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EFFECTS OF TOWN DEVELOPMENT ON GROUND WATERS EXAMPLE OF A SMALL TOWN

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ABSTRACT

The increasing town development and engineering activity leads to a serious disturbance of hydrogeological conditions, especially in the top water-bearing level. Investigations carried on in recent years by our Institute showed a considerable dependence of the unfavourable ground water changes on the town development progress, which is a particular risk for towns where ground water is the only source of water supply. These changes find expression in the increase of some nitrogen compounds, trace elements and bacteriological contamination, harmful to the human system.

Moreover, on the site of the agglomeration concerned, as a result of the drawdown of the water table, an anthropogenic depression trough has been formed, changing the existing ground water conditions.

INTRODUCTION

Numerous investigations have been made in the last years in the field of the hydrochemical and hydrodynamic changes arising in ground waters, brought about by human economic activity. It seems, however, that the rate of the unfavourable changes in ground waters proceeds in a fast way, while the number of investigations conducted in that field is inadequate. The changes occurring nowadays in ground waters are in many cases irreversible and are likely to affect the following generations /ref. 6/.

It is a known fact that there are many various sources polluting ground waters. These sources are differently systematized /ref. 1/. They are generally connected with the human economic activity, and particularly with the town planning development /but not solely/.

Town planning always disturbs the natural geological medium and in the first place causes serious hydrochemical and hydrodynamic changes of ground waters, acting on them through various sources and causes of pollution /ref. 5, 8/.

Research work dealing with the influence of town development on ground waters was started by the Institute of Environmental Development in Warsaw in the late seventies, and it is based on field investigation, archival materials, bibliographic studies and the like /ref. 9/.

RESULTS

Geological and Town Planning Characteristics of the Town concerned

The town on whose site investigation is made covers an area of 13 sq km, has a population of over 14.000 people and has been steadily extended during the last 20 years. It is situated on a Quaternary postglacial plain. Under the surface there are deposed water-bearing sands of varying grain coarseness, with gravel and clay lenses. The depth of that stratum is from several to several tens of metres. The sands are underlaid by glacial till, under which are Tertiary loams /Fig. 1/. The whole of these formations has undergone heavy glacitectonic disturbances, so that in some parts not only the clay, but also the loams have been pressed out to the subsurface area.

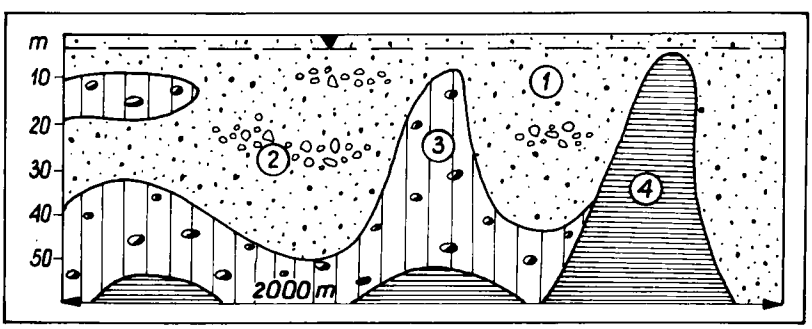

Fig. 1. Schematic geological section

1 - sands of varying grain coarseness, 2 - gravel, 3 - glacial till, 4 - Tertiary loams

The buildings in the town are in 70 p.c. low individual houses, the remainder consists of high many-flat houses and industrial buildings. The main and sole water supply source are ground waters with intake by means of deep drilling wells of 20 - 40 m depth and shallow hand-made wells of 5 - 10 m depth.

Industrial and municipal wastes are drained to surface sumps through the local sewage treatment plant, in the same manner as in industrial works or some municipal units, while in individual houses the sewage is drained to septic tanks, from which drains run into the soil.

Every individual property is generally provided with an own well and close to it an own septic tank. The local sewage system is thus one of the many water pollution sources /ref. 8/. Both the deep drilling wells and the shallow hand-made ones draw water from the same water-bearing level at a depth of 2 - 6 m /Fig. 1/.

