Buletinul Ştiinţific al Universităţii "POLITEHNICA" din Timişoara

Seria HIDROTEHNICA

TRANSACTIONS on HYDROTECHNICS

Tom 58(72), Fascicola 2, 2013

WATER QUALITY MONITORING AT RESITA WATER TREATMENT PLANT

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Abstract: Drinking water supply for consumers in Resita town is done by surface resources. Water is extracted from the settling basin of Crăinicel Hydroelectric Power Plant located on Bîrzava River, upstream of Resita town. The water treatment station provides 1 m^3/s discharge. Water quality monitoring in the treatment plant permits adjustments to the parameters of technological installations. Likewise it seeks to ensure that drinking water supplied to Resita consumers is within water quality parameters set by existing regulations. Water quality measurements, analysed in this paper, were made for a two year period (2010 - 2011). Analyzed quality parameters in this paper are: water turbidity, pH, water oxidation, ammonium, nitrate concentrations. The average yield reduction of presented parameters was between 1.93 (for pH)), and 49.61 (for ammonium). The comparison of values from analyzed parameters at the exit of water treatment plant with the current regulation ones for drinking water allowed us to conclude that the supplied water to residents of Resita town corresponds in terms of quality, to a good quality drinking water.

Keywords: water source, drinking water, quality parameters, water treatment plant, monitoring.

1. INTRODUCTION

Water is one of the fundamental natural resources and represents one of the basic factors of existence and development. Water consumption is linked to water demand for urban and rural population (drinking water), industrial needs (process water), agriculture needs (water for irrigation and pisciculture) as well as urban and recreational needs. In terms of quantity, water consumption is constantly increasing, influenced by the high pace of industrialization, population growth, urbanization, rising living standards and the growing demands of intensive agriculture. Water consumption is an indicator of the level of civilization of a community. In Romania, water is a specific resource. It's usage in natural conditions is approximately 1,870 m3/capita/year, which ranks us on the 13th place in Europe (the European average is 4,000 m^3/capita/year). Surface water in rivers and lakes is the most easily accessible source. This source has the disadvantage that has high load of salts and other dissolved substances, suspensions (silt, sand) as well as organic load and biological (bacteria, viruses). To be consumed by people, with no risk of disease, the water must be treated before use.

2. THE TECHNOLOGICAL WATER TREATMENT PROCESS IN RESITA WATER TREATMENT PLANT

Water subjected to treatment process in Resita water treatment plant comes from Bîrzava River. Upstream of Resita, Bîrzava River crosses a mountainous area without major anthropogenic sources of pollution. On Bîrzava River, upstream of Resita, there are three reservoirs which feed the hydroelectric plants. From the settling basin of Carinicel Hydroelectric Plant water is sent by pumping to the water treatment plant (figure 1).

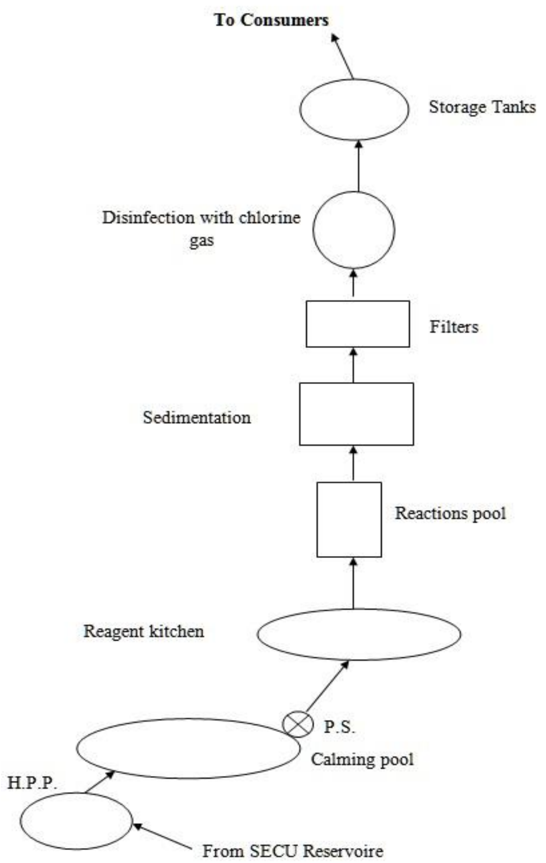

Fig.1 Water Treatment Plant of Reşiţa

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The lime line is composed of a lime deposit, a pool of 1 m^3 used to slack lime, pumps which send "milk" lime into two containers of 2.5 m^3 for diluted suspension, and 1+1 recirculation pumps towards the containers with dispensing nozzles. Sulphate aluminium line comprises a pool of approx. 30 m^3, decanting pumps of the concentrated solution in two dilution containers of 2.5 m^3 from where the diluted solution is pumped into containers with dispensing nozzles and recirculation of excess solution. At the reagents household floor we find the analysis laboratory, reagents storage, a locker and bathroom. The mixing chamber has a volume of 42 m^3 and provides a contact time of 42 sec. The two sedimentation tanks with a diameter of 32 m and a volume of 4800 m^3 each, ensuring a flow rate of 500 l/s with a settling time of 2.6 hours. The Plant is equipped with 24 sand filter tanks with a total area of 572 m^2. Purified water is stored in tanks inside the treatment plant, with a total capacity of 5000 m^3. At a flow rate of 1 m^3/s the time it takes the water to pass through the treatment plant reservoirs is 1.25 h.

