

Effective Chemical Treatment at Borovitsa Drinking Water Treatment Plant

Summary

The drinking water treatment plant “Borovitsa” is based on multi step purification process - coagulation, decantation, filtration, ozonation and chlorination. According to the design scheme, the coagulation was with Aluminum sulphate, and the disinfection with ozone and chlorine gas. The application of the Aluminum sulphate didn't ensure below 0.2 mg/l reduction of the residual aluminum in the treated water. An alternative treatment with a coagulant - flocculent - sorbent CFS-SOLVO[®] has been done. The water quality results of chemical products change are described below.

Quality Parameters of Raw Water (Dam “Borovitsa”)

Turbidity

The annual turbidity range of the dam's water is 10 - 15 mg/l (Fig.1). Turbidity above 20 mg/l was registered only for short periods during January-March 2000, February – March 2001, and after August 2002. In December 2003 the maximum value of turbidity has been registered – 150 mg/l. From March 2000 to January 2001 and after July 2001 to August 2002 the turbidity of dam's water was below 5 mg/l and there was no necessity to apply any coagulant.

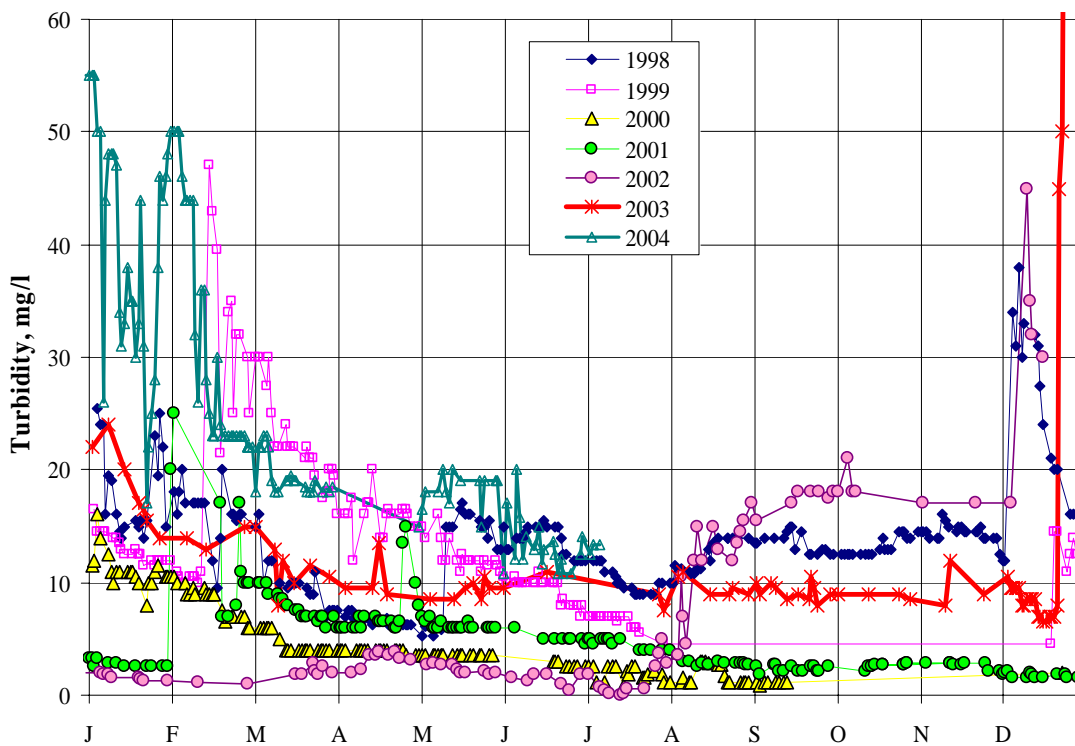


Fig. 1. Water turbidity of dam “Borovitsa” in the period of 1998- 2004

It is evident by the Fig. 1 that the turbidity change of dam's water for the period August 2002-March 2003 is very similar with the same of 1998. 10 mg/l turbidity was in 2003 summer and autumn. In January-March 2004 the turbidity variation is from 20 to 50 mg/l with a tendency of decreasing. The low values (below 3-4 mg/l) are possible in each season but the maximum values 30-50-150 mg/l have been registered in December and February only. According to the investigations of Institute of General and Inorganic Chemistry-Bulgarian Academy of Sciences the fine clay minerals are source of turbidity. In 2003 the stable turbidity of 10 mg/l was based on finer dispersed fractions than the fractions in raw water in the period 1998-2003.

