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Some Aspects of Surface Water Treatment Technology in Tirana Drinking Water Treatment Plant[#]

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Abstract: Tirana's Bovilla treatment plant was the first of its kind for Albania, which treats surface water. The input water comes from the Bovilla artificial lake, around which, the presence of villages induces pollution in the surface water and therefore affects the efficiency of treatment plant and consequently the quality of drinking water. The treatment plant is a simple conventional system and includes pre-oxidation, coagulation, flocculation & sedimentation, fast filtration, post-oxidation. It started functioning in 2000 and after only one year some problems were noticed related with doors and taste of the water after its treatment. The majority of all biologically caused taste-and-odour outbreaks in drinking water were caused by microbial production of geosmin. To eliminate these taste and odour problems, it was decided to use activated carbon powder (PAC) in the treatment process. Nevertheless, from time to time, these problems continue to emerge in the drinking water.

***Key words**: Bovilla Lake, water treatment, pollution, indicators, technology*

Introduction

Bovilla reservoir was created by damming Terkuza River at a narrow gorge of a mountain range, 15 km northeast from Tirana. The dam was built in the upper part of the slope and was secured with a PVC geo-membrane, coupled with polyester fibbers. In the lowest part of the dam there is the prism built with calcareous stones with fractions of 100 to 300 mm. Bovilla reservoir has a collecting capacity of 80 million cubic meters with a maximal depth of 60 meters. The water of this reservoir was predicted to be used mainly for drinking water and partially for irrigation. Since 2000, from this reservoir 1800 l/s of water are drawn, which after treatment with conventional methods at the specifically built water treatment plant, joins the Tirana's supply system. Before 2000, Tirana was supplied with drinking water from a) natural springs (Selita water-supply 700 l/s, Shenmeria water-supply 700 l/s and Bovilla natural spring 440 l/s) and b) heavily pumped wells 550 l/s).

Bovilla treatment plant was the first of its kind for Albania, which treats surface water. Given the fact that the input water comes from an artificial lake surrounded by 8 villages with a total of 5600 inhabitants, whom activities are agriculture, farming (therefore use chemicals, herbicides, pesticides and organic fertilizers), stockbreeding, etc. the impact of these activities influences the efficiency of the treatment plant and consequently the quality of drinking water.

Material and Methods

Classical analytical techniques were used for the determination of the ions and physical parameters using the methods described in APHA (1998) and AFNOR (1994).

All chemicals used were of analytical reagent grade and all solutions were prepared in double-distilled water. A spectrophotometer method (analyticjena SPECORD 40) and an atomic absorption spectroscopy (flame) method (atomic absorber type novAA 300) were used for this study. The operating parameters for working elements were set as recommended by the manufacturer.

The samples were collected at the open part of the water reservoir and after the treatment plant. Assessment of the water quality based on the biological data was considered taking into account the zooplankton species. Being rather tolerant to different environmental conditions, many zooplankton species are good indicators of water quality and can be used for the ecological monitoring of water

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bodies. Increase in human population and development of tourism cause harmful changes in ecosystems.

Results and Discussion

1. Physical, geographical, chemical and biological features of Bovilla watershed.

The mountain slopes that surround the lake are composed of carbonate rocks; meanwhile the lower valley is covered by sandy formations intermixed with clay. The annual average of water flow in Terkuza River is 105 million cubic meters. In autumn and winter the flow increases due to mountain streams. In these areas the main type of soils are brown and dark brown forest soils. Bovilla reservoir has its hydrology and physical, chemical and biological characteristics which depend on the watershed features (see Table 1)

The lake fluctuates from a high oligotrophic to oligotrophic status, with the diatomeas being the most abundant species, especially the genus *Cyclotella*. Seasonal changes are most likely to happen due to the relative high depth of the Bovilla Lake (Shumka, 2008). The consequences of that are changes in qualitative and quantitative compositions of biocenoses. Because of that is possible to explore conditions in some ecosystems by using composition of organisms that live in it - bioindicators. Being rather tolerant to different environmental conditions, many rotifer species are good indicators of water quality and can be used for the ecological monitoring of water bodies (Radman, 1963; Sladacek, 1983; Shumka, 2008).

2. Water treatment technology of Bovilla treatment plant

The Bovilla drinking water treatment plant with a capacity of 1800 l/s, is supplied with water from Bovilla Lake (318 m a.s.l) with self-flowing water going through a 900 mm pipe for 10 kilometers. The treatment plant is located at 250 m a.s.l. where a simple technological process is applied (see Figure 1).

At first the water is accumulated in a collecting tank with a 30 000 cubic meters capacity where the chemicals used for the treatment of water intended for human consumption, are added. These include: coagulant – polyaluminium chloride hydroxide, PAC, ($Al(OH)_aCl_b$ with a+b = 3) – 13%, which is conformed to ISO 9001 : 2000, hydrochloric acid (31 – 33%) – conform EN 939 : 1999 and sodium hypochloride (NaOCl 12 - 14%) conform EN 901 : 1999. The rapid-mix coagulation process is 30 minutes long. The chemicals were chosen in a way that they would be specifically indicated for the drinking water characteristics.

