MONITORING THE BIOLOGICAL QUALITY OF DRINKING WATER IN THE DISTRIBUTION NETWORKS

STUDIES OF 4 MUNICIPALITIES IN POLAND

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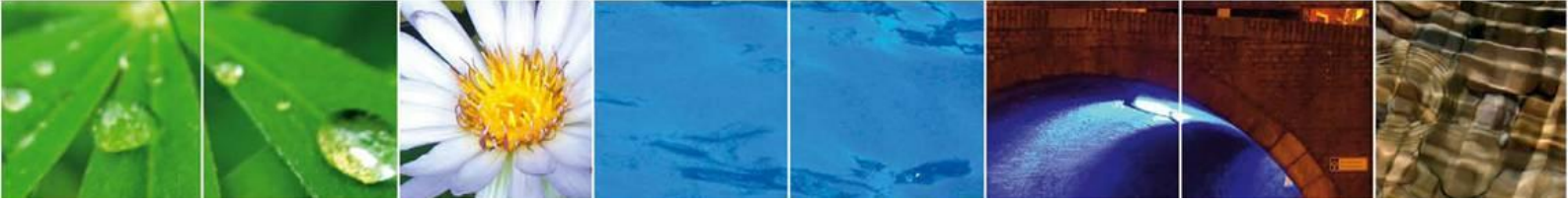
ABSTRACT

Follow-up of the biological quality of the water in the distribution networks: studies of 4 municipalities in Poland. Water quality monitoring have been conducted in four drinking water treatment plants located near the town of Buślary, Rąbinko, Oborniki and Podstolice in Poland. Active biomass quantification by ATP measurement, through the use of the Quench-Gone Aqueous™ kit, has highlighted some microbiological drifts associated to the drinking water treatments and networks. Thus, biomass quantification is a suitable field tool for monitoring the water quality in the drinking water production and distributions systems.

INTRODUCTION

Raw water is collected in the environment and treated by different processes depending on the quality of the water resources (WHO, 2008). The purpose of the different processes used in the treatment of drinking water is to eliminate pathogenic microorganisms. However, some microorganisms in the water resource can enter, pass through and develop within the treatment processes (filter media: Activated carbon and sand) (Schreiber 1997, Hammes et al., 2008). The drinking water networks may also be involved in the deterioration of the water quality.

The reasons why the water after treatment, is subjected to microbial contamination are numerous. This may result either from an operational accident at the treatment, storage, distribution levels or a microbial development in the distribution system (Delahaye et al. 2003; Beaudeau et al., 2007).



Microorganisms in drinking water can colonize the distribution system and proliferate in niches called biofilms (LeChevallier et al., 1996). Therefore, failure in the drinking water production and distribution systems can lead to serious consequences on public health (Craun et al. 2006; Hrudey et al. 2006; Rizak and Hrudey 2007). Inadequate protection of catchments, treatment disabilities or poor maintenance of the distribution network can be a source of waterborne outbreaks (O'Connor 2002; Beaudeau et al., 2007). Thus, the quality control of drinking water requires a risk management strategy based on a comprehensive approach to each step of the drinking water production and distribution.

