# CONSIDERATIONS ON THE GROUND POLLUTANT EFFECT ON DRINKING WATER CONVEYANCE PIPES

## CONSIDERAȚII PRIVIND EFECTUL POLUANT AL TERENULUI ASUPRA CONDUCTELOR DE TRANSPORT ALE APEI POTABILE

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***Abstract.*** *The water supply system pipe networks are made of tubes and pipes joined by sockets or welds, on which a series of fittings are placed. The construction unit interacts with the degradation factors present on site. The research has shown that the main external mechanisms of pipe degradation result from the physico-chemical properties of the site's ground and external loads. External processes, which occur on the ground, lead to the degradation of the pipe network through the appearance of micro-pores, pores, fissures or cracks. Under specific operating conditions, water emission areas can become entering pathways for pollutants from the external environment inside the pipeline, causing the contamination of the drinking water conveyed. Considering the hydro-climatic phenomena in recent years, which have put pressure on viable drinking water resources, it is necessary to identify the external sources of degradation of the pipe networks.*

**Key words:** contamination, degradation, pollutant, potability, pipe network

***Rezumat.****Rețelele de conducte din sistemele de alimentare cu apă sunt alcătuite din tuburi şi țevi îmbinate prin mufe sau suduri, pe care sunt dispuse o serie de armături. Ansamblul constructiv interacționează cu factorii de degradare prezenți în terenul de amplasament. Cercetarea efectuată a arătat că principalele mecanisme externe de deteriorare a conductelor rezultă din proprietățile fizico-chimice ale pământurilor din amplasament şi din încărcările exterioare. Procesele externe, care se manifestă în teren, conduc la degradarea rețelei de conducte prin apariția de micro-pori, pori, fisuri sau crăpături. În condiții specifice de funcționare, zonele de emisie ale apei pot deveni căi de pătrundere a poluanților din mediul extern în interiorul conductei, producând contaminarea apei potabile transportată. În situația în care fenomenele hidro-climatice din ultimii ani au pus presiune pe resursele viabile de apă potabilă, este necesară identificarea surselor externe de degradare a rețelelor de conducte.*

**Cuvinte cheie:** contaminare, degradare, poluant, potabilitate, rețea de conducte

## INTRODUCTION

The ground pollutant effect is materialised both through degradation on the underground water conveyance structures and alteration of the quality parameters of potable water in pipes. The structural degradation of the pipes creates water emission areas. However, the resulting emitters can transform into entering pathways for external pollutants (Luca *et al.,* 2015).

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Drinking water conveyance pipes can operate under pressure or by free flowing. Pressure variations in water supply systems maintain the drinking water contamination phenomena. Under normal operating conditions, drinking water is pushed out into the embedding environment through existing emitters on the pipes (pores, holes, cracks, etc.). In exceptional cases, when the system operates under very low or vacuum pressure, elements from the external environment can penetrate the pipe, contaminating the conveyed drinking water (Chirica, 2018). The situation is frequently encountered during operational procedures, as part of repair operations of the damages identified on the pipe network. Controlled drainage of water conveyance pipes creates a favourable environment for external infiltration (Luca *et al.*, 2008). Infiltrations consist of solid or liquid matter with different chemical or organic charges.

## MATERIAL AND METHOD

The material under investigation consists of the features and elements with destructive potential of terrains where potable water conveyance pipes are located. The analysis aims at identifying and quantifying the risk factors in the pipe embedding environment.

Drinking water conveyance pipes are located in environments defined by risk factors. According to the risk factors location, internal and external elements are distinguished. The embedding environment acts on the buried pipes through the nature of the rocks on site, the groundwater, landslide phenomena, ground fractures or soil liquefaction etc. Internal factors are joined by those present at the site's surface. Among these, the most frequent risk elements result from loads from traffic transmitted from the ground surface, over ground structures with a pollutant effect (domestic and industrial waste landfills etc.), agricultural areas treated with pesticides and fertilizers etc.

The research method aims to identify and analyse the characteristic ground parameters, which through the pollutant effect lead to the degradation of drinking water conveyance pipes. The risk factors in the embedding environment which manifest themselves on pipe networks influence the performance of the entire water supply system. On site degradation mechanisms are constantly evolving and lead to pipe decay. The size of the affected area evolves over time, resulting in water emission areas. At the same time, emitters can facilitate the ingress of pollutants from the outside, leading to contamination of the conveyed water.

## RESULTS AND DISCUSSIONS

Iaşi County is located in Moldavian Platform structural unit. The bedding of the area is represented by the Sarmatian, which consists of clays with sand layers and waterproof argillaceous marl. The deposited aquifer complexes are characterised by a high concentration of salts, being represented by sulphurous, chlor-alkali, bromo-iodine, calcic magnesian, alkaline bicarbonates waters. The Sarmatian is covered by the Quaternary. The Quaternary is characterised by a mixture of contractile loams, silty sands, followed by sandy silt, sand and gravel (Chirica *et al.,* 2018) (fig. 1).

