PROTECTION OF DISTRIBUTION NETWORKS WATER QUALITY

PROTECȚIA CALITĂȚII APEI POTABILE DIN REȚELELE DE DISTRIBUȚIE

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Abstract. *This paper presents a number of issues regarding the protection of drinking water quality in conveyance and distribution networks. Studies and research have shown that the physical and hydraulic integrity of the conveyance and distribution system influences the drinking water quality parameters. The state of pipelines, tanks, and hydraulic installations' physical integrity may influence the influx of contaminants into drinking water. The physical integrity factors considered in the research are: pipe material, geometric parameters, interior and exterior protection quality, corrosion, structural failure, degradation. The hydraulic integrity factors considered in the research are: variation of flow and pressure, velocity, sedimentation phenomenon, cavitation. Water integrity factors are: disinfectant dose, storage and movement time, physical and chemical reactions with the pipe, contaminant infiltration, age, biological stability. The case study for Iaşi city confirms the evolution of water quality parameters along the pipe network.*
Key words: physical integrity, hydraulic parameters, pollutants

Rezumat. *Lucrarea prezintă o serie de aspecte privind protecția calității apei potabile din rețelele de transport şi distribuție. Studiile şi cercetările efectuate au arătat că integritatea fizică şi hidraulică a sistemului de transport şi distribuție influențează parametrii de calitate ai apei potabile. Starea integrității fizice a conductelor, a rezervoarelor, a instalațiilor hidraulice pot influența afluxul de contaminanți în apa potabilă. Factorii de integritate fizică considerați în cercetare sunt: materialul pentru conductă, parametri geometrici, calitatea protecției interioare şi exterioare, coroziunea, cedări structurale, degradări. Factorii de integritate hidraulică considerați în cercetare sunt: variația debitului şi presiunii, viteza, fenomenul de sedimentare, cavitația. Factorii de integritate ai apei sunt: doza de dezinfectant, timpul de stocare şi mişcare, reacțiile fizico-chimice cu conducta, infiltrația contaminanților, vârsta, stabilitatea biologică. Studiul de caz întocmit pentru oraşul Iaşi confirmă evoluția parametrilor de calitate ai apei în lungul rețelei de conducte.*
Cuvinte cheie: integritate fizică, parametri hidraulici, poluanți

INTRODUCTION

Water supply systems provide the consumers' water demand, in accordance

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with the quality and quantity parameters imposed by the standards in force. Drinking water quality parameters are corrected when entering the system through treatment plants. Throughout their layout, in accordance with the networks' size and the recorded consumption, there can be found intermediate chlorination points within the storage tanks or directly into the pipeline distribution network.

Water supply distribution networks can have layouts covering thousands of kilometers, located both in urban and rural areas. Due to the extensive spatial distribution, the situations which can occur and influence the quality parameters of the water conveyed are extremely varied. Factors interfering with distribution networks can substantially change the characteristics of supplied water. An important requirement in the drinking water distribution management is the compliance with the quality parameters values required by the standards in force.

MATERIAL AND METHOD

The material used for research consists of the distribution network components with impact on the quality of drinking water conveyed to consumers. The pipeline distribution network is influenced externally and internally by a series of factors which can change water quality parameters locally and along the pipeline.

External factors which have an impact on water quality depend on the pipeline network's embedding surroundings through the rock's structure and physico - chemical parameters. Physical parameters consist of soil electric conductivity, cohesion and hydraulic conductivity. Chemical parameters include chemical conductivity and dissolved chemical content. Biological parameters interfere through areas with intermittent or continuous bacteriological potential. Other external factors include sewerage networks position in relation to water pipes, land use in the area, density of fittings, joints or branches and their degree of pipe sealing etc.

Internal factors which have an impact on water quality depend on the nature of the pipe material, the lack of disinfectants, the network running time and the consumption degree. These are elements which dictate the water age inside the pipes, the evolution of pathogens through virus and bacterial pollution, biofilm layer formation on pipe walls, the presence of organic or inorganic compounds which can react with the disinfectant used etc. Water quality must be constantly monitored. Delivering water which does not comply with the required standards is a major risk to the health of the population and can have serious consequences.

The research method analyses and evaluates the factors which affect drinking water quality parameters in distribution networks by using statistical calculation and graphic processing programs. The evolution of drinking water quality parameters transported through pipelines is analysed with appropriate computing software (eg EPANET), or developed in MATLAB computer programming environment.

RESULTS AND DISCUSSION

Water from the exterior can enter the pipe distribution network via various paths. The most common entering areas are pores, micro-cracks, cracks, fissures in pipe walls and related installations. Infiltrations from the embedding environment cause changes in the quality parameters of the water transported by pipeline to consumers. Contaminated water may come from damaged sewer networks, uncontrolled discharges from animal husbandry farms, agricultural land chemical stress, seepage from domestic and industrial waste dumps, accidental pollution etc.