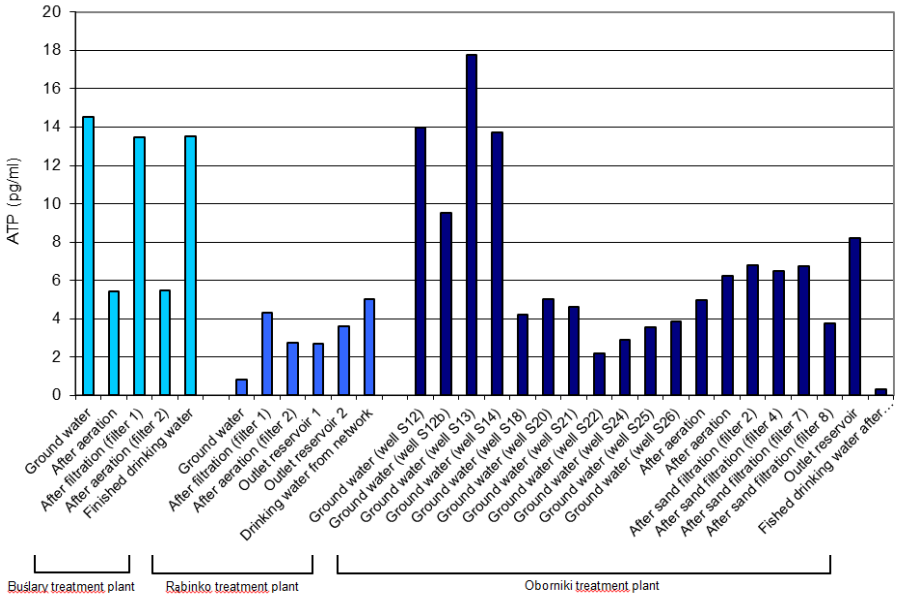


Figure 1 ATP concentrations at each treatment step in the Buślary, Rąbinko and Oborniki plants

The microbiological quality of water and the effectiveness of treatment are based on fecal contamination indicators. These methods are based on the ability of bacteria to grow on artificial culture medium. Therefore, several limitations are associated with this analytical method: the difficulty in cultivating bacteria stressed by treatment or time spent in the distribution network, interference with the growth of non-target bacteria, the growth time of certain bacteria (Rompré et al. 2002; Tallon et al., 2005). This last point raises an important microbiological impairment for the water quality control. The minimum time between the water sampling and the analytical results is about 24 hours. According to the regulatory requirements, this period may be even longer in some cases where further

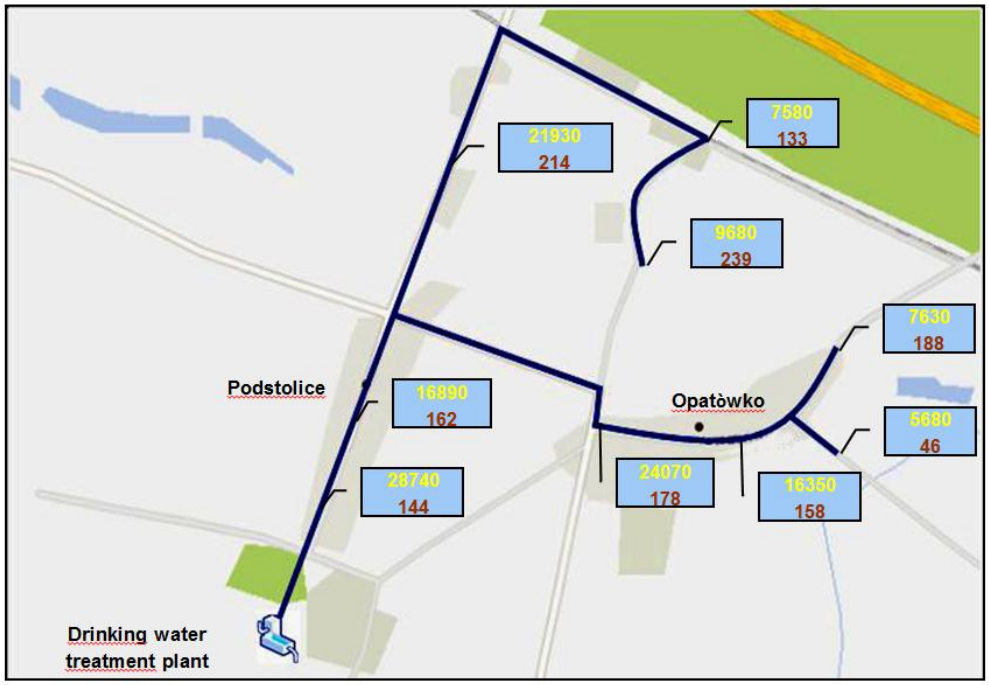
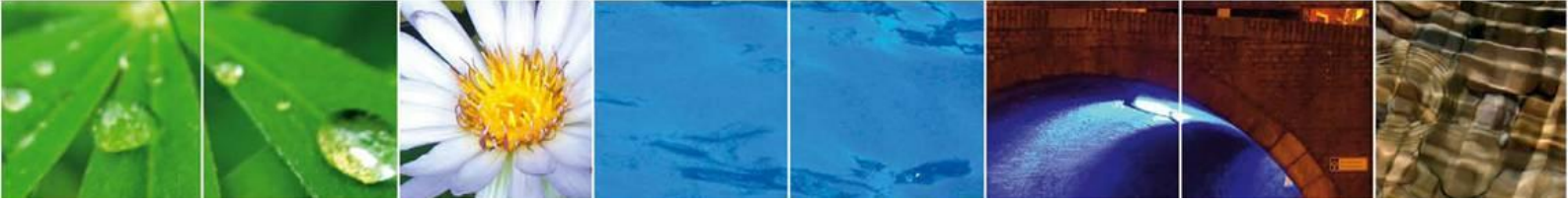


