

Drinking water disinfectants used in Vojvodina
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Introduce

This paper gives an overview of the current situation in water supply systems in Vojvodina, in terms of used disinfectants. Summary of data on water quality, applied disinfectants (chlorine gas, sodium hypochlorite, chlorine dioxide, hydrogen peroxide + silver), material and age of pipeline, and the problems of corrosion and hygienic and health aspects in correlation with applied disinfectant.

Situation in Vojvodina

Vojvodina is the northern province of Republic of Serbia, which covers an area of 21.506 km², consist of 45 municipalities in 7 districts, with 2.031.992 habitants (27,1% of Serbia population) (Chart 1)



Chart 1. Republic of Serbia

The most usually raw water source is underground water, exploited by wells, with different depths (50-300m), organized through water catchments, or individually wells.

In other region of Republic of Serbia, the water supply systems using the surface water, from rivers, accumulation lakes, or mix surface water with wells water.

This paper includes information collected through the questionnaires submitted, from 25 water supply systems. These supply systems supplied 1.111.000 habitants - 55% of the total population in Vojvodina and approx. 15% of Serbia population, with capacity of 3 to 1500 l per s, with the annual exploitation 75.000 do 35.000.000 m³, for 350 to 330.000 consumers, with different physical, chemical and microbiological

water quality in distribution networks, with different materials and pipeline diameters, and different state of systems.

Raw water quality in Vojvodina

The quality of raw waters is very different, depending the area, depth of wells and physical and chemical parameters of raw water.

The most important differences in quality are between „white“ and „yellow“ waters. The „white“ raw water common have higher concentration of iron, manganese, higher totally hardness, but lower content of organic matter, and ammonium. The „yellow“ waters are, in most cases, with a higher content of methane, hydrogen sulfide, organic matter, with specific odor, taste, color, with low hardness... Content of arsenic depends on the characteristics of the source and the largest one in eastern and northwestern parts of Vojvodina.

Table 1. Typical characteristics of raw water in Vojvodina

No.	Parameter	Unit	White raw water	Yellow raw water	MAC*
1.	pH	/	7,5 -8,5	7,5-8,5	6,8-8,5
2.	Conductivity	µS/cm	500-1100	1500 - 3300	1000
3.	Color	mgPt/l	5-10	60-90	5
4.	Odor	/	odorless	characteristic	odorless
5.	Turbidity	NTU	0,5-3	0,4-1,5	1
6.	Ammonium	mg/l	1-3	3 - 70	0,1 (1)
7.	Iron	mg/l	0,04-1,5	0,2-1	0,3
8.	Manganese	mg/l	0,07-0,1	0,02-0,05	0,05
9.	Remaining after evapor.	mg/l	400-900	900 - 2000	/
10.	Chloride	mg/l	5-20	30-120	200
11.	Nitrites	mg/l	< 0,01-0,02	< 0,01	0,03
12.	Nitrates	mg/l	< 0,01-1,4	1-8	50
13.	KMnO4 consumption	mg/l	0,5-12	40 - 95	8
14.	As	mg/l	< 0,01-0,10	0,01-0,20	0,01
15.	Na	mg/l	50-200	200-400	150

* - Regulation on the hygiene of drinking water

Lately, more and more mention B and Br, but their content is not include in mandatory testing and is not known in most drinking water.

In corelation with raw water conditioning treatments to drinking water quality, in Vojvodina, we have public utilities for water supply with acceptable treatment, with quality of output water according Regulation. But, in small settlements, with individually wells, we have water distribution without any treatment, only with disinfection, almost with sodium hypochlorite.

In some settlements, with „yellow“ water in distribution net, the disinfection with chlorine gas or with sodium hypochlorite is not acceptable solution, because the products of disifection are toxic and cancerogenic TCM's, or HAAs. In this cases, disconitual disinfection of well and net with sodium hypochlorite is usual, with warning the population that not use water for cooking or water for livestock, for several hours after disinfection.

In cases that the high content of organic matter or ammonium is not the only one problem, the usage of water from distrubution net for drinking is prohibited, from the reason of content of arsenic, or maganese, iron, odor, turbidity, color,...

