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Drinking water quality assessment in Constanta town

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Abstract The quality of drinking water is an issue of primary interest for the residents of the European Union. Water is essential to sustain life, and a satisfactory supply must be made available to consumers. Failure to provide effective treatment of water sources and safe distribution of treated drinking water can expose the community to the risk of outbreaks of diseases or other adverse heath effects.
The paper aims to emphasize the actual sources of water supply in Constanta town, the applied treatments according to their quality and the water treatment processes performances obtained in 2009.
All the studied quality parameters (turbidity, pH, ammonium, nitrites, nitrates, free residual chlorine, chlorides, permanganate indices, total hardness, total dry residues, sulfates, conductivity) have been maintained in the accepted limits. Important removal efficiencies have been observed for turbidity (65-93%), nitrites (72-96%) and organic substances (46-78%).

Keywords: drinking water, turbidity, nitrites, organic substances, removal efficiencies

1. Introduction

Drinking water is an essential environmental constituent, but also could be considered a major source of food with important impact upon the quality of life and the health state of the population. There are speculations that associate the modern civilization with the rediscovery of hygiene, rather than with the industrial revolution meeting the following demands: it should not contain microorganisms, parasites or substances that might represent a potential hazard for human health and it must meet the minimal requirements stipulated in regulations concerning the quality parameters of potable water (microbiological and chemical indicators) [1, 2]. The quality of drinking water is an issue of primary interest for the residents of the European Union. Water is essential to sustain life, and a satisfactory supply must be made available to consumers. Failure to provide effective treatment of water sources and safe distribution of treated drinking water can expose the community to the risk of outbreaks of diseases or other adverse heath effects [3].

The necessary treatments for drinking water, according to the water source quality, as prescribed by Directive 75/440/EC, are: (i) "Intensive physical and chemical treatment, extended treatment and disinfection: chlorination to break-point, coagulation, flocculation, decantation, filtration, adsorption (activated carbon), disinfection (ozone, final chlorination)" for surface water of Category A3, (ii) "Normal physical treatment, chemical treatment and disinfection: pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination)" for surface water of Category A2 and (iii) "Simple physical treatment and disinfection: rapid filtration and disinfection" for surface water of Category A1, which is usually also used for groundwater.

In the last decade, new water purification technologies have received growing attention: reverse osmose-desalination [4], electrocoagulation [5], membrane filtration coupled with coagulation [6] or biological treatment [7], photocatalytic oxidation [8].

New filters like silver-impregnated ceramic have been proposed for low-cost household drinking water treatment.

The aim of this study is to present the actual sources of water supply in Constanta town, the applied treatments according to their quality and the water treatment processes performances obtained in 2009.

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2. Experimental

The technological flow of the studied drinking water facility and sampling points are presented in **Fig.1.**

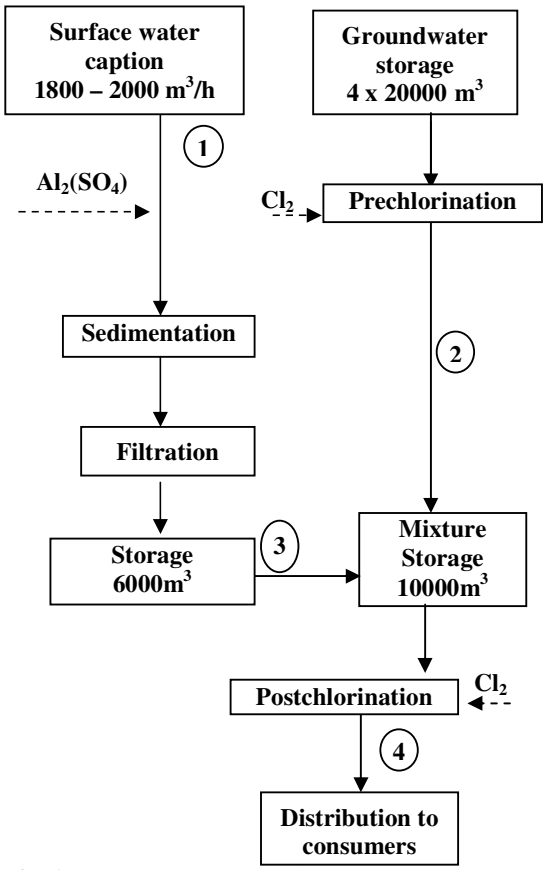

Fig. 1. Technological flow of drinking water facility and sampling points

Water treatment facilities for drinking water processes for Constanta town two types of conventional clean water: (i) surface waters from the Danube, Galesu source, located on the branch Poarta Alba - Midia – Navodari of the Danube - Black Sea Canal and (ii) groundwater from two sources: Cismea I and Cismea II.