3. THE TREATMENT PLANT ANALYSIS LABORATORY

The treatment plant analysis laboratory is structured in 3 units with different functions:

- *Technological Laboratory of physico-chemical raw and decanted water*- wherein quality indicators are determined for raw water to properly establish reagents dosage, as well as quality indicators for the technological steps in order to optimize process flow. This Laboratory is equipped with: turbid meter, pH meter, test device for Jarr test, zeta meter.

- *Physico-chemical Laboratory for filtered water* – purified water which will be distributed to consumers. Test results from this laboratory are used to properly modify filters operation, dosage adjustment of chorine, as well as monitoring water from the distribution network. This Laboratory is equipped with: turbid meter, pH meter, oxygen meter, UV-VIS spectrometer, oven, distilled-bidistilled device, analytical balance, technical balance, conductivity meter, water bath.

- *Bacteriology Laboratory* which is performing bacteriological analysis of raw water, decanted water, filtered water, drinking water which will be distributed to consumers as well as the water from the distribution network. The decisions of washing-disinfection of installations as well as modifying residual chlorine level in order to ensure quality requirements of legal norms are based on these test results. This Laboratory is equipped with: autoclave, two thermostats, two ovens, microscope, centrifuge, water bath, Millipore filter installation, microbiological hood, colony counter.

4. HARVESTING PROGRAM OF WATER SAMPLES

Sampling and analyzes are made in several sections. Sections from which sampling and analysis are made:

- At the station entrance raw water is harvested from the water outlet. Hourly turbidity is performed [7]. Three times a day, at 8 am, 3 and 11 pm, determinations are performed for temperature, smell, colour [4], pH [5], organic matter, alkalinity, total hardness, temporary hardness, permanent hardness, oxidisability [3], ammonia [8], nitrates, nitrites [6] as well as bacteriological analysis (number of bacteria, total coliforms, faecal coliforms, faecal streptococcus). Once a day dissolved oxygen and conductivity is measured.

- At the sedimentation tanks spillway the following analysis are performed three times a day for temperature, turbidity, pH, organic matter and weekly number of bacteria, total coliforms, faecal coliforms, faecal streptococcus. Three times a day samples from two filters are taken for analysis of pH, turbidity, organic matter. Once a week bacteriological analysis regarding bacteria number, total coliforms, faecal coliforms, and faecal streptococcus is made.

- At the station exit samples from drinking water reservoirs is taken. Analyses are performed three times a day at 8 am, 3 and 11 pm, when temperature, smell, colour, taste, pH, turbidity, organic matter, residual chlorine, alkalinity, total hardness, temporary hardness, permanent hardness, oxidisability, ammonia, nitrates, nitrites are determined. Once a day, determination for aluminium, dissolved oxygen, conductivity is made, and twice a day for bacteria number, coliform bacteria, E. coli, faecal streptococcus.

The results of physico-chemical and bacteriological analyses are underlying the efficiency calculations performed on the technological process by treatment steps as well as monitoring the quality of water in the distribution network. Frequency of analyses is increased whenever necessary, both in terms of number and sampling locations in the technological flow and distribution network.

5. EQUIPMENT USED IN WATER QUALITY ANALYSIS LABORATORY

Determination of pH was carried out with METLER TOLEDO Ph METER (figure 2), turbidity with AN IS-HACH 2100 turbidity meter (figure 3), ammonia is determined with photo chlorine meter S.Q. 118, nitrite with photo spectrometer UV-VIZ CINTRA 20. Oxidisability is determined by organic substances oxidation with $KMnO_4$ in acidic medium as the water to be treated has chlorine content less than 300 mg/l.