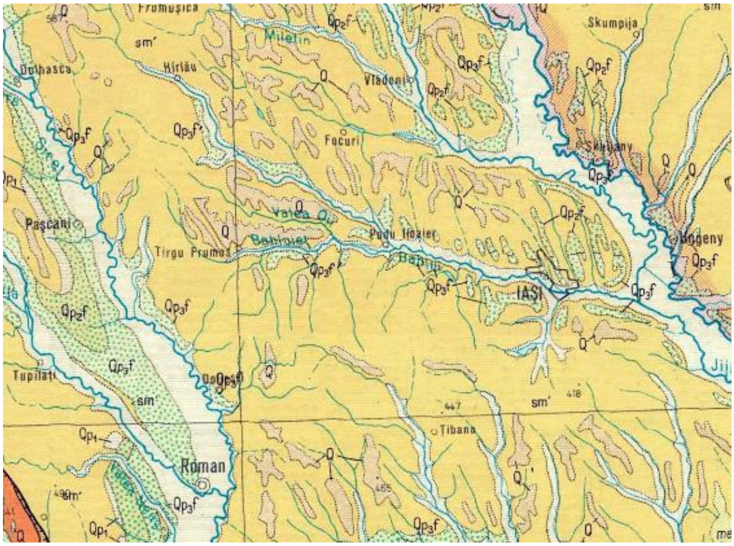


**Fig. 1** Geological map of Iaşi county: $Qp_3f$ – Upper Pleistocene river deposits; $Qp_2f$ – Middle Pleistocene fluvial deposits; Q – undivided Quaternary; sm' – Extra-Carpathian Sarmatian (source: Institutul de Geologie şi Geofizică, 1978)

The terrain from the pipe embedding environment is made up of clayey silt, silty clays and loams with layers of clayey silts. In this situation, the land has a strong contractile character, and the likelihood of shrinkage - swelling phenomena with the humidity variation is very high. Among the properties of clays with impact on underground pipes are moisture, pH and oxygen content.

Analysis data showed that cast iron tubes are corroded in terrains with saturated or partially saturated clays. Electrochemical oxidation occurs in the presence of hydrogen peroxide. Graphical corrosion occurs as a result of the formation of a galvanic cell between the cast iron (anode) and the high conductivity embedding environment (cathode). The metal surface reacts with the oxygen and groundwater, donating electrons (Moghareh Abed, 2014).

Pipes located in clayey terrains will develop chemical corrosion areas following the development of anode surfaces with low dissolved oxygen values. When the pipe is also in contact with other ground types, more permeable, the aeration difference between the two environments leads to the emergence of a local corrosion phenomenon, only in the clay contact area (fig. 2). Cathodic surfaces develop in grounds more permeable than clay, where the dissolved oxygen content is higher than in the areas in contact with the clay.

Research has shown that acid grounds react with concrete tubes, attacking the alkaline compounds. Pipe degradation occurs as a result of cement calcium oxide neutralisation. Thus, the pH of the concrete structure will decrease and the calcium silicate will dissolve. Analysis and interpretation of data from the studies of Jack and Wilmott (2011) and Uhlig (1963), quoted by Petersen and Melchers, show that a pH lower than 4 will amplify the corrosion process. Alkaline grounds are characterised by the presence of calcium and magnesium ions, which enable the build-up of carbonate protective layers on the surface of the pipe (Petersen and Melchers, 2012; Chirica, 2018).

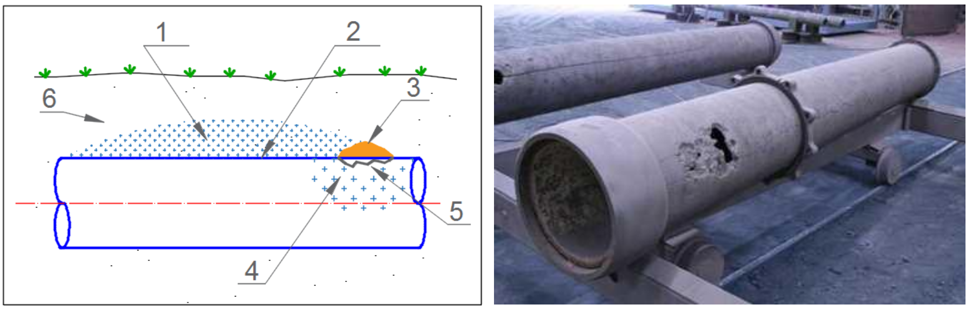


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**Fig. 2** Corrosion resulted from the contact with different ground types; a - schematic representation; b - corrosion on a pipe operated in an environment with different ground types (source: Petersen and Melchers, 2012; Chirica, 2018); 1 - cathodic area; 2 - increased level of dissolved oxygen; 3 - clay lump; 4 – anodic area with low dissolved oxygen; 5 - pipe corroded area; 6 - embedding environment consisting of sands.