The treatment plant consists of two technological lines for treatment of surface water: the old line (station I) with a treatment capacity of 1.75 m^3 / s currently pending in the conservation and new line (station II) with a capacity treatment of 2.00 m^3 / s. As the Fig. 1 shows, the treatment processes involve coagulation flocculation, filtration and sterilization using chlorine.

To achieve the proposed studies, in 2009 samples have been collected as follows: 1 - raw surface water, 2 – raw prechlorinated groundwater, 3 - treated surface water, 4 - drinking water distributed to consumers. The next quality parameters have been determined: turbidity, pH, ammonium, nitrites, nitrates, chlorides, free residual chlorine, permanganate index, total hardness, dry residuum, conductivity and sulfates, using official analytical methods from Romanian regulations [10-13].

The removal efficiencies of the selected parameters (turbidity, permanganate index and nitrites) have been calculated using the relation (1).

$$Ef\% = \frac{I - E}{I} \times 100 \qquad (1)$$

where: I - concentration in raw water (influent), E - concentration in drinking water (effluent).

3. Results and Discussions

Evolution of the studied water quality parameters in various stages of technological process are presented in **Tables 1, 2. 3**. and **4**.
It can be observed .that in all cases the analyzed indicators have values below the accepted limits (listed in brackets).

Comparing water quality parameters from two sources (surface and groundwater) it was found that groundwater has slightly higher salinity demonstrated by the conductivity values, dry residue, chlorides, sulfates and total hardness.

Concentration of dissolved organic substances evidenced by permanganate index is higher in surfaced water (1.01-2.44mgO_2/L) than in the groundwater (1.74-3.64mg O_2/L).

Carefully analyzing the data presented in Table 4. it can be noticed that the distributed drinking water in the city of Constanta in 2009 fully fitted the imposed quality standards.

Concerning the water treatment performances, the montly averages removal efficiencies for turbidity, nitrites and organic substances are presented in **Fig. 1-3**.

Table 1. Quality parameters of raw surface water (sample 1), in Constanta, monthly averages 2009

Parameter (accepted limit, UM)	**Min**	**Max**	**Mean**
Turbidity (<5 NTU)	1.42	15.26	4.29
pH (6.5-9.5)	7.88	8.36	8.08
Amonium (NH_4^+) (0.5 mg/L)	0.001	0.488	0.052
Nitrites (NO_2^-) (0.5 mg/L)	0.011	0.081	0.038
Nitrates (NO_3^-) (50 mg/L)	3.15	14.6	9.37
Clorides (Cl^-) (250 mg/L)	28.22	58.6	42.21
Permanganate index (5 mgO_2/L)	1.74	3.64	2.39
Total hardness (>5^{0}G)	10.18	16.7	12.87
Dry rezidue at 105^{0}C. mg/L	287	454	362
Conductivity (2500µS/cm)	420	771	565
Sulphates (SO_4^{2-}) (250 mg/L)	38.4	89.7	57.8

Table 2
Quality parameters of prechlorinated groundwater (sample 2), in Constanta, monthly averages 2009

Parameter (accepted limit, UM)	**Min**	**Max**	**Mean**
Turbidity (<5 NTU)	0.06	0.22	0.14
pH (6.5-9.5)	7.47	7.86	7.58
Amonium (NH_4^+) (0.5 mg/L)	0.000	0.000	0
Nitrites (NO_2^-) (0.5 mg/L)	0.000	0.001	0.001
Nitrates (NO_3^-) (50 mg/L)	7.35	14.9	9.92
Free residual chlorine (0.5mg/L)	0.50	0.66	0.56
Clorides (Cl^-) (250 mg/L)	74.1	90.1	87.67
Permanganate index (5 mgO_2/L)	0.382	0.569	0.473
Total hardness (>5^{0}G)	19.0	20.3	19.96
Dry rezidue at 105^{0}C. mg/L	513	638	560
Conductivity (2500µS/cm)	879	990	956
Sulphates (SO_4^{2-}) (250 mg/L)	83.3	109	99

Table 3
Quality parameters of treated surface water (sample 3), in Constanta, monthly averages 2009