The hydrochloric acid, besides helping in the process of flocculation, reacts with the bicarbonate alkalinity (HCO_3^-) of the water and therefore decreases the temporary hardness and eliminates CO_2. The use of poly aluminium chloride can increase the concentration of trivalent aluminium in the water exceeding the standard value (0.2 mg/l). The acid needed for pH regulation affects the dissolubility of aluminium ions in water.

In regard to the chemical, physical and biological data obtained from the water of Bovilla Lake, it was supposed that the chosen technology (Figure 1) would have been sufficient to provide drinking water intended for human consumption according to EU Directive No. 80/778 in sense of article 15 of the Law No. 183, 16 April 1987.

The treatment plant started functioning in 2000 and after only one year, in autumn 2001, some problems were noticed related with odours and taste of the water after its treatment. The majority of all biologically caused taste-and-odour outbreaks in drinking water were caused by microbial production of geosmin [(-)-(4*S*,4a*S*,8a*R*)-4,8adimethyloctahydronaphthalen-4a-ol] and (-)-2-methylisoborneol (2-MIB) {(1*R*-exo)-1,2,7,7-tetramethylbicyclo[2.2.1]heptan-2-ol} (Juntter & Watson, 2002).
Since they were first identified in the early 1960s, these two earthy-muddy-smelling metabolites have been the focus of considerable research, which has collectively produced many scientific paper and reports. Up to now this has not been performed in Bovilla water system, and in many cases different hypotheses have been launched.

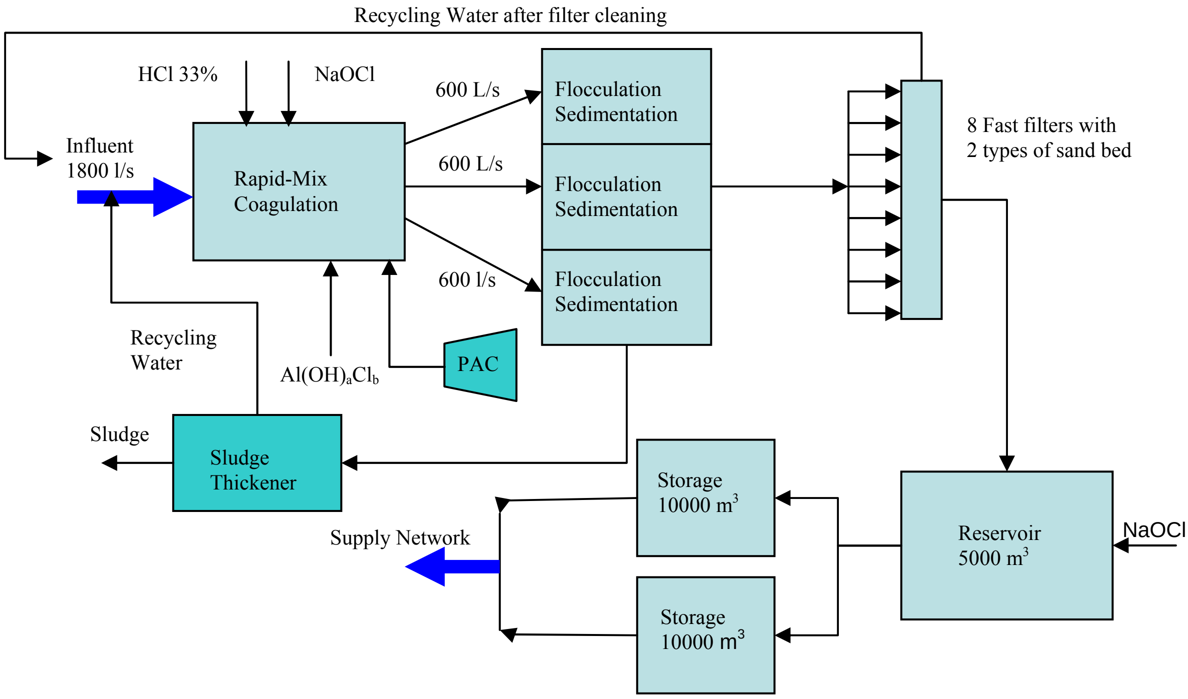

Figure 1. Technological scheme of water treatment in Bovilla plant

To eliminate these taste and odour problems, it was decided to use activated carbon powder (PAC) in the treatment process (PAC sign at fig. 1.) as the fastest and cheapest solution. Nevertheless, from time to time, these problems continue to emerge in the drinking water. A better solution in this case would be to use granulome activated carbon (GAC), taking in mind its physical structure, which increases significantly the contact surface with water and therefore it increases the adsorption rate compared to PAC usage. GAC not only eliminates taste, bad odour and organic matter but would also ensure a lower concentration of suspended solids and as a consequence a lower turbidity. This would translate into lower microbiological pollution (Degremont, 1998). Considering the above, in the technological scheme a better option would be to add a GAC layer above the already existing fast filters (Fig. 2). From time to time this layer would need to be regenerated.