There is a correlation between the raw water turbidity and all other water quality parameters.

Color

To 1995 the color of dam's water was according to the Bulgarian potable water standard- below 150. The color levels of 100-120° Pt-Co Scale have been registered since 1995. The small number of

phytoplankton's cells is not possible to change the water color. The main reason of water coloration is the colloid clay minerals with dimension 1-100^o Pt-Co Scale.

Oxidizability

The oxidizability (KMnO₄) of dam's water is about 2 mgO₂/l due to the low level of organic substances. The correlation between oxidizability and turbidity is shown at Fig.2.

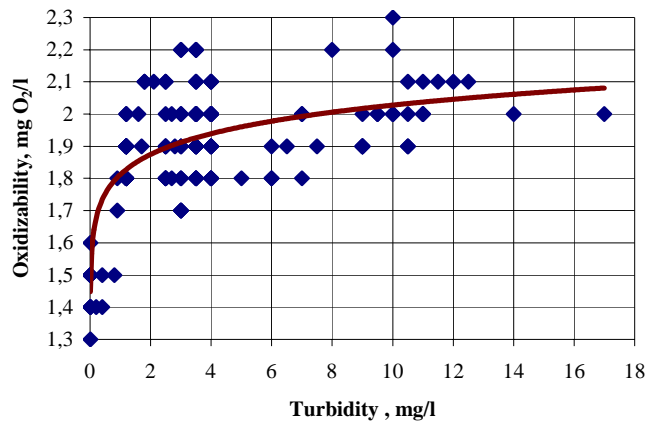


Fig. 2. Oxidizability and turbidity of Borovitsa water

Residual aluminum

The content of dissolved aluminum in dam's water, correlated to the dam's turbidity, is an exception at country level (Fig.3).

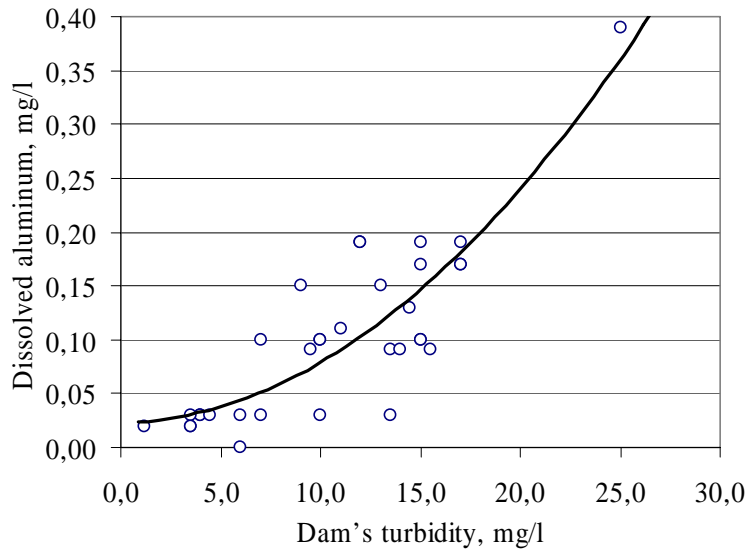


Fig.3. Aluminum and turbidity of Borovitsa water

The optimum dozes of Aluminium sulphate decrease the water turbidity but the value of residual aluminium in treated drinking water is upper the standard level with an health risk. Also, the residual dissolved aluminium is a result of incomplete hydrolyzing process of Aluminium sulphate which doesn't work effectively at low turbidity of raw water and additionally acidifies the treated water (Fig.4.)