Parameter (accepted limit, UM)	**Min**	**Max**	**Mean**
Turbidity (<5 NTU)	0.80	4.60	1.77
pH (6.5-9.5)	7.51	8.30	7.97
Amonium (NH_4^+) (0.5 mg/L)	0.000	0.000	0.006
Nitrites (NO_2^-) (0.5 mg/L)	0.000	0.008	0.006
Nitrates (NO_3^-) (50 mg/L)	2.80	12.4	7.76
Free residual chlorine (0.5mg/L)	0.58	0.74	0.66
Clorides (Cl^-) (250 mg/L)	31.7	59.3	43.55
Permanganate index (5 mgO_2/L)	1.01	2.44	1.68
Total hardness (>5^{0}G)	11.3	16.4	13.09
Dry rezidue at 105^{0}C. mg/L	280	459	346
Conductivity (2500µS/cm)	437	818	583
Sulphates (SO_4^{2-}) (250 mg/L)	44.8	96.1	63

Table 4
Quality parameters of drinking water distributed to consumers (sample 4), in Constanta, monthly averages 2009

Parameter (accepted limit, UM)	**Min**	**Max**	**Mean**
Turbidity (<5 NTU)	0.19	1.51	0.79
pH (6.5-9.5)	7.50	8.14	7.75
Amonium (NH_4^+) (0.5 mg/L)	0.000	0.000	0
Nitrites (NO_2^-) (0.5 mg/L)	0.001	0.005	0.002
Nitrates (NO_3^-) (50 mg/L)	3.35	13.9	9.17
Free residual chlorine (0.5mg/L)	0.48	0.53	0.51
Clorides (Cl^-) (250 mg/L)	37.5	89.6	55.61
Permanganate index (5 mgO_2/L)	0.78	1.73	1.27
Total hardness (>5^{0}G)	12.3	19.9	14.98
Dry rezidue at 105^{0}C. mg/L	317	563	411
Conductivity (2500µS/cm)	542	992	692
Sulphates (SO_4^{2-}) (250 mg/L)	51.3	103	72

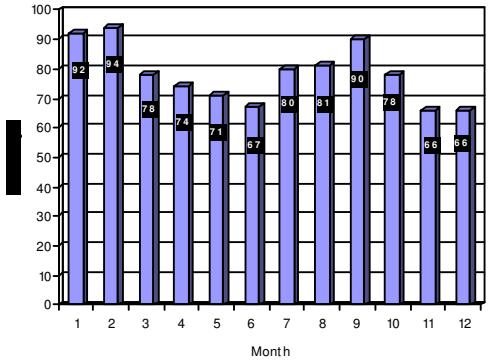

Fig.1. Evolution of turbidity removal efficiencies in Constanta drinking water treatment plant in 2009.

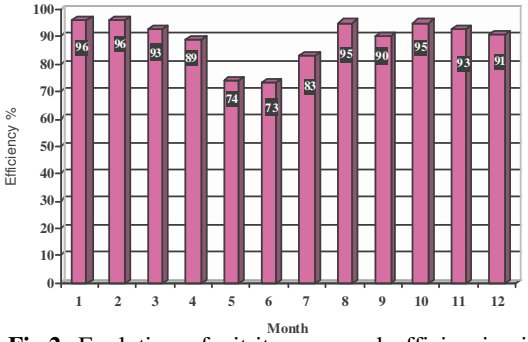

Fig.2. Evolution of nitrites removal efficiencies in Constanta drinking water treatment plant in 2009.

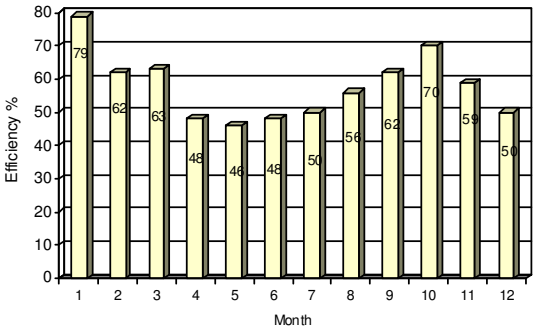

Fig.3. Evolution of organic substances removal efficiencies in Constanta drinking water treatment plant in 2009.

The turbidity removal efficiencies vary between 65.66 to 93.82%, nitrites are removed in percents between 72.73% - 96.36% and organic substances determined as permanganate index register between 46.17% - 78.62% removal efficiencies.

4. Conclusions

The fresh surface water from Danube and groundwater used as raw water sources for Constanta city corresponds to the water quality requirements for human consumption.

The obtained results concerning drinking water quality show that in 2009 in Constanta city all quality parameters have respected the imposed limits by Romanian regulations.

Water treatment applied treatments led to good removal of turbidity, nitrites and organic substances performances.

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