The main water quality parameters are established by standards and norms, in conjunction with those from the European Community. Permissible concentrations are regulated in Romania by Law 458/2002 (tab. 1) and other standards.

Table 1

Potable water quality parameters

Parameters	Unit	Permissible concentration
1. Organoleptic parameters		
Colour	-	Acceptable
Taste	-	Acceptable
Smell	-	Acceptable
2. Disinfection parameters		
Free residual chlorine	mg/L	0.1 – 0.5
3. Physico – chemical parameters		
Ammonium	mg/L	max. 0.5
Nitrite	mg/L	max. 0.5
Nitrate	mg/L	max. 50
Hardness	^{o} Ge	min. 5
Turbidity	UNT	max. 5
Sulphates	mg/L	max. 250
pH	pH units	6.5 – 9.5
Conductivity	µS/cm	max. 2500
Free cyanide	mg/L	max. 0.01
Sodium	mg/L	max. 200
Lead	mg/L	max. 0.01
4. Radioactivity parameters		
α global activity	Bq/L	max. 0.1
β global activity	Bq/L	max. 1
5. Microbiological parameters		
Escherichia coli	no./100 mL	0
Coliform bacteria	no./100 mL	0
Enterococci	no./100 mL	0
Clostridium perfringens	no./100 mL	0

S.C. APAVITAL S.A. Iaşi regional operator constantly monitors the quality of drinking water distributed, from source to consumer. Analyses are carried out at the water’s entry point into the system, the treatment plant, the storage tanks, as well as at characteristic points on the distribution network. In addition to the water company’s monitoring activity, Public Health Department supervises in parallel the water quality parameters provided to consumers.

The data gathered by DSP Iaşi from the analyses carried out to evaluate the quality parameters of the drinking water distributed through the regional water supply system can be found in figure 1. Parameters which showed non-compliant values were chemical and bacteriological ones. The analysis of radioactivity parameters did not show any values exceeding the permitted limits.

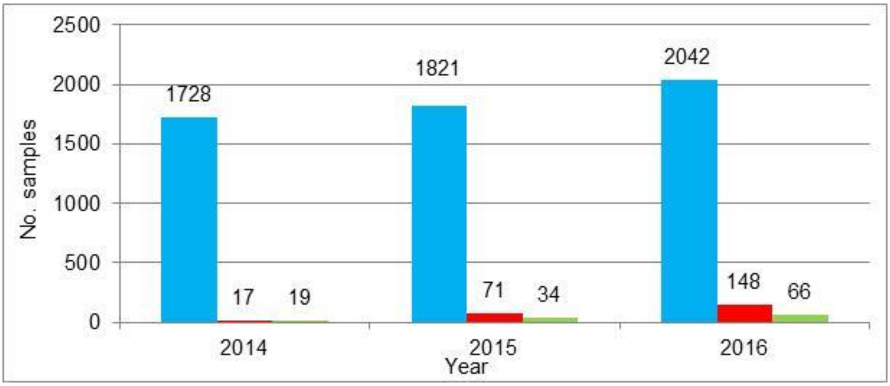

Fig. 1 Quality of drinking water in Iaşi County distribution networks (the color code represents: blue - the number of water samples, red - unsatisfactory chemical samples, green - unsatisfactory bacteriological samples (DSP Iaşi, 2017).

The number of samples taken during 2014 - 2016 has steadily increased. This is related to the expansion and establishment rate of water supply systems, especially in rural areas. The analyses revealed many unsatisfactory chemical and bacteriological samples. From 2042 samples taken in 2016, 7.25% did not meet the chemical requirements and 3.23 the bacteriological ones.

According to the Drinking Water Quality Law 458/2002, the permitted free residual chlorine value at the system's entry point is 0.5 mg/l and at the end of the distribution network is 0.1 mg/L. The studies show that some average monthly values obtained by the regional operator in Iaşi City in 2016 for the free residual chlorine parameter are below the permitted limit (fig. 2). Samples taken from Aurora tanks and distribution network are shown in parallel. The difference between the values obtained at the water departure point and those from the distribution network shows that there are reactions and processes inside the pipes which cause the disinfectant concentration to decrease. External contamination, disinfectant reactions with pipe material, accidental contamination, or water loss along the pipe lay-out are the most common factors affecting water quality.

Aurora tanks store the water that reaches Iaşi City from Timişeşti catchment fronts. The free residual chlorine values recorded during 2016 show compliance with the limits imposed by the Drinking Water Quality Law. The lowest value recorded is 0.23 mg/L, and the highest one is 0.44 mg/L. The water volumes distributed from Aurora tanks are chlorinated again, in order to bring the free residual chlorine value to 0.5 mg/L, according to the law.

The average values of free residual chlorine in the distribution network are very close to the minimum allowed by law. Towards the end of the distribution network there is an increased risk that the supplied water does not meet the required quality parameters. Figure 2 shows the value registered in May of 0.11 mg/L exceeds only by 0.01 mg/L the minimum allowed by Law 458/2002. The highest registered value was 0.27 mg/L in September.

