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The Effect of the Anthropic Factors on the Quality of the Underground Waters within the Area of the Danube - Black Sea Canal

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Abstract

By its constructive characteristics, the Danube - Black Sea Canal is one of the most important constructions of this type in Europe. Its construction, the execution of the water captations' works in Caragea, Caragea Dermen, Eforie, Costinesti, Basarabi, Valul lui Traian, Medgidia etc. and the existence of the irrigation system have modified the natural hydrogeological conditions of the aquifer system. There are many pollutant sources along the canal, which in the case of an accident can have a powerful impact on the canal water, and this, on its turn, can become a secondary pollution source.
For establishing the effect of the anthropic factors on the quality of the underground water within the area of the Danube - Black Sea canal, it was realized: a chart of the phreatic level variations from the canal area, the hydrochemical monitoring of the canal and standpipes water, as well as a simulation program of the pollutant transport to the potable water captations.

Key words: *underground water, hydrochemical monitoring, aquifer, pollutants*

Introduction

A system of navigation canals was realized between the Danube and the Black Sea, including the main canal - Danube - Black Sea - which crosses Dobrogea from West to East and the North side Poarta Albă - Midia Năvodari that links the main canal with Midia Sea Port and the Taşaul lake.

The Danube - Black Sea navigation canal, 64.4 km long and with a hydrographic basin of approximately 870 km2, is an important part of the navigation way between the Black Sea and the North Sea (through the Rhin-Main-Danube Canal) and it links the Cernavoda sea port from the Constanta sea port, its course shorting the way to the Black Sea with almost 400 km.

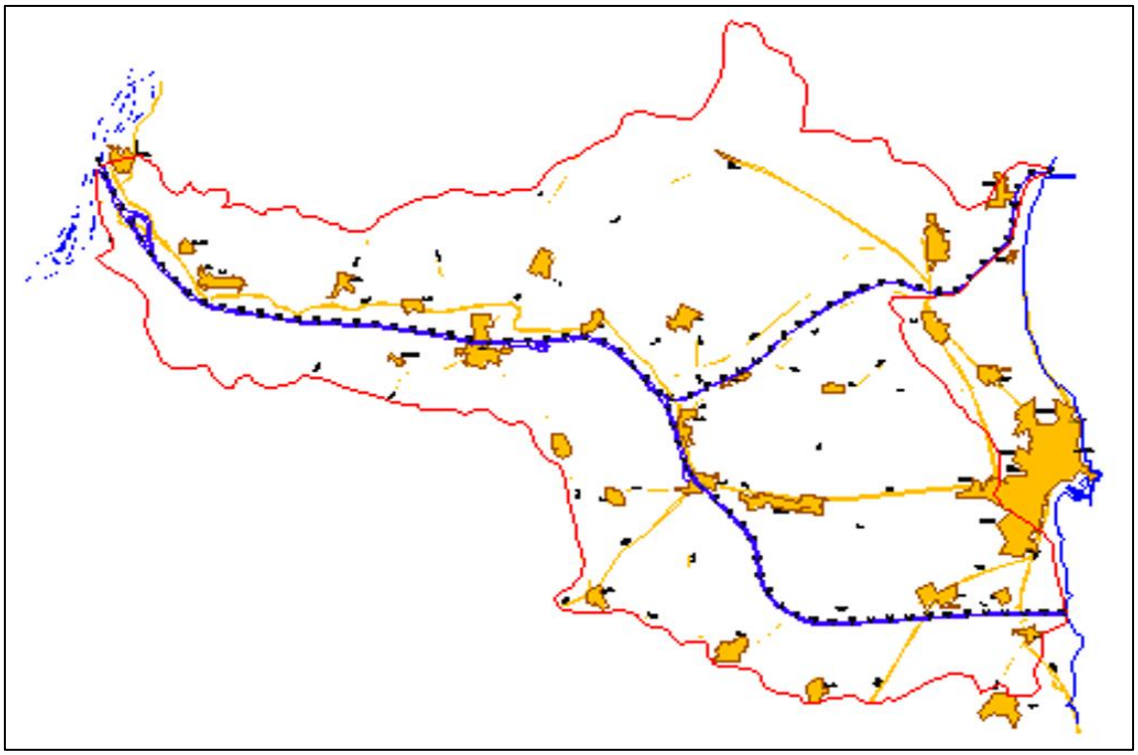


Fig. 1. Map of the courses in the Danube - Black Sea Canal and Poarta Alba – Midia Navodari