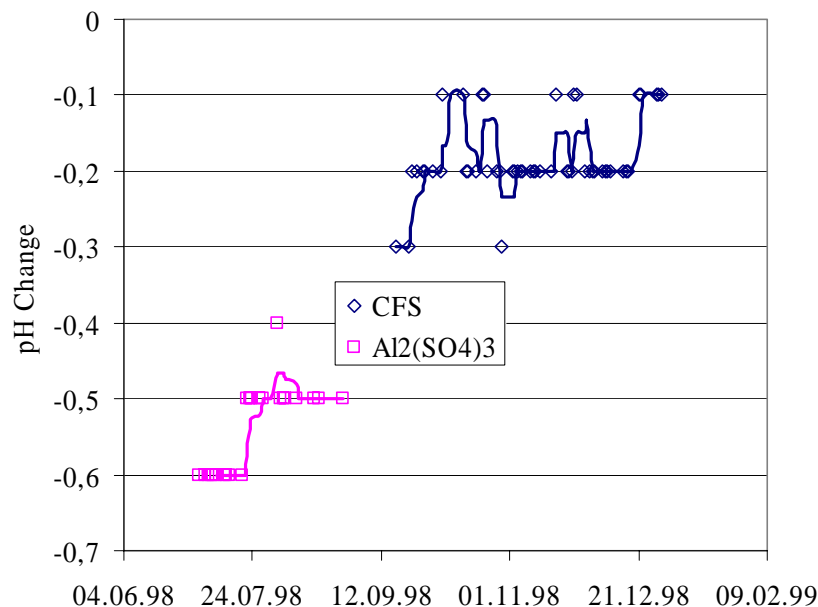


Fig.4. pH variations of treated water due to the type of coagulant used

The Aluminium sulphate is not acceptable coagulant at low turbidity and temperature, and high colour of raw water. The main reason is the incomplete hydrolyzing process which decreases pH and the value of residual dissolved aluminium is above 0.2 mg/l. The change of bad working Aluminium sulphate with CFS was done in 1998.

In August 1998, a comparative investigation between the Aluminum Sulphate and CFS-SOLVO[®] took place at drinking water treatment plant “Borovitsa”. The water quality parameters of raw water were as follows as: turbidity 14 mg/l, color 120° Pt-Co Scale and temperature 5°C. The water quantity was 2050 m³/h . The regular application of CFS with optimal dosage started since September 15, 1998.

Fifty percentages of existing filters are filled with local perlit filtration material and other fifty percentages of filters with zeolite which is also local material. The perlit filters work more efficiently than zeolite filters (Fig.5).