Figure 2 Mapping of ATP concentrations (microbial equivalent/ml in yellow), and total bacterial counts at 22 ° C (CFU/ml in red) in drinking water distribution network of Podstolice / Opatòwko.



analysis is required. The water then passes through the distribution system and is consumed before an assessment is made. Moreover, the time for obtaining results does not allow a risk management in emergency. As a consequence, the drinking water quality control requires new analytical methods rapid, sensitive and accessible for a routine use.

The measurement of active biomass by ATPmetry, using the kit Quench-Gone Aqueous ™ marketed by Aqua-tools is a rapid and sensitive test that can check the microbiological quality of water. The objective of this study was to apply this analytical method to monitor the biological quality of water in several drinking water production and distribution systems.

RESULTS AND DISCUSSION

Monitoring water quality in the treatment processes

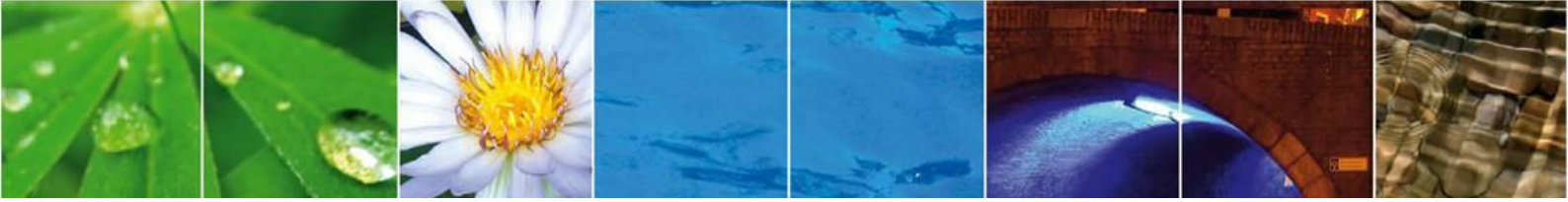
Two analytical campaigns were carried out: 15 February 2011 for the drinking water treatment plant (DWTP) supplying the city Oborniki and 20 April 2011 for the drinking water treatment plants supplying the cities of Buślary and Rąbinko.

The three DWTPs treat ground water by implementing several stages of treatment: aeration, sand filtration and disinfection with sodium perchlorate. The results of the ATP concentrations using the QGA™ kit and total bacterial counts at 22 ° C (according to the PN-EN ISO 6222:2004 standard) are shown in Table 1 and Figure 1. The ATP concentrations measured in the ground water are ranged between 14.52 and 0.83 pg / ml or 1450 and 830 microbial equivalent / ml (Table 1). The low biomass in the ground water sample from the Rąbinko plant indicates a good biological quality of the raw water.

After filtration, the results show an increase in ATP levels except for the filter 8 (Oborniki). This can be explained by a height difference of the sand filter between the filter 8 and others.

