead, we would like to indicate a few examples of pollution, which have been studied during the recent years.

2. - EXAMPLES OF GROUNDWATER POLLUTION IN THE PO VALLEY

The Po Valley is the largest plain of Italy (15% of the total national territory surface, 71% of the total flat areas) and in it the great majority of the national productive activities are concentrated, together with the highest population densities. From a geological point of view the Po Valley is a large sedimentary basin in which the alluvial continental deposits of the Quaternary were buried with variable thickness down to 500/600 m, a substratum of Pleistocene and pre-Quaternary marine formations which are formed mainly by marls and clays near the Apennine range to the South and by limestones, sandstones and also igneous-metamorphic rocks to the West and to the North near the Alpine range.

These examples of pollution refer to the high plain at the foot of the Apennines (heights between 40 and 120 m above sea level), situated immediately the towns of Modena and Bologna, where the water-courses descending from the mountains have formed wide alluvial fans, the main ones having a maximum length of 15 km in their frontal part. These alluvial fans are often interdigited between themselves and are composed of indifferentiated gravels in the apex part, where a surface aquifer is localized, and of alternations of silt-clayey and gravelly layers in the middle and frontal part, where confined aquifers are localized. On the whole the underground aquiferous of these alluvial fans is of the "mono-stratum" type. Only below a certain depth (50 m in the apex zone, 200 m in the front one) it is possible to find aquifers still permeated by fresh not directly fed from the surface

and, in any case, with a very low renewal rate.

The alimentation of these water-bearing strata takes place by dispersion from the water course bed and by infiltration of precipitation waters: the total inflow to the aquifers, for each alluvial fan having dimensions like those above mentioned, amounts on average to 2-3 m^3/s. In the area studied the pumping of groundwater causes a small deficit in hydric balance: in fact around Modena, in an area of about 600 km^2, over 15,000 piped wells reaching depths usually included between 30 and 200 m, have been counted. Their functions cover the irrigation, industrial, zootechnical and drinking uses.

The first three examples refer to the alluvial fans of the rivers Secchia and Panaro, right-hand tributaries of the Po river. In the environs of Sassuolo, at the apex of the Secchia river alluvial fan, since 1950 over 300 factories for the production of ceramic tiles have been built on an area of about 100 km^2. The outflow of the industrial waste used to take place directly onto the superficial waterbodies , without undergoing any purification treatment. These waste waters had a high content of toxic elements derived from the preparation of ceramic enamels, mainly Pb and Zn, but also from other materials used as colouring matters. Also the fall-out of the fumes produced during the baking of the enamels and of the tiles, which are rich in fluorine derived from the clays, has caused a pollution of the superficial layers of the agricultural lands. The washing away of these lands and the contemporary infiltration of the polluted superficial waters have contaminated the underground waters. In a similar way the stocking of muds derived from the industrial processes in abandoned gravel quarries, has often caused the appearance of toxic elements in the aquifers waters. This pollution phenomenon has been limited both by the scarce solubility of the contaminating elements, which is governed by the pH of the aquifer waters, and by ionic exchanges with clayey layers present in the water-bearing strata.

In groundwaters the maxima levels of lead found are greater than 16 µg/l and they are often associated with high levels of ABS (up to 0.45 mg/l) found in the groundwaters, derived from the infiltration of urban sewage waters. The ABS concentration seems, therefore, to favour the diffusion of other pollutants, increasing the solubility and at the same time varing the surface tension in the porous medium of the aquifer as noted in other cases. At East of Sassuolo, near Castelnuovo Rangone, groundwater pollution has been noted, caused by the dispersion on the surface and in water-courses, directly connected with the aquifers, of waste from zootechnical production plants and related food industries. The superficial soils have a prevalently sandy matrix composed of colluvial palaeo-soils covering a Mindel-Riss palaeo-soil which, in its turn, is superimposed on gravel lenses and this has permitted the infiltration of polluted waters underground with an intensity and proportion seldom found elsewhere. At the same time the pumping of water from underground is really remarkable: there are about 1,000 piped wells concentrated in 25 km^2. In about 170 watersamples examined over 100 were found to be not fit for drinking due to the presence of bacteria and/or to an excessive content of ammonia, nitrites and nitrates; 16 samples were suspect, while another 19 had a nitrate content of up to 100 mg/l. A demonstration of the lack of adeguate planning and territorial protection is to be found in Castelnuovo Rangone where the main industry of transformation of the slaughterhouse by-product has been built on the palaeo-river-bed of one of the water-courses in the area.