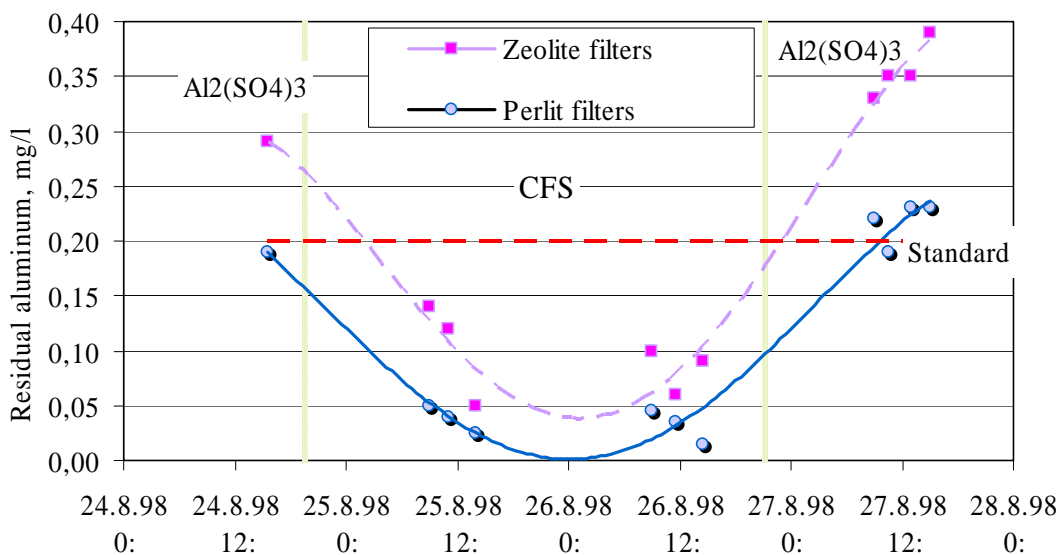


Fig.5. Dissolved residual aluminum in treated water with Aluminum sulphate and CFS-SOLVO[®] by perlit and zeolite filters

The big variations of residual dissolved aluminum values after application of Aluminum sulphate show the unsustainable work of Borovitsa plant due to the need of strict aluminum dosage ac-

According to raw water quality parameters (Fig. 6). The change with CFS-SOLVO[®] decreases the value of dissolved residual aluminum as well as its variation e.g. there is a sustainable plant's work with the new coagulant. Also, there is an independence of CFS doses by the values of water quality (Fig. 6). The statistical data show that for the period September 1998 to February 2000, the turbidity of the raw water was in the range of 6 to 20 mg/l, while the dosage of the applied coagulant CFS-SOLVO[®] has been fixed at 3.4 mg Al₂O₃/l.

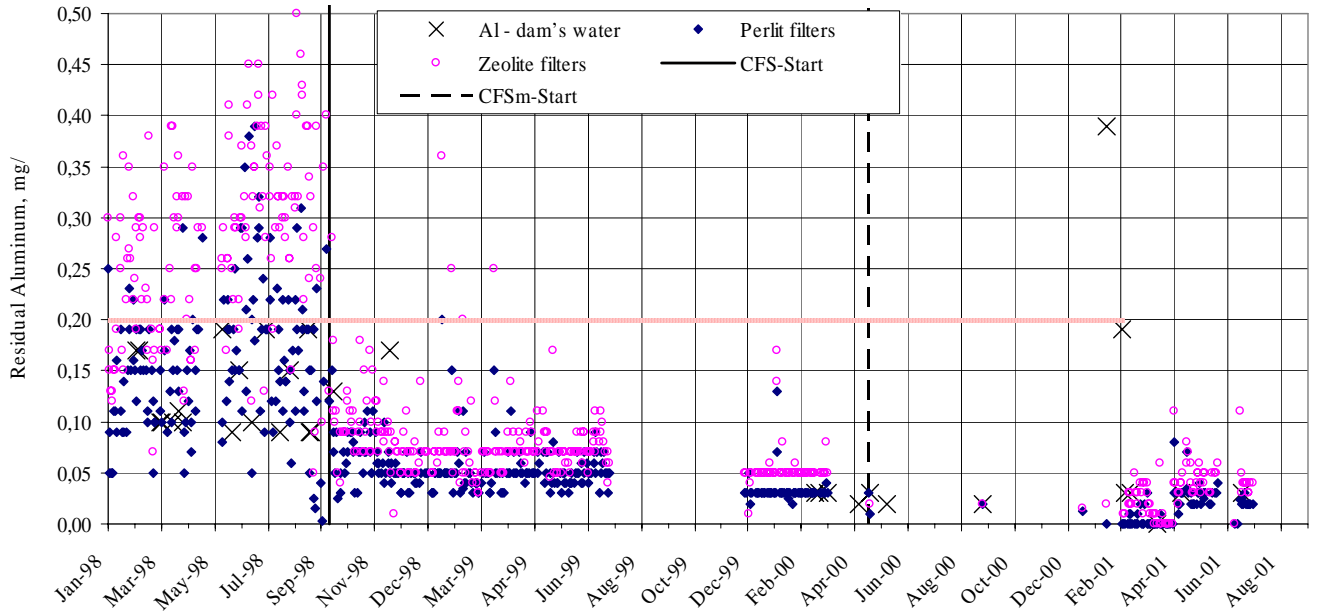


Fig.6. Residual dissolved aluminum in treated water by different coagulants after filtration

The construction of radial sedimentation tanks (high water speed and water vorticity in its central parts) is not suitable for the specific conditions of Borovitsa plant (Fig.7). The decrease of turbidity to 8 mg/l after sedimentation tanks (turbidity of 15 mg/l before sedimentation tanks) requires a reconstruction of radial sedimentation tanks.