Magnesium, sodium or calcium sulphates from terrains or groundwater have destructive potential on concrete pipes when they penetrate into their structure through pores and accumulate over time. Sulphates react with some of the concrete compounds, dissolving the cement hydration products. The ions that penetrate into the structure of the concrete form volume - enhancing products such as gypsum, which destroy the structure of the concrete (Rozière *et al*., 2009).

The chlorides in the embedding environment attack the steel pipes, but also the reinforcement elements of the reinforced concrete pipes. In the case of reinforced concrete pipes, chlorides no longer allow the concrete to protect the reinforcement from the action of acids. Corrosion of metal surfaces will occur in the presence of oxygen on site. The greater the permeability of the concrete, the more porous, with cracks and fissures and calcium chloride in its composition, the more severe the degradation will be (American Concrete Pipe Association, 2016).

Phreatic water confined in Iaşi County is characterised by intense sulphatic aggressiveness and weak magnesian aggression on concrete structures, according to STAS 3349/1-83. For this reason, concrete and steel pipes will be affected by chemical corrosion phenomena. The aggressiveness of groundwater requires special corrosion protection measures for underground pipelines. Unconfined phreatic waters located in Sarmatian formations are characterised by a superior degree of mineralisation. The ground waters from Tomeşti, Breazu, Copou and Picioru Lupului are sulphated, sodium and magnesic. Those in Pârcovaci, Răducăneni and Strunga areas are sulphurous, sodium and bicarbonated (Chirica *et al.,* 2018).

Timişeşti – Iaşi main water supply pipe AdII conveys water from the Timişeşti source up to the entrance of Iaşi Municipality on the Săbăoani, Strunga, Târgu Frumos route. The pipe is made of PREMO tubes with a diameter of 1000 and 800 mm. In Strunga, the pipe crosses Strunga Hill through a hydro-technical gallery. The sulphurous water present outside Strunga hydro-technical gallery led to the degradation of the objective's building materials. The high degree of mineralisation of the aquifer in the Strunga area is confirmed by the existence of a climatic bath resort in this area. The corrosive effect of the embedding environment and groundwater has degraded the concrete and reinforcement elements. The research shows the degradation at the top of the dome, the destruction of the concrete and binder elements (Luca *et al.,* 2008). The concrete walls of the gallery show numerous micro-fissures, fissures and cracks in the horizontal and vertical directions (fig. 3).

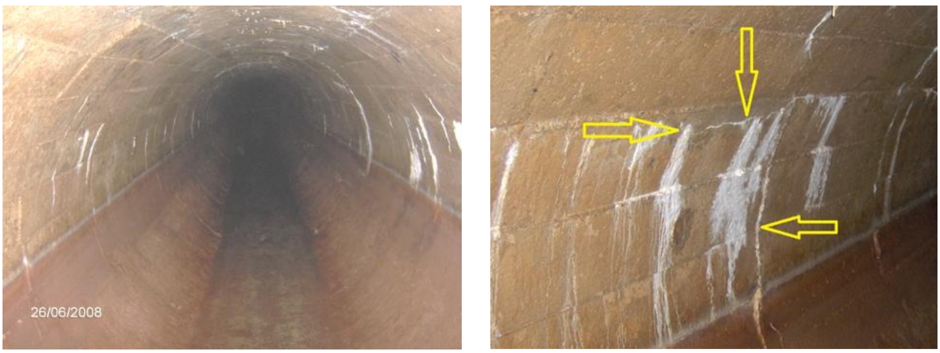


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**Fig. 3** Structural degradation of Strunga hydro-technical gallery located on AdII Timişeşti - Iaşi water supply pipe due to the site's ground pollutant effect; a - reinforced concrete water flow section; b - fissures and micro-fissures in the gallery wall (Luca *et al.,* 2008)

The degradation areas resulted enable infiltration - seepage processes through the Gallery wall, resulting an exchange between the water transported by the Gallery and the one existing in the embedding environment (Luca and Hobjilă, 2005). The contamination of drinking water conveyed through the Gallery takes place on the sections where the pores, micro-fissures and fissures in the structure wall have formed waterways. Water intrusion from the outside through the infiltration process will be enabled when the hydrostatic level of the water in the embedding environment is high. Similarly, if the Gallery does not carry water (situation encountered in case of water supply discontinuity following interventions, scheduled inspections or rehabilitation works) there will be infiltrations from the outside. Water seepage processes from inside the Gallery to the embedding environment are recorded when the water hydrostatic level in the ground is low.

## CONCLUSIONS

1. The drinking water conveyance pipes embedding environment has multiple risk factors that can lead to degradation phenomena of the underground systems, but also to the quality deterioration of the water conveyed by them.

2. One of the most important sources of contamination is the presence of sulphates and chlorides in the site's terrain or groundwater.

3. Iaşi County territory is characterised by aquifer complexes with high mineralisation levels, which create risk situations in the operational process of the drinking water conveyance pipes.

4. The research carried out at the Strunga hydro-technical gallery on Timişeşti - Iaşi supply pipe Ad II highlighted a series of degradations of the concrete structure following its exposure to sulphurous groundwater on site, phenomena exposed by infiltration - seepage processes through the concrete wall.

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