This navigation way which crosses South Dobrogea also became the main surface water source used for irrigations and industrial water, as well as for potable water supplying of the adjacent localities. As a result, satisfying the quality demands of the existent and future water usage is an essential problem.

During the period when the canal was executed, no studies or researches that would determine the influence it may have on the regime of the underground waters and the Techirghiol lake were considered; the only aspects considered were the hydro technical constructions from the canal area (wells, Watergates, etc.) and the stability of its banks.

Theoretical and Experimental Details

In order to estimate the vulnerability of the water resources from the South Dobrogea area, an area influenced by the constructions of the Danube - Black Sea Canal, the Poarta Albă - Midia – Năvodari Canal, as well as of the irrigation system, it was necessary to take into account lots of factors like: monitoring the phreatic level variations from the influence area of the canal, the hydrochemical monitoring of the canal and phreatic water, the canal bathymetry and sedimentology, the problem of the canal relations with the Jurassic - Cretatic aquifer, this being the main water supply source of Constanta city and of the industrial platforms within the area.

The researches performed when studying the course of the Danube - Black Sea Canal have pointed out from a hydrogeological point of view: quaternary aquifer complexes quartered in alluvial deposits characterized by a high lithological, granulometric and thickness non-uniformity**.** The hydrogeological parameters of these aquifers are very fluctuant and they depend on the spatial repartition of the deposits they quarter.

The water level in the quaternary aquifer is directly influenced by the canal water level and by the precipitations in the lower areas, while in the plateau area (Basarabi - Agigea area and

Poarta Alba - Ovidiu area), it depends only on the regime of the precipitations and the supply of water from irrigations.

The quaternary aquifer is, also, supplied on the SW - NE direction, by a component with a flow direction coming from the Bulgarian border.

The sarmatian aquifer is supplied from infiltrations coming from irrigations, ex-filtrations from the irrigation system's canals and from water infiltrations in the irrigation periods. The highest infiltrations can be found in the area of the irrigation canal Basarabi – Negru Vodă.