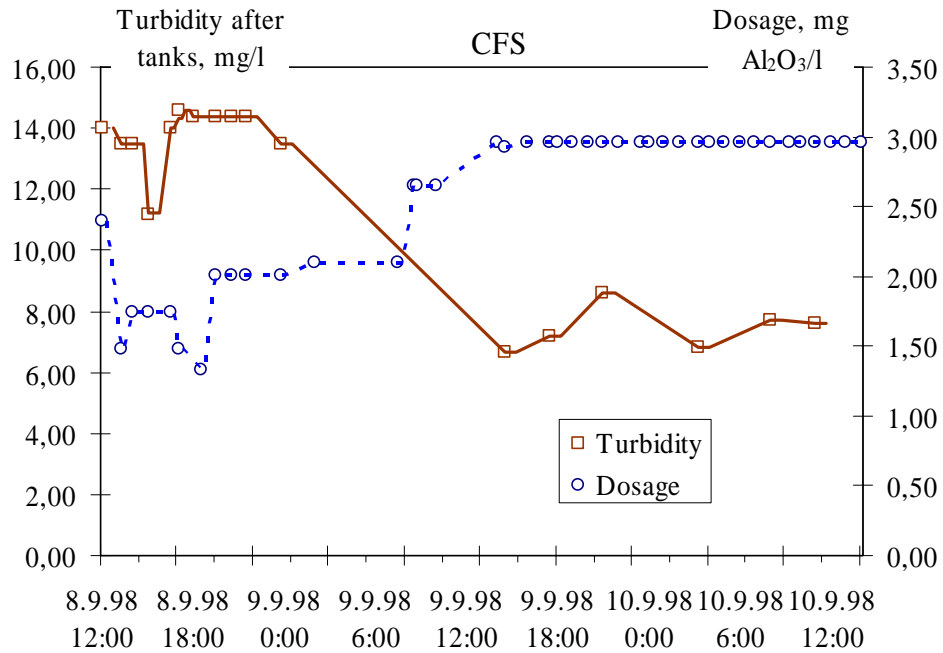


Fig.7. Water turbidity after sedimentation tanks at different coagulant dosage

During a long period from March 2000 to January 2001, the turbidity of raw water was lower than 5 mg/l and no coagulant had been applied (Fig. 1). The filters layers only without CFS reduce the turbidity with approximately 0.5 mg/l (Fig. 8).

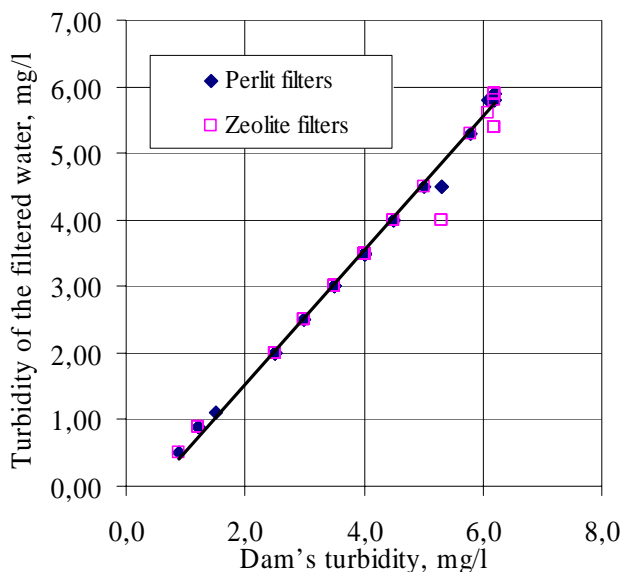


Fig. 8. Turbidity of the filtered and raw water (without coagulant)

The turbidity value of 1 NTU in treated water according to Act № 9/16.03.2001 and European standard 98/83/EC is not achieved. A modified CFS_m has been developed for achievement of turbidity concentration below 1 mg/l. The investigations in May 2000 showed the excellent CFS_m behaviour and lead to its application since then (Fig. 9.).