Qualitative changes in Underground Waters

There being no insulating stratum from the surface of the site, and as a result of the shallow level of ground waters, these waters are exposed to pollution caused by numeral circumstances and sources, such as:

- the increased number of septic tanks parallel with the development of individual construction; this risk is particularly great on account of the non-existence of a central sewage system,
- the leakage of the local sewers,
- the leakage in well casings,
- the irregular liquidation of old wells,
- the storage of wastes.

From the individual sources the pollution spreads both vertically and horizontally in the water-bearing stratum.

On the area concerned the water generally shows a natural increased content of iron and manganese compounds. In the last twenty years have been observed the rise of nitrogen compound content, the iron oxidization and the bacteriological contamination /the coli bacteria/. The nitrate content sometimes reaches several tens mg/cu·dcm at an admissible standard content of 10 mg/cu·dcm. In the world bibliography a number of works have already dealt with the origin of nitrogen compounds in the aquiferous stratum and their great harmfulness to the human system. It seems, however, that the problem should receive much more attention in view of the steadily growing quantity of nitrogen

compounds penetrating into the water-bearing strata. The nitrogen compounds get into the ground waters from numerous pollution sources /ref. 2/ and practically there is no possibility to remove those compounds from the aquiferous stratum for technical and economic reasons /ref. 3/. If the sources from which the nitrogen compounds penetrate into the ground waters are not made safe or eliminated, it is likely that in some tens of years the whole water-bearing stratum will become polluted.

Analyses of trace elements made on a specimen of water drawn in the course of trial pumping from one of the deep drilling wells on the area of an industrial plant showed in that water distinct pollution of municipal industrial type, which was evidenced by increased contents of chromium, barium, rubidium, antimony.

At this stage of investigations no tendency was found to the growth of chloride and sulphate content which is specific for the Milwaukee-Visconsin town pollution /ref. 7/. The increased content of chlorides and sulphates was only determined in the region of the municipal waste storage, in hydrological exploratory holes made at a distance of 50 - 250 m from the storage yard.

Bacteriological coli contamination very frequently appears in places where the technical-sanitary conditions around the well are irregular. It is a known fact that the bacteriological contamination, though very dangerous for the human system, is a much smaller risk for the aquiferous stratum than chemical pollution. The bacteriological contamination may be eliminated from water by a proper decontamination of the well, while the removal of chemical pollution, as already said, is in many cases impossible.

Chemical pollution, contrary to the bacteriological one, may spread over considerable distances, both bertically and horizontally, in the water-bearing stratum.

Changes in Water Dynamics

The dynamic changes in the water table have been found by comparing the water table level determined in 1980 on the basis of the water table measurements made in several hundred wells with the water table level ascertained according to drilling archival materials obtained 10, 20, 30 years ago and from talks with the local population. As a general rule it is found that the water table has dropped by 2 m within 20 - 30 years, and in the Western part of the town where the industrial and communal building load is the heaviest, the drop is considerably greater,

reaching 4 - 6m. Here, indeed, along the town extension building axis, within the last 20 - 10 years, an anthropogenic depression trough has been formed. That new hydrogeological formation brought about a change in the original water run-off direction towards NE to a centripetal direction of NE on one side and SW on the other /Fig. 2/.