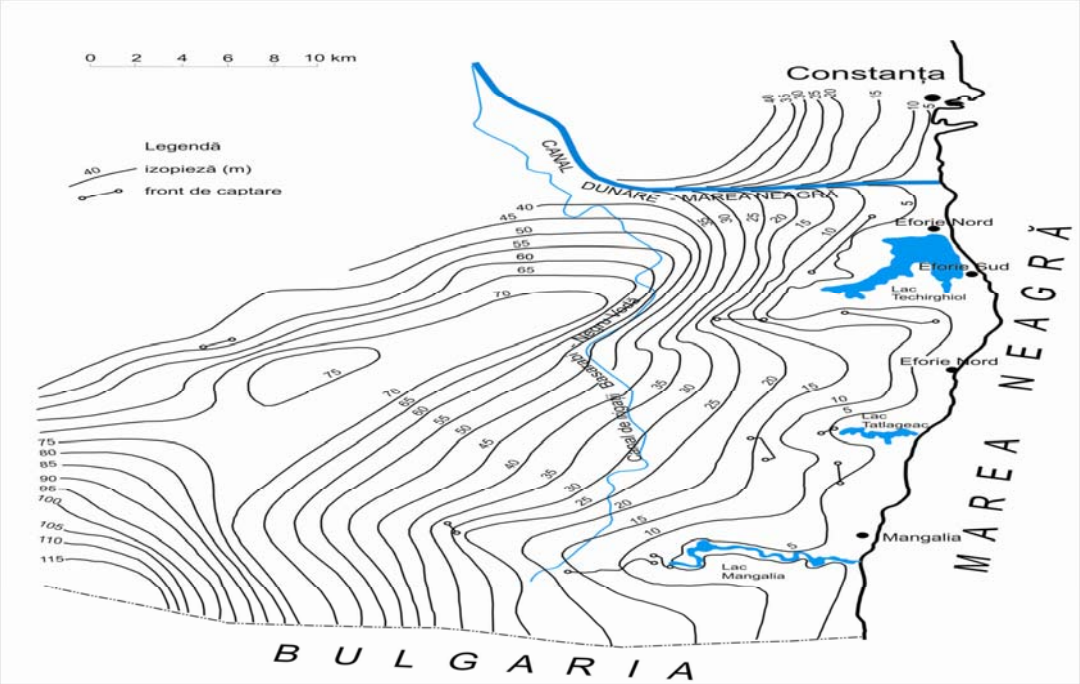


Fig. 2. Standpipe map of the sarmatian aquifer (see Moldoveanu, 1998, modified)

The medium depth aquifer, quartered in sarmațian, represents the main water supply source of the localities south from Eforie. Seasonal level variations in the sarmațian aquifer as a consequence of the precipitation regime prove its phreatic character.

The Danube – Black Sea Canal intercepts the sarmațian aquifer only on the last 5-6 km, before its inflow into the sea, sector in which this aquifer is drained by the canal.

According to the available measurements, the quotas of the hydrostatic levels in the sarmațian aquifer are included between the 115.6 m quota in the Cerchezu area and the 0.2 m quota from Schitu and between 22 m and in the neighborhood of the Bulgarian border and 0.7 m in the Constanta captation area.

Important captations exploiting the superior - inferior Jurassic aquifer can be found in Constanta, Medgidia and Basarabi - Valul lui Traian.

Along the canal, there are many pollutant sources which in the case of an accident can have a powerful impact on the canal water, and this, on its turn, can become a secondary pollution source (for the aquifer located within its area of influence) depending on the amplitude of the accident, the pollutant's nature, the soil permeability and the hydraulic conductivity.

For estimating the effect of the anthropic factors on the quality of the underground waters within the area of the canal, it was necessary to point out the pollutant/ potential pollutant

sources and to distribute the canal water into quality classes, as well as to highlight the influence of the canal water on the potable water sources within its areas of influence.

In the areas adjacent to the Danube - the Black Sea Canal and Poarta Albă-Midia Năvodari, the following pollutant/ potential pollutant sources were identified, such as: the waste water purifying plants, waste water pumping station, industrial sewage of economic units situated in the neighborhood of the canal, pluvial sewage, the garbage ramps, the animal farms, the pipes transporting petroleum products from the area of the hydrographic basin of the Danube - Black Sea canal, the ships and convoys of ships passing through the navigation canals and those operating in sea ports, hydraulic oil leakage from the Cernavoda and Agigea Watergates, etc.

In order to establish the vulnerability of the water resources in South Dobrogea caused by the possible action of certain chemical pollutants found in the canal water, samples of the surface and standpipes water was taken and analyzed periodically, trying to point out the reciprocal influences of the aquifer and the canal water.

Results

The water samples taken from the canal, when analyzed, pointed out a low carbonate - calcium mineralization or a carbonate - soda and sulphate - magnesium mineralization. Considering their content, they belong to 3rd quality class.

Because of the sulphates content which exceeds 300 mg/l, the water samples taken from the canal, near the bore holes located near the pumping stations and Ovidiu Sea Port belong to the 4th quality class.

From the pH point of view, the samples generally had a neutral character with values between 6.7 - 7.92. The only value of the pH higher than 8.5 was determined in the case of the water sample taken from the canal near the bore hole located near Agigea locality. All the water samples taken from the canal frequently pointed out a content of organic substances under 30 mg/l $KMnO_4$ and a content of nutrients, compounds of nitrogen within the 2nd quality class limits and phosphorus within the 4th quality class limits.