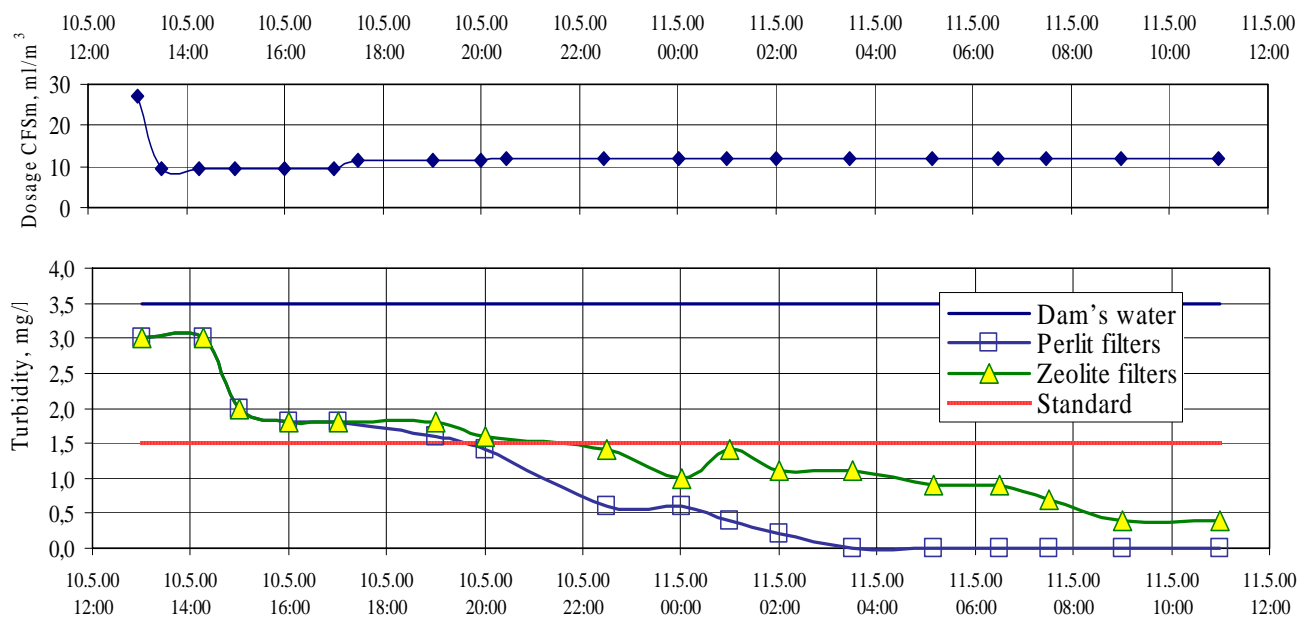


Fig. 9. CFS_m coagulation and water turbidity

The data with the application of $CFS-SOLVO^{\text{®}}$ show that the turbidity and residual aluminum values are about zero (Fig. 4, 5 and 7). As a result, better quality of the treated water is achieved and the ozone and chlorine absorption is substantially reduced that leads to the lower operational cost of disinfections.

The consumption of electricity, CFS_m , ozone and chlorine as well as total expenses are shown in Table 1.

Table 1.