Table 1: Biological parameters measured during the two analytical campaigns

Plants	Samples	ATP (pg/ml)	ATP (microbial equivalent /ml)	Total flora at 22°C (CFU/ml)
Buślary	Ground water	14.52	14520	10
	After aeration	5.45	5450	16
	After sand filtration (filter 1)	13.47	13470	272
	After sand filtration (filter 2)	5.47	5466	30
	Finished drinking water	13.51	13510	3800
Rąbinko	Ground water	0.83	830	0
	After sand filtration (filter 1)	4.32	4320	7
	After sand filtration (filter 2)	2.74	2740	4
	Reservoir outlet 2	3.6	3600	1
	Drinking water from the network	5.01	5010	310
Oborniki	Ground water (well S12)	13.97	13970	24
	Ground water (well S12b)	9.533	9533	12
	Ground water (well S13)	17.79	17790	11
	Ground water (well S14)	13.7	13700	22
	Ground water (well S18)	4.222	4222	10
	Ground water (well S20)	5.045	5045	1
	Ground water (well S21)	4.62	4620	8
	Ground water (well S22)	2.204	2204	2
	Ground water (well S24)	2.921	2921	1
	Ground water (well S25)	3.532	3532	6
	Ground water (well S26)	3.877	3877	28
	After aeration	4.992	4992	2
	After aeration	6.24	6240	2
	After sand filtration (filter 2)	6.771	6479	13
	After sand filtration (filter 4)	6.479	6771	54
	After sand filtration (filter 7)	6.745	6745	2
	After sand filtration (filter 8)	3.771	3771	1
	Reservoir outlet	8.205	8205	1
	Finished drinking water	0.3452	345	0



The filter media used in the DWTPs can be colonized by microorganisms in treated water (Stewart et al. 1990; Leilei et al. 2008). Such microbial growth can lead to an increase in biomass after filtration. The impact of disinfection has been evaluated for the Oborniki DWTP. The results show a decrease in ATP concentrations of 8.2 to 0.3 pg/ml or 8200-300 microbial equivalent/ml.