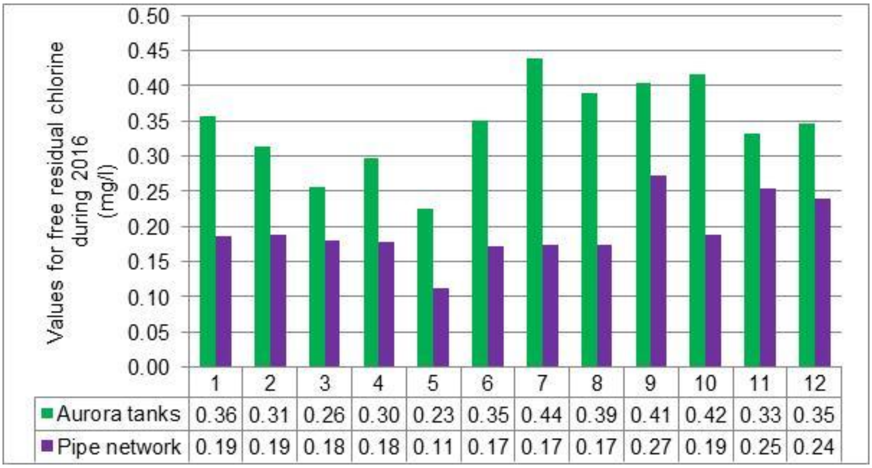

Fig. 2 The evolution of free residual chlorine in the Aurora tanks and the distribution network of Iaşi City in 2016

Measurements conducted in one of the worst case operating points on the distribution network (fig. 3) show the values for the free residual chlorine parameter reach the lowest limit permitted by law for about half of the analysed samples. This requires the development of a research program to highlight the factors which influence the reduction of residual chlorine.

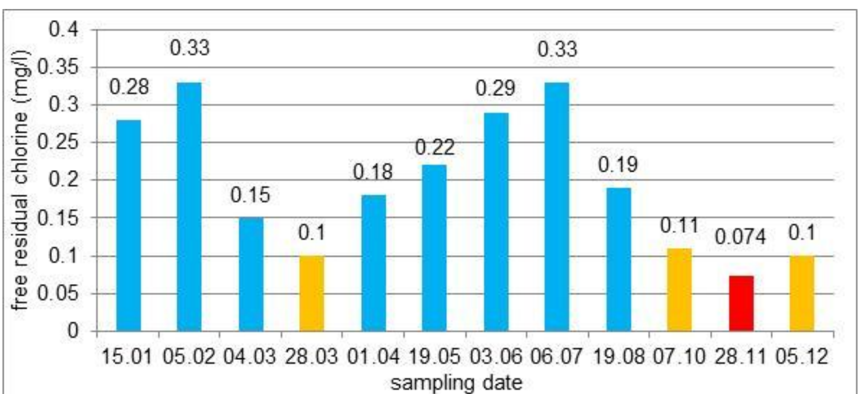

Fig. 3 Values for free residual chlorine in Piața Halei measuring point, year 2016 (the color code represents: blue – values permitted by law, orange – values close to the lowest permitted limit, red – values bellow the permitted limit)

Piața Halei monitoring point analysis show the variation in free residual chlorine concentrations ranges from 0.33 mg/L to 0.074 mg/L. In March, October and December, values of 0.1 mg/L are recorded, and the November results indicate a value below the permitted potable limit.

Fluctuations of the free residual chlorine value show the action of some temporary factors which do not permanently affect the water quality. Since February, recorded values have declined from 0.33 mg/L to 0.1 mg/L in March, after which the chlorine concentration increases to a maximum of 0.33 mg/l in July. The same phenomenon also occurred in July, when values began to drop steadily to 0.074 mg/L in November, after which the free residual chlorine concentration began to rise again. This pattern suggests the presence of external contaminants, which penetrated the distribution network through the pipes' cracks and pores. Variations can also be caused by water losses along the pipe network up to the measuring point. These elements may cause a decrease in the disinfectant concentration which does not return to normal values until the disturbing factors are removed or remedied. All this confirms the necessity of field studies and research to highlight the factors influencing the reduction of residual chlorine on the transport and distribution network.

CONCLUSIONS

1. Studies and research have shown that the physical and hydraulic integrity of the transport and distribution pipe network significantly influences drinking water quality parameters.

2. The study shows an external and internal type of water contamination, where the external contamination is mainly caused by the infiltration of pollutants and the internal one is represented by the physical and chemical transformations occurring inside the pipes, tanks and hydraulic installations.

3. In-situ analyses have shown that disinfectant concentration decreasing may be the result of external contamination, but this may also be the result of disinfectant reactions with pipe walls and organic matter left in the water.

4. The absence of a residual disinfectant shows that the system's integrity has been compromised and the drinking water contamination rapidly occurs downstream to the consumer, without measures to restore the quality parameter.

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