In Vojvodina region is ussualy that habitants drinkig the „yellow“ water from public arteric wells (in Becej, Backo Petrovo Selo, Senta, Zrenjanin). This termomineral yellow water waters have high content of sodium, high electro-conductivity, high mineral content, potential danger for health. At some arteric wells were posted warnings about the recommanded limited use in case of individual health problems.

Legal framework

The valid regulations in Republic of Serbia are:

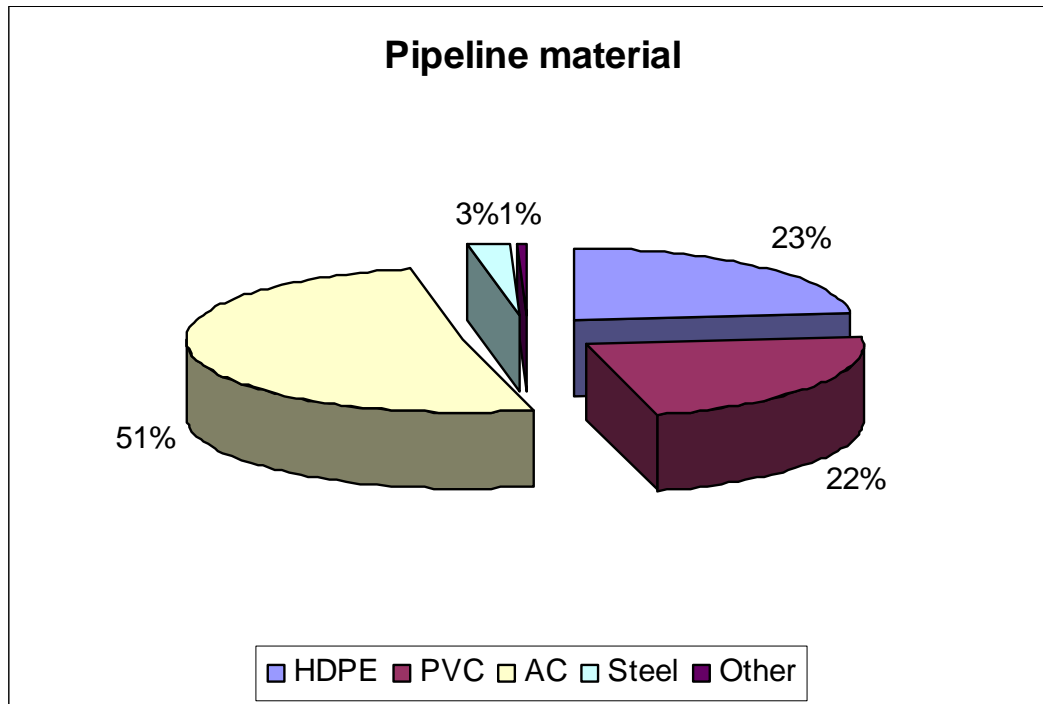
- Water Low [1]
- Regulation on disinfection and inspection of drinking water [2],
- Regulation about methods of sampling and methods of laboratory analysis of drinking water [3],
- Regulation on the hygiene of drinking water [4],
- Vojvodina Water Supply Strategy [5].

The new Regulation on Health Safety of drinking water, done in accordance with requirements of European community and guidelines about water quality, on base of EU drinking water standards and Council Directive 98/83/EC, has been prepared by Working group of Ministry of health and is now standard procedure of adopted by the Republic Assembly.

The drinking water quality in public water supply systems is under supervising of authorized Public health Institutes, and Sanitary inspections.

Water supply systems in Vojvodina

The water utilities are mainly asbestos cement, metal and plastic (HDPE, PVC) pipes. Proportion of different pipeline material in water supply systems is shown in Graph 1.