Date	Water quantity l/s m ³ /day		Electricity consumption				CFS consumption		Chlorine consumption		Total expenses		Residual		
			Power kW	Tariff	Consumption kWh/d	Cost BGN*/kwh	Amount BGN/d	Amount kg/d	Amount BGN/d	Amount kg/d	Amount BGN/d	Per day BGN/d	m ³ BGN/m ³	O ₃ mg/l	Cl mg/l
One ozone generator															
06.06.2001	385	32 264	30		1320		139.72	1 240	508.40	19.2	15.36	663.48	0.020	0.30	0.5
<i>Turbidity: Raw water 6 Purified water 0.9</i>				<i>Day:</i>	500	0.101	50.5								
				<i>Night:</i>	440	0.062	27.28								
				<i>Max.:</i>	380	0.163	61.94								
One ozone generator															
03.10.2001	380	32 832	27		1080		115.48			28.8	23.04	138.52	0.004	0.0006	0.5
<i>Turbidity: Raw water 2.5 Purified water 1.2</i>				<i>Day:</i>	260	0.101	26.26								
				<i>Night:</i>	440	0.062	27.28								
				<i>Max.:</i>	380	0.163	61.94								
Two ozone generators															
06.11.2001	380	32 832	55		2620		259.52			28.8	23.04	282.56	0.009	0.16	0.5
<i>Turbidity: Raw water 2.9 Purified water 1.8</i>				<i>Day:</i>	780	0.101	78.78								
				<i>Night:</i>	1180	0.062	73.16								
				<i>Max.:</i>	660	0.163	107.58								

*BGN- Bulgarian currency Euro 1=BGN 1.95583

The comparative data at low turbidity of raw water are as follows as:

- it is not possible to achieve the standard norm of water turbidity without coagulation when the raw water turbidity is 2.5 и 2.9 mg/l. In the case with one ozone generator, the residual chlorine in purified water is practically absent, and the chlorine need is with 33% higher. With two ozone generators in work, the electricity consumption is doubled but the ozone concentration 0.3- 0.4 mg/l is not achieved. At the same time, the chlorine consumption increases too;
- the needed residual ozone dosage of 0.3- 0.4 mg/l is achieved by one ozone generator only after CFS usage. A turbidity value below 1 mg/l is guaranteed before.

Conclusions

1. The Aluminium sulphate is not suitable coagulant for the treatment of Borovitsa dam water. The coagulation process is incomplete with decreasing of pH of purified water and with dissolved residual aluminium above 0.2 mg/l. The technological optimisation of coagulant's quantity is very difficult due to the limited range of dosage.
2. The purified water with CFS-SOLVO[®] at Borovitsa drinking water treatment plant corresponds to Regulation No. 9/16.03.2001.
3. The modified type of CFS-SOLVO[®], produced for Borovitsa raw water – low turbidity and temperature, high colour and short decantation time, guarantees total elimination of turbidity and zero value of residual dissolved aluminium in purified water.
4. The needed CFS-SOLVO[®] dose is from 3 to 6 mg Al₂O₃/l in seven years period with raw water turbidity from 0 to 150 mg/l. The dosage is technically easy and not so strict.
5. A reconstruction of radial sedimentation tanks is required for optimization of filters layers work.
6. The above investigations as well as microscope investigations show the necessity of zeolite filters change by perlit filter layers.
7. The treatment with CFS-SOLVO[®] helps to reach the required concentration of 0.3-0.4 mg/l residual ozone.
8. The electricity consumption of ozone generation is reduced with 50% due to application of CFS-SOLVO[®]. Chlorine consumption is also reduced and the THM formation is limited.

9. Without any coagulant, at raw water turbidity higher than 1.5 mg/l, the purified water doesn't correspond to the requirements of Regulation № 9/16.03.2001. The required ozone concentration can't be achieved too e.g. the ozone generation is in vain.
10. The optimization of technological process at Borovitsa plant depends on raw water quality and O&M expenses.
11. The water price of coagulation with CFS-SOLVO[®] at Borovitsa drinking water treatment plant is with 2% higher but the water quality effectiveness is guaranteed at all cases.

Thanks to the help of Borovitsa staff these investigations were carried out.

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