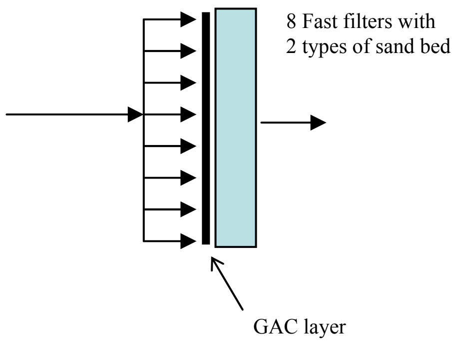

Figure 2. Filtration scheme using GAC and fast sand filtration

The pre-disinfestations process as it is shown on Figure 1 is done with NaOCl. At the Bovilla treatment plant equipment for the "in-situ" production of chlorine dioxide (ClO_2) has been installed involving the reactions of hydrochloric acid (HCl) with sodium chlorite ($NaClO_3$). Taking in mind the occasional changes that can happen to the Bovilla reservoir the use of ClO_2 is more appropriate for the pre-oxidation process for the following reasons (Degremont, 1998; Lykins, 1986):

- To avoid the collateral products of chlorination (threehalomethanes)
- To increase the efficiency of chemical oxidation and bactericide effect

It is worth to mention that threehalomethanes (THM), toxic elements, total organic carbon (TOC) and dissolved organic carbon (DOC) are not monitored in the drinking water supply system of Tirana. A considerable part of the heavy metals precipitates during the coagulation process and goes with the sludge, but there still remain, especially some of them (for instance Mn). In the table 1 are presented the highest value of the parameters obtained during the four seasons of the last year.

In order for the disinfection process to be efficient there is the need for a comprehensive post-disinfection component in order to secure safety of water in the supply network, there is a need for residual chlorine. In the current situation this process is done by using the same disinfectant (NaOCl), with the purpose that in the supply system we would have a residual chlorine level of 0.3-0.5 mg/l according to Albanian standard, measured by DPD (N,N-diethyl-p-phenylenediamine) methods (APHA, 1998). The disinfection time needed when using NaOCl is 30 minutes, whereas when using ClO_2 the contact time is only 15 minutes.

Table 1. The main chemical parameters of Bovilla Lake

Parameters	Measure units	Standard	Untreated water	Treated water
Water inflow	l/s		1800	1750
Air temp.	^0C		22.0	22.0
Water temp.	^0C	8 – 15	13.5	14.3
pH		6.5 – 8.5	7.87	7.79
Turbidity	NTU	0.4	1.55	0.24
Conductivity	µS/cm a 20°C	400	-	-
Alkalinity	mg/l $CaCO_3$		135	135
Hardness	^{0} German	10 – 15	7.71	7.71
Residual chlorine	mg/l Cl_2	0.3	-	0.70
Dissolved oxygen	mg/l O_2	> = 8	9.0	
Calcium	mg/l Ca	75	38.0	38.0
Chloride	mg/l Cl^-	25	7.09	12.41
Sulfates	mg/l SO_4^{2-}	25	23.88	23.88
Ammonia	mg/l NH_4^+	0	0.08	0.00
Nitrites	mg/l NO_2	0	0.005	0.00
Nitrates	mg/l NO_3	25	1.36	1.34
Phosphates	µg/l P_2O_5	400	771.4	344.8
Sulphides	µg/l H_2S	0	17.08	0.00
Aluminium	µg /l Al^{3+}	50	23.0	54
Iron	µg/l Fe	50	256	32.7
Lead	µg/l Pb	0	6.1	4.8
Zinc	µg/l Zn	100	48.5	18.3
Manganese	µg/l Mn	20	58.8	18.8
Copper	µg/l Cu	100	3.2	0.6
Nickel	µg/l Ni	20	28.2	3.8

A negative aspect of using ClO_2 is the production of ClO^-_2 which is toxic and easily can eliminate during the treatment process. Based on above there is a need of specific monitoring of the organic compounds, biological parameters, including microbiological ones (bacteria), phytoplankton, macro-benthos and fishery (Sladacek 2002; Shumka, 2008). Furthermore the process of elimination in the water treatment plant of Bovilla has to be adequately developed.

Conclusions

Taking in mind that the main source of Tirana's drinking water comes from surface water of Bovilla reservoir – being more vulnerable to human activities and which is affected by seasonal changes with the diatomeas being the most abundant species, especially the genus *Cyclotella* we recommend some changes in the technological processes of the Bovilla treatment plant:

- To halt the use of NaOCl for disinfection processes and to be replaced with the use of ClO_2

- To replace PAC that is injected in the main collecting tank with the use of GAC as an additional layer above fast sand filters.
- To monitor THM and heavy metals as predicted.

With this proposed changes, based on our results, the aim is to improve the drinking water quality in Tirana's water supply system (furnishing about 30% of Albania's population), with reasonable costs and efficiency.

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