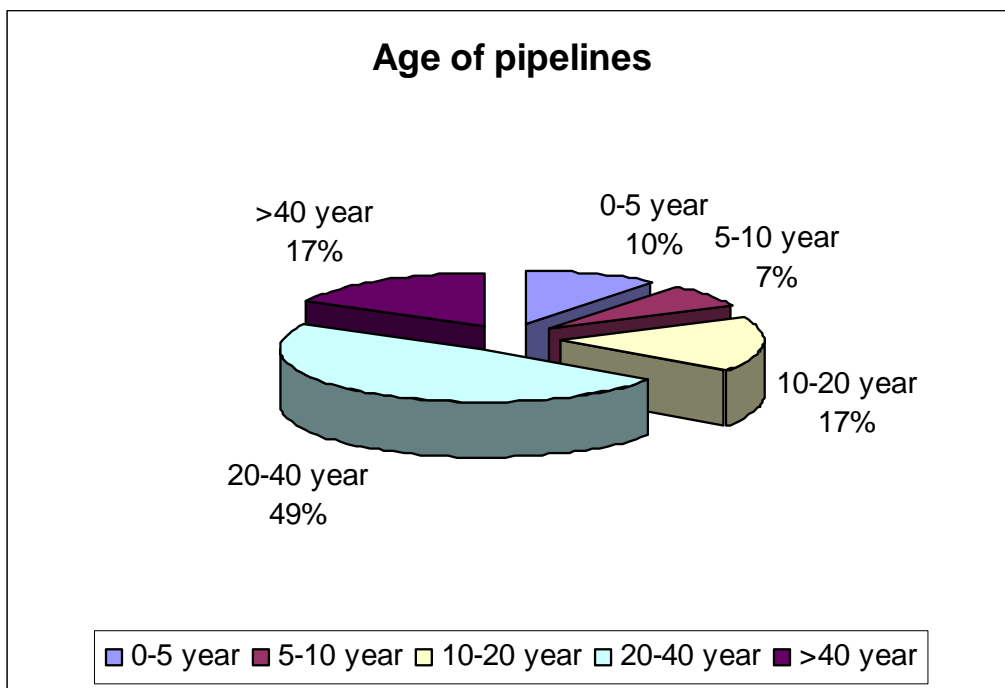


Graph 1. Pipeline material in water supply systems in Vojvodina

Water supply network in the water supply in Vojvodina was partially reconstructed during the past 10 years, especially in larger towns. However, in much of small settlements, the following problems:

- network is worn out (mechanically damaged in the case of asbestos cement pipes and corroded in the case of zinc galvanized metal pipe),
- the improper pipe diameter,
- technically faulty joints,
- with a blind arms, without circular flow,
- without the possibility of rinse of network
- with high levels of leakage (to 80%).

Water supply systems were built starting from almost 50 years ago. Age of the pipeline is shown in Graph 2.



Graph 2. Age of pipeline in water supply systems in Vojvodina

Disinfection in water supply systems in Vojvodina

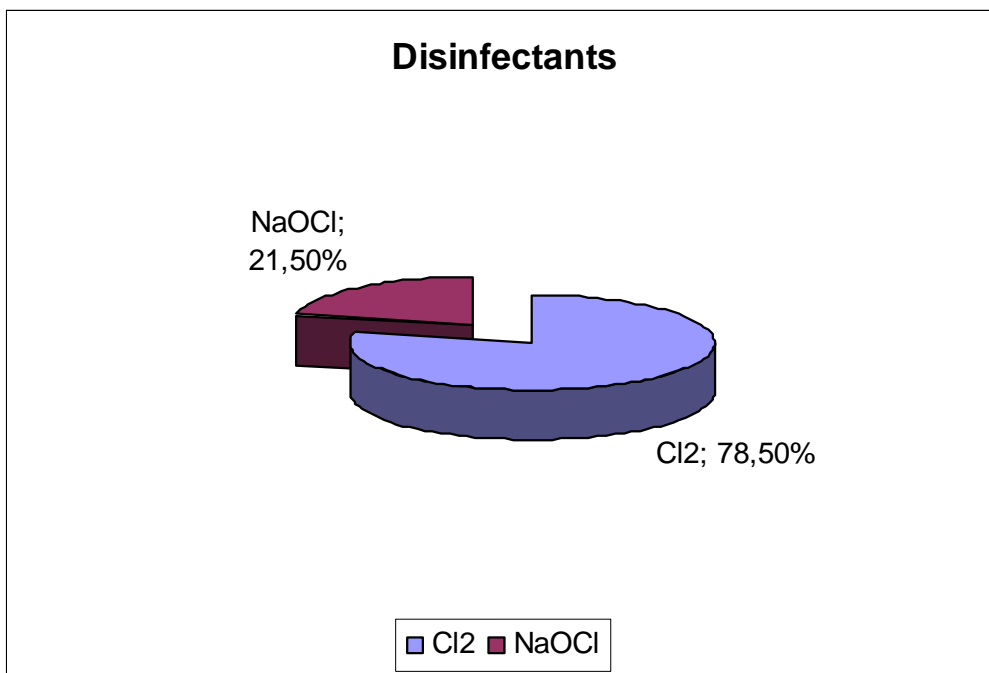
Disinfection is accomplished by adding disinfectant chemicals in the last step in purifying drinking water (when raw water treatment exist), or directly, in water on output from well (with continual dosage, or discontinual). Water is disinfected to kill any pathogens: viruses and bacteria (*Escherichia coli*, *Campylobacter*, *Shigella*, *Giardia lamblia*, *Cryptosporidia*). Public water supplies are required to maintain a residual disinfecting agent throughout the distribution system.