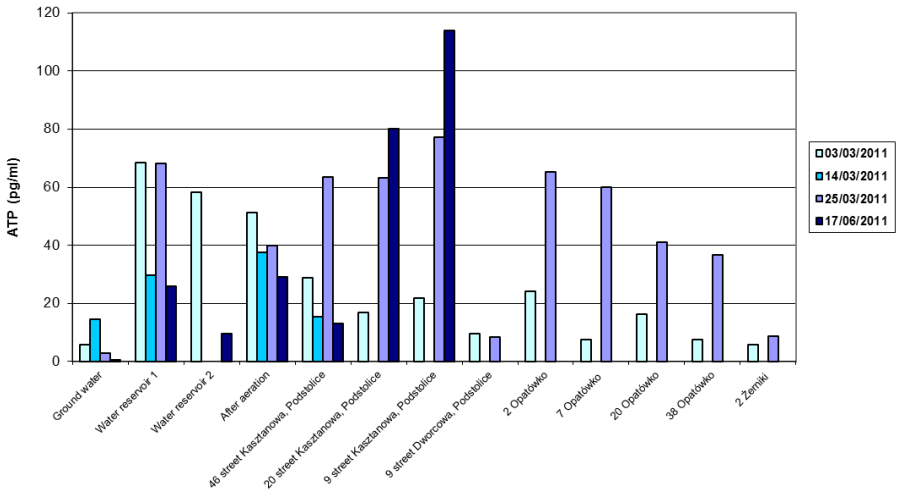


Figure 3 ATP concentrations in the drinking water system of Podstolice

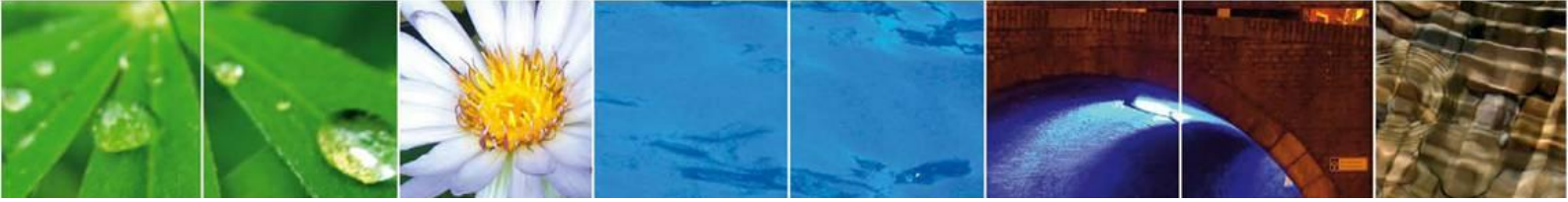
This has not been detected for the Buślary DWTP since it is a discontinuous disinfection.

Mapping a drinking water network

In order to monitor the water quality within the distribution system, a survey of the biological quality of distributed water in the cities of Podstolice and Opatòwko was conducted the 3 March 2011 (Figure 2). The distribution network is supplied by ground water submitted to an aeration, sand filtration and disinfection treatment steps. The disinfection is performed by addition of sodium perchlorate directly into the distribution network at the output of the Podstolice DWTP. For the majority of measured points, ATP concentrations decrease with the distance traveled by water in the network. An increase in contact time with the disinfectant may cause a decrease in biomass in the water during its transport.

Table 2: Biological parameters measured during the three analytical campaigns conducted in the drinking water systems from the city of Podstolice

Samples	03/03/2011			14/03/2011			25/03/2011		
	ATP (pg/ml)	ATP (equivalent /ml)	Total counts at 22°C (CFU/ml)	ATP (pg/ml)	ATP (equivalent /ml)	Total counts at 22°C (CFU/ml)	ATP (pg/ml)	ATP (equivalent /ml)	Total counts at 22°C (CFU/ml)
Ground water	5.65	5650	0	14.62	14620	0	2.747	2747	121
After aeration	51.36	51360	279	37.43	37430	256	39.77	39770	>3000
Treated water reservoir	68.57	68570	224	29.73	29730	532	68.16	68160	>3000
46 street Kasztanowa, Podstolice	28.74	28740	144	15.27	15270	191	63.38	63380	>3000
20 street Kasztanowa, Podstolice	16.89	16890	162				63.11	63110	>3000
9 street Kasztanowa, Podstolice	21.93	21930	214				77.3	77300	>3000
9 street Dworcowa, Podstolice	9.68	9680	239				8.509	8509	182
2 Opatówko	24.07	24070	178				65.35	65350	>3000
7 Opatówko	7.58	7580	133				60.07	60070	>3000
20 Opatówko	16.35	16350	158				41.05	41050	>3000
38 Opatówko	7.63	7630	188				36.78	36780	>3000
2 Żerniki	5.88	5880	46				8.658	8658	>3000



Temporal variation of the biological quality of water

Three analytical campaigns analytical were carried out on drinking water facilities from the city of Podstolice. The results, represented in Figure 3 and Table 2, show a marked increase in the concentration of ATP and total counts at 22 ° C during the treatments. This suggests that a degradation of the biological water quality occurs in the Podstolice DWTP. During the last campaign, there was an overall increase in concentrations of ATP and total counts at 22 ° C between samples taken from the treatment facility and those taken in the distribution network. This indicates a major failure in the treatment process requiring corrective action.

CONCLUSIONS

The measurement of active biomass by ATPmetry allows to monitor the water quality in the drinking water production and distribution systems and to highlight several risk areas requiring corrective action. This method can be applied as part of usual bacterial control and allows regular monitoring of the quality of drinking water networks. Quantification of biomass using the QGA kit ™ is a simple, rapid and sensitive method. Analysis can be performed in minutes on site.

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