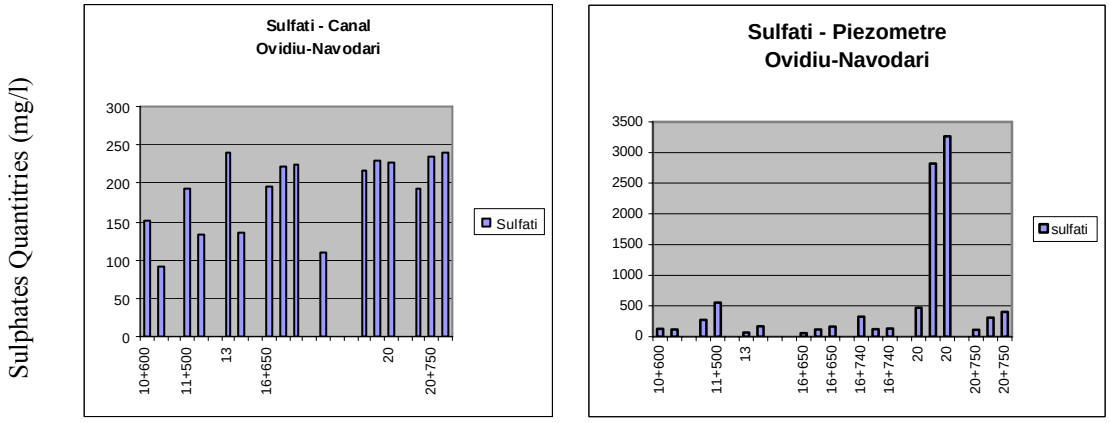
The analyses performed on the water samples taken from the canal pointed out the fact that except for the mentioned areas, the canal water is not affected by any significant pollution.

For establishing the quality of the phreatic waters influenced by the Danube - Black Sea Canal, water samples were taken and analyzed in the laboratory from the 18 standpipes in which the phreatic aquifer was met. The results obtained pointed out, in all the standpipes, a variable salinity, a soda - bicarbonate dominant water, rarely calcium, magnesium or sulphate water and with a fix residue with values between 168 and 4150 mg/l. Most of the water samples analyzed presented a neutral pH, except for samples from three bore holes located in the section between Castelu and Poarta Alba. These samples had a low acidity character.

The samples taken from a bore hole situated on the Poarta Alba - Midia - Navodari canal, near the locality Lumina and another bore hole situated upstream station 2 on the Poarta Alba – Agigea section (according to the numbering of the sampling stations for water and canal deposits, established in the research program), located on the sides of the canal, had a powerful basic pH. Therefore, the water was not within the potability parameters (pH = 9.8 - 11.69).

Some chemical indicators (sulphates, chlorides and sodium) were above the admitted concentration limit. In the boreholes upstream station 10, (station located near Medgidia city), the phreatic water had concentrations of sulphates and chlorides over 250 mg /l and of sodium over 200 mg/l.

Upstream station 2 and on the Poarta Alba - Midia - Navodari canal, near Valea Adanca locality, the water sampled from the bore holes presented quantities of sulphates and sodium over 200 mg/l, and in a bore hole located near Lumina locality, the water had concentrations of sulphates, chlorides and sodium over the admitted limit.



Locations of the sampling points from the canal Poarta Alba - Midia Navodari Area (km)

Locations of the sampling points from the standpipes Poarta Alba - Midia Navodari Area (km)

Fig. 3. Charts with quantities of sulphates over 200 mg/l in the Poarta Alba - Midia Navodari Area

In the other bore holes, at least one of the mentioned chemical indicators was above the admitted limit. Big quantities of organic substances were pointed out almost in all the bore holes. The water sampled near Medgidia city and Poarta Alba - Midia - Navodari canal on the section between Lumina and Mamaia village, presented the highest values.