Disinfecting the drinking water to be done with chlorine, sodium-hypochlorite, chlorine dioxide, hydrogen peroxide with a silver, ozone, UV, ...

Disinfection of water supply systems in Vojvodina is carried out mainly gaseous chlorine or sodium-hypochlorite. Rarely used other chemicals – chlorine dioxide, or hydrogen peroxide with a silver, in case of disinfection of wells, certain objects or part of network, when it comes to specific contamination or super – disinfection. Table 2 presents the characteristics of common disinfectants and Grapf 3 is shown the ratio applied common disinfectants.

Table 2. The characteristics of common disinfectants

Disinfectant	Characteristics	Benefits	Problems
Chlorine gas	Chemical that rapidly kill harmful microorganisms	-Strong oxidant -Inexpensive	-Toxic gas -Harmful by-products with natural organic compounds (THMs,HAAs) -Limited effectiveness against <i>Giardia lamblia</i> and <i>Cryptosporidia</i>
Sodium hypochlorite, liquid	Chemical that rapidly kill harmful microorganisms	-Strong oxidant -Inexpensive	- Harmful by-products with natural organic compounds (THMs,HAAs) -Limited effectiveness against <i>Giardia lamblia</i> and <i>Cryptosporidia</i>
Chlorine dioxide	Advanced disinfectant	-Strong oxidant -Superior to chlorine: for control <i>Legionella</i> , operating above pH 7, in presence of ammonia and amines (less harmful by-products) - Control biofilms	- Toxic - Oxidising - Corrosive - Higher price - Residual is more difficult to achieve than with chlorine - Residual is controlled by specific test on ClO ₂
Hydrogen peroxide with colloidal silver	Advanced disinfectant	-Strong oxidant -Superior to chlorine for control <i>Legionella</i> and <i>Pseudomona</i> operating in wide range pH, without harmful by-products, - Longlasting due to Ag - Control biofilms	- Oxidising - Residual is controlled by specific test on H ₂ O ₂



Graph 3. Disinfectants in water supply systems in Vojvodina

Monitoring the corrosion of pipelines, as a result of electro-chemical reaction of water and soil, various physical parameters of water regime and the application of disinfectants (different chemicals and different concentrations) did not practice in Vojvodina

Conclusion

The final solution is the obligation of the authorities to ensure hygienic-sanitary acceptable quality of drinking water in distribution nets, through appropriate treatment of raw water, with removal of chemical substances from raw water and disinfection.

However, given the necessity to improve the water supply system to health, sanitary and economic standpoint, according HACCP requirements, in the near future will be inevitable to take into account the choice of disinfectant, optimizing the concentration and proper selection of pipeline material, depending on the characteristics of water, disinfectant and soil.

The big problem in business as a public water supply system of state utilities is a non-economic cost of water (between 10 and 85 EU cents per m³), depending on municipality; water quality; sewage net and waste water treatment plant,...Operations in these conditions does not provide elementary maintenance, construction or improve the water supply systems.

Literature

1. Water Law, Official Gazette Republic of Serbia, No.30/2010
2. Regulation on disinfection and inspection of drinking water, Official Gazette Republic of Serbia, No.60/1981
3. Regulation about methods of sampling and methods of laboratory analysis of drinking water, Official Gazette Republic of Yugoslavia, No.33/1987
4. Regulation on the hygiene of drinking water, Official Gazette Republic of Serbia, No.42/1998, 44/1999
5. Vojvodina Water Supply Strategy, Official Gazette Region of Vojvodina, No.01/2010