Figure 2 pH meter METLER TOLEDO

Figure 3 Turbidity meter AN IS-HACH 2100

6. STATISTICAL ANALYSIS OF MEASUREMENTS

The initial set of measurements comprises a volume of 2189 simultaneous measurements performed at the stations entry and exit between 1.01.2010 and 31.12.2011 [1]. Of all the water quality indicators determined at Reşiţa Treatment Plant, only a few of them are being analysed in terms of statistics, and they are: turbidity, pH, oxidisability, ammonia, and nitrite. The maximum, minimum and average values for the intended parameters are given in table no. 1; the quality limits allowed by Law 458/2002 [2] supplemented by Law 311/2004 are present in table no. 2

Table 1. The maximum, minimum and average values (2189 measurements)

Value	TURBIDITY (UNT)		pH (U pH)		OXIDISABILITY (mg O_2/l)		AMMONIA (mg/l)		NITRITE (mg/l)	
	RAW WATER	PURIFIED WATER	RAW WATER	PURIFIED WATER	RAW WATER	PURIFIED WATER	RAW WATER	PURIFIED WATER	RAW WATER	PURIFIED WATER
maximum	710,00	63,40	7,95	7,86	7,99	7,04	1,895	0,487	0,014	0,008
minimum	0,91	0,50	6,51	6,19	1,28	0,96	0,010	0,002	0,001	0,001
average	6,213	2,903	7,171	7,031	2,256	1,565	0,080	0,040	0,003	0,002

Table 2. Limit values of Law 458/2002 supplemented with law 311/2004

Maximum permissible values					
Turbidity	Colour	*p*H	Oxidisability	Ammonia	Nitrite
65 turbidity units	Acceptable to consumers and no abnormal change	9,5 *p*H units	5,0 mg O_2/l	0,50 mg/l	0,50 mg/l

Detection and elimination of outliers from the initial set of measurements was made according to STAS 11278-79 [9], using Grubbs-Smirnov. For each set of tracked parameters, the following calculations were made:

- arithmetic average value for the string data, with equation (1), and average quadratic deviation (standard deviation) with relation (2):

$$\overline{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad (1)$$

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2}{n-1}} \qquad (2)$$

Checking if a measurement is anomalous or not was made using the relations (3), (4), for the minimum value, respectively for the maximum value in the string:

$$u_n = \frac{x_n - \bar{x}}{s} \quad (3) \qquad u_1 = \frac{\bar{x} - x_1}{s} \quad (4)$$

Decision on retention or removal of a string value is made by comparing u_1, respectively u_n, with the standard value h (STAS 11278-79), determined according to the number of data in the string and the level of significance chosen. For the large volume of existing data in the string and a degree of significance α=0,001, table 4 showed the value h = 4.607.

Values from the string which $u_1<h$, $u_n<h$ where kept, those who where $u_1>h$, $u_n>h$ where eliminated from the string.

Applying this test resulted in eliminating:

- 77 measurements regarding turbidity of raw water entering the station and 12 values regarding turbidity of water at the output;
- 3 measurements regarding water pH entering the station and 2 values regarding water pH at the station output;
- 16 measurements regarding water oxidisability entering the station and 22 values regarding water oxidisability at the station output;
- 70 measurements regarding water ammonium content entering the station and 25 values regarding water ammonium content at the station output;
- 18 measurements regarding water nitrite content entering the station and 27 values regarding water nitrite content at the station output;

The stations yield was calculated for the followed parameters, resulting in eliminating of values from the string which corresponded to a negative yield:

- 5 measurements regarding water pH;
- 1 measurement regarding waters oxidisability
- 5 measurements regarding waters ammonium content;

In table 3 maximum, minimum, average and yield values are presented for our tracked parameters after eliminating negative values of yield.

Table 3. The maximum, minimum, average and yield values (2029 measurements)

SPECIFICATION	TURBIDITY (UNT)			pH (U pH)			OXIDISABILITY (mg O_2/l)		
	Val. max.	Val. avg.	Val. min.	Val. max.	Val. avg.	Val. min.	Val. max.	Val. avg.	Val. min.
RAW WATER	22,90	4,11	0,91	7,70	7,17	6,60	4,00	2,19	1,28
PURIFIED WATER	11,40	2,47	0,50	7,39	7,03	6,19	2,40	1,53	0,96
YIELD	87,15	33,36	0.93	12,82	1,93	2,64	60,29	29,02	3,85

7. RESULTS

Eliminating outliers by applying Grubbs-Smirnov method has reduced the number of measurements from 2189 to 2029.
The remaining string values are used to determine correlations between analyzed parameters. You can also calculate the stations yield. Treated water quality, supplied to consumers in Resita, is good and the parameters analyzed are within the limits established by the regulations in force [6].

REFERENCES

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2. *** – Legea nr. 458/2002 completată cu Legea 311/2004.
3. *** – SR ISO 6060/96 privind determinarea oxidabilităţii.
4. *** – SR ISO 7887/97 privind determinarea culorii.
5. *** – SR ISO 10523/97 privind determinarea pH-ului.
6. *** – STAS 3048/2-96 privind determinarea nitriţiilor.
7. *** – STAS 6323/88 privind determinarea turbidităţii.
8. *** – STAS 6328/85 privind determinarea amoniului.
9. ******* – STAS 11278-79 privind identificarea rezultatelor aberante ale măsurătorilor.