In Spilamberto, in the upper part of the alluvial fan of the Panaro river, where the gravels appear directly on the surface and in depth form an indifferentiated aquifer about 100 m thick, a nitrocellulose producing industry until 1978 discharged directly into the surface waters a sulphur-nitric mixture a pH between 1 and 2, by

means of a non impermeabilized canal. In the presence of calcareous alluvial deposits this determined the appearance of the nitric ion in high concentration in the aquifer waters (up to 1,350 mg/l), an increase in the total alcalinity concentration (up to 58°F) and of the total hardness (up to 281°F) and a simultaneous reduction of the pH from 7 to 6. Moreover in the water - bearing stratum there occurred the precipitation of $CaSO_4$ caused by the Ca^{++} ion, solubilized also as a nitrate,which inevitably led to the disappearance of the $SO_4^{=}$ ion in the waters taken from underground. About 18 months after the installation of stainless steel pipes leading to the waste water treatement plant, the nitrates values in the aquifer waters were stabilized at 45 mg/l in the well nearest to the original outflow point of waste waters underground. Instead, about 1 km downstream maximum values of 188 mg/l are still registered. Also for the other parameters there has been a shift, corresponding to the direction of the flow of the aquifer waters, in the maximum concentrations found, and a general lowering of the values in absolute terms, except for the ion $SO_4^{=}$ and for total hardness. Although they present a diffusional course similar to the others', these parameters were found in greater quantities, for example up to 128 mg/l for the ion $SO_4^{=}$: this fact is to be correlated with the ridissolving of $CaSO_4$ previously precipitated in the aquifer.

3. - AN EXAMPLE IN CENTRAL ITALY

The town of Todi is representative of a typical situation in Central and Southern Italy, where many centers are placed on the summit of heights with obsolete and damaged sewer networks which are responsible for leakage of waste water.

Todi (in the centre of the Tiber Valley in Umbria) is placed on the top of a hill formed by a fluvio-lacustrine Pliopleistocene sequence, made up of 3 complexes; the lower two consist mainly of a silty clay, with a lenticular bedding and some coarser sediments. The upper complex, resting on a green silty clay through an irregular contact, is a conglomerate, consisting in a mixture of gravel, sand and silty sand with clay intercalations. The bedding is lenticular with sudden lithologic and granulometric variations. Throughout the sequence the clay material is mainly illitic-kaolinitic.

The total surface of the hill is about 4 km^2, while the elevation above the plane is 250 m.

Although the overall permeability of the two inferior complexes is low, the numerous lenses with coarse granulometry levels as well as the joints in the clay and upper detrital lid, allow some ground water circulation, so that there are a few non permanent springs and several wells dug by farmers for drawing potable water. The coarse complex of the summit is considerably more permeable than the inferior complexes and so in it there is a water body. Many small tunnels (many of Roman age) have been dug in order to artificially drain away this water. Most of these tunnels are no longer in use and those which still are functioning are sometimes being used as sewers.

The town sewers flow into the open in about ten different places allaround the town at the base of the summit conglomerate. With only a few exceptions, the sewer network's water flows down the hill through steep canals with natural beds and banks completely lacking paving. Measures of the flow rate of the main canals show that the amount of polluted water lost in the ground is about 120,000 m^3/year.

The pollution of the hill's groundwater is widely documented by analysis at 100 different springs and wells. The distribution of detergents and phosphates indicates that the dispertion of dirty water takes place not only through the

canals on the hill-side but also through percolation from the summit plate and the hygly jointed green clay.

There are numerous landslides on the hill; the most obvious and dramatic are to be found on the lower clay complexes. The upper conglomeratic complex usually has steep, and sometimes almost vertical, walls which indicate a demolition modulated by landslips on the lower complexes. All the hill's canals are in erosion: deep with vertical or nearly vertical banks. The mechanical characteristics of the material and the erosion cause the rapid slipping of the walls so that the adjoining areas are continuously pulled in. Landslips due to a sliding movement parallel to the slope (depth 2-3 m), and many large and deep (20-30 m) rotational landslides are present.

The most active landslides at the moment are localized in the very areas where the highest pollution by dirty water has been detected by chemical analysis.

There is some evidence that the chemical content of these waters might alter the mechanical characteristics of the clayey material, accelerating the pre-existing landslides. To test this hypothesis, studies, which are still going on were, designed. Preliminary results show that variations of the chemical contents, similar to those found in the field, are responsible for some modification in the Atteberg limits. In the great majority of cases, treatment with sodium diminishes the material's resistance to the blows for water contents less than the liquid limit.

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