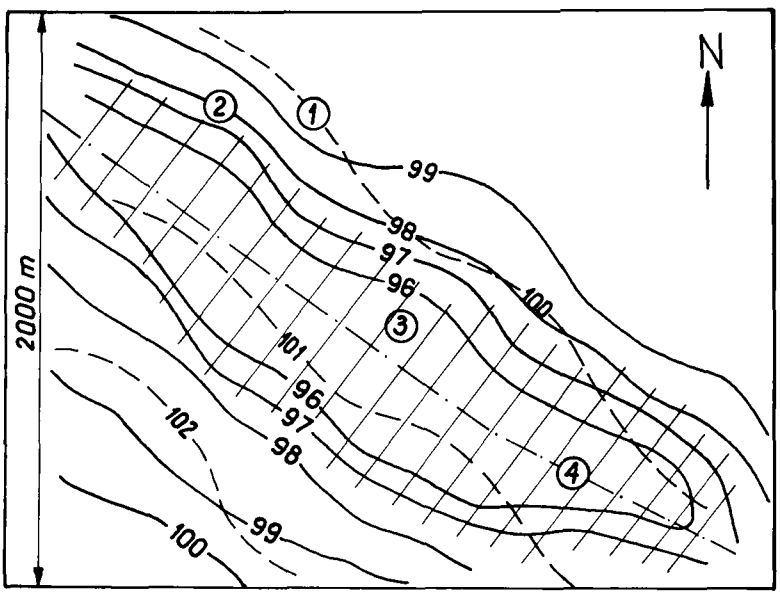

Fig. 2. Course of the points of equal elevation /contour lines/ in the W part of the town 30 - 20 years ago and in 1980

1 - contour lines 30 - 20 years ago, 2 - contour lines in 1980, 3 - site of extensive building, 4 - axis of the anthropogenic hydrogeological trough

That anthropogenic hydrogeological formation is of about 4 km length and about 1.5 km width. The deepening process of that anthropogenic trough is in time donnection with the progressing construction extension and building plan of that town district. Actually in many hand-made wells the water has dropped below the bottom of the well. In the part of the town under review the water consumption both by the industry and the communal economy is very heavy. As a result of the water vanishing in wells, many individual users build deep drilling wells, which in turn make water disappear in the neighbouring properties. Moreover, in that town district a sanitary sewer has been constructed. Although that

sewer is not yet operated, but in connection with its situation on some sections below the water table it has a drainage action, causing the drop of the water table by a couple of metres, so that some hand-made wells are deprived of water. All building work connected with the laying of foundations below the surface of the soil involves the drop of the water table arising from the dewatering of the foundation trench.

It may, therefore, be said that there is a number of causes which lead to hydrodynamic changes on the town site, these are among others:
dewatering of the foundation trenches for industrial and communal construction; construction of sewage systems; growth of water consumption by the developing industry, services, communal economy; increase of the number of water consumers resulting from the concentration of building lots; more numerous deep drilling wells.

CONCLUSIONS

The further extension of the town requires regular ground water control, permanent supervision of the existing and newly occurring sources and causes of ground water degradation by means, among other measures, of setting up of an adequate number of hydrological control openings /ref. 4/.

The progressing quantitative and qualitative changes are likely to result in the unsettling of the municipal water economics and of the soil and water conditions, which would affect the plant cover.

Particularly in towns where ground waters are the sole source of water supply, any extension of the town should be preceded by a thorough examination of hydrological conditions.

REFERENCES

1 A. Hunter Blair in J. A. Cole /Ed/, Proc. Conf. Groundwater Pollution in Europa. England, September 1972, Water Inf. Centr. Inc. Port Washinkton. New York, pp 40-48.
2 K. D. Schmidt, Journal AWWA, 3/1973/146-148.
3 R.G.Holzmacher, Water and Sawage works 4/1976/185-190.
4 A. F. Diefondorf and R. Ausburn, Public Works. July /1977/48-51.
5 H. Bujwid, Proc. 1st. Symp. Problems of the ground water utylization in the communal economics, Częstochowa, Poland, October 1977 C.T.K. NOT, 1977 pp.55-62.
6 W. A. Pettyjohn, Ground Water, 1/1979/18-21.
7 Craing Eisen and Mary P. Anderson. Ground Water 5/1979/456-462.
8 J. Bize end B. Guerin, T.S.M. L'Eou 6/1979/339-353.
9 H. Bujwid, Investigation of the effects of town planning processes on the changes of hydrogeological conditions. Library of the Research Inst. of Env. Develop. Warsaw, 1980.