Big quantities of pollutant elements like ammonium, nitrites and nitrates, iron and phosphates were pointed out in the same bore holes located near Medgidia city, as well as in the bore holes near Lumina and Valea Adanca localities and on the canal section, between Lumina locality and Mamaia Village.

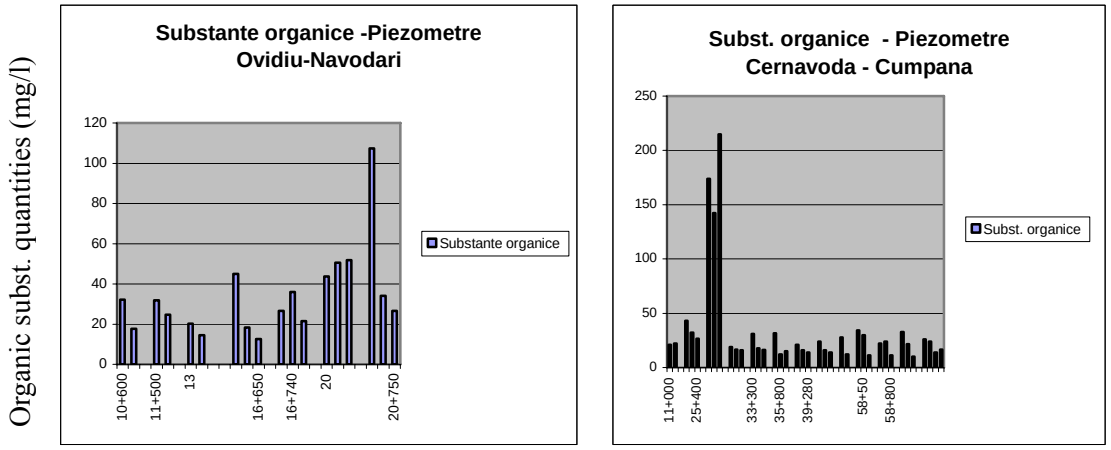
Organic substances, determined by the chemical consumption of oxygen, by using the potassium permanganate method, were found in quantities over 20 mg/l $KMnO_4$ in most of the stand pipes, while in the bore holes near the Lumina (at km 20+750 on the section Ovidiu Navodari) and Medgidia (at km 25+900 on the section Cernavoda – Cumpana) values exceeding 40 mg/l were found.

In the phreatic water, besides organic substances, pollutant elements in slightly raised quantities were observed like the following:

- ammonium, over 0.5 mg/l (in the bore holes from the Medgidia area, km 25+900 and in the bore holes located on the way to Navodari city),
- nitrates, over 50 mg/l (in the bore holes located between Lumina and Cumpana - Lazu localities and in the Ovidiu Sea Port),
- nitrites, over 0.5 mg/l (in the bore holes located between Lumina and Cumpana - Lazu localities and in the bore hole located on the other side of Nazarcea locality,
- iron, over 0,2 mg/l (Medgidia and Ovidiu Sea Port,)
- phosphates, over 0.5mg/l in almost all the bore holes.

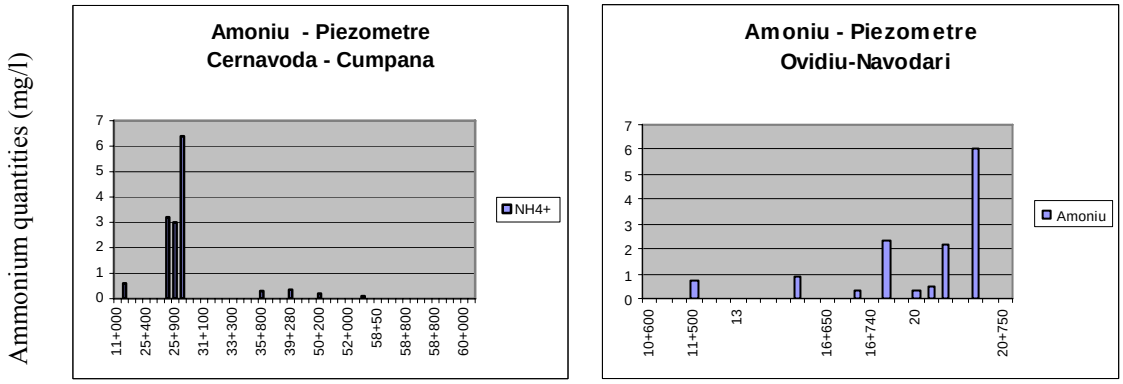
The analyses performed on the water samples taken from the standpipes pointed out that in all the bore holes there is at least one chemical parameter with values exceeding the admitted

potability limits. The bore holes located near Medgidia, Cumpana - Lazu, Ovidiu Sea Port and Navodari are the most polluted.



Location: Ovidiu – Navodari section (km) Location: Cernavoda – Cumpana section (km)

Fig. 4. Graphics with values of organic substances over 40 mg/l



Location: Cernavoda – Cumpana Section (km) Location: Ovidiu – Navodari Section (km)

Fig. 5. Graphics with values of ammonium over 0.5 mg/l

One of problems still present is the pollution with petroleum products. Between 1999 and 2004, petroleum products coming from the diesel and gas transport pipes damaged with the purpose of taking the petroleum product or from the deterioration of certain ships carrying such products have reached into the canal.

Although, no visible petrol or fats irizations were found on the water surface, in some of the samples taken both from the bore holes and canal water, light recoverable oil, present in quantities exceeding the admitted limit, was found in the old polluted areas: in the Basarabi captation area, Ovidiu Sea Port, Murfatlar vineyard on the right side and near the Nisipari valley.

Fig. 6. Pollution with petroleum product in the canal water between km 24 and km 29 (2004).

Conclusions

After analyzing the water samples taken both from the canal and from the monitoring stand pipes, it results that the pollutant analyzed are present in higher quantities (both in the stand pipes as well as in the canal water), in areas of human concentrations (where there are leaks of waste and industrial waters in the canal), in sections influenced by the garbage holes, in areas located near affluents of the canal (which bring with them chemical compounds used in agriculture or in zootechnics), in the areas of purifying stations or in areas affected by leaks from damaged oil pipe lines.

In order to point out the effects of an accidental pollution of the canal water on the water captations, it was performed a simulation of the pollutant transportation, in the Ovidiu area, considering the cvasi - steady flow regime and the constant exploitation capacities. The pollutant concentration and the environment dispersivity were different.

The transport model showed that, irrespective of the value of the concentration and dispersivity, after 20 years, the pollution effect manifests only on a limited area around the pollution source. This happens because of the hydrodynamic conditions in the area. The simulation results cannot be generalized because the parameters used for simulation are valid only for a granular environment and permanent flow.

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Efectul factorilor antropici asupra calității apelor subterane din perimetrul Canalului Dunăre – Marea Neagră

Rezumat

Prin caracteristicile sale constructive Canalul Dunare - Marea Neagra se plaseaza in categoria celor mai complexe constructii de acest gen din Europa. Constructia acestuia ca si executia lucrarilor de captari de apa de la Caragea, Caragea Dermen, Eforie, Costinesti, Basarabi, Valul lui Traian, Medgidia etc. si existenta sistemului de irigatii au modificat conditiile hidrogeologice naturale ale sistemului acvifer. Numeroasele surse potential poluatoare existente de-a lungul canalului, in cazul unui accident, ar afecta apa canalulu. Pentru stabilirea efectului factorilor antropici asupra calitatii apelor subterane din perimetrul canalului Dunare – Marea Neagra s-a realizat tabloul variatiei nivelurilor freatice din zona canalului, monitorizarea hidrochimica a apei din canal si din piezometre, cat si un program de modelare al transportului de poluant spre captarile de apa potabila.