

Application of nanosilver in swimming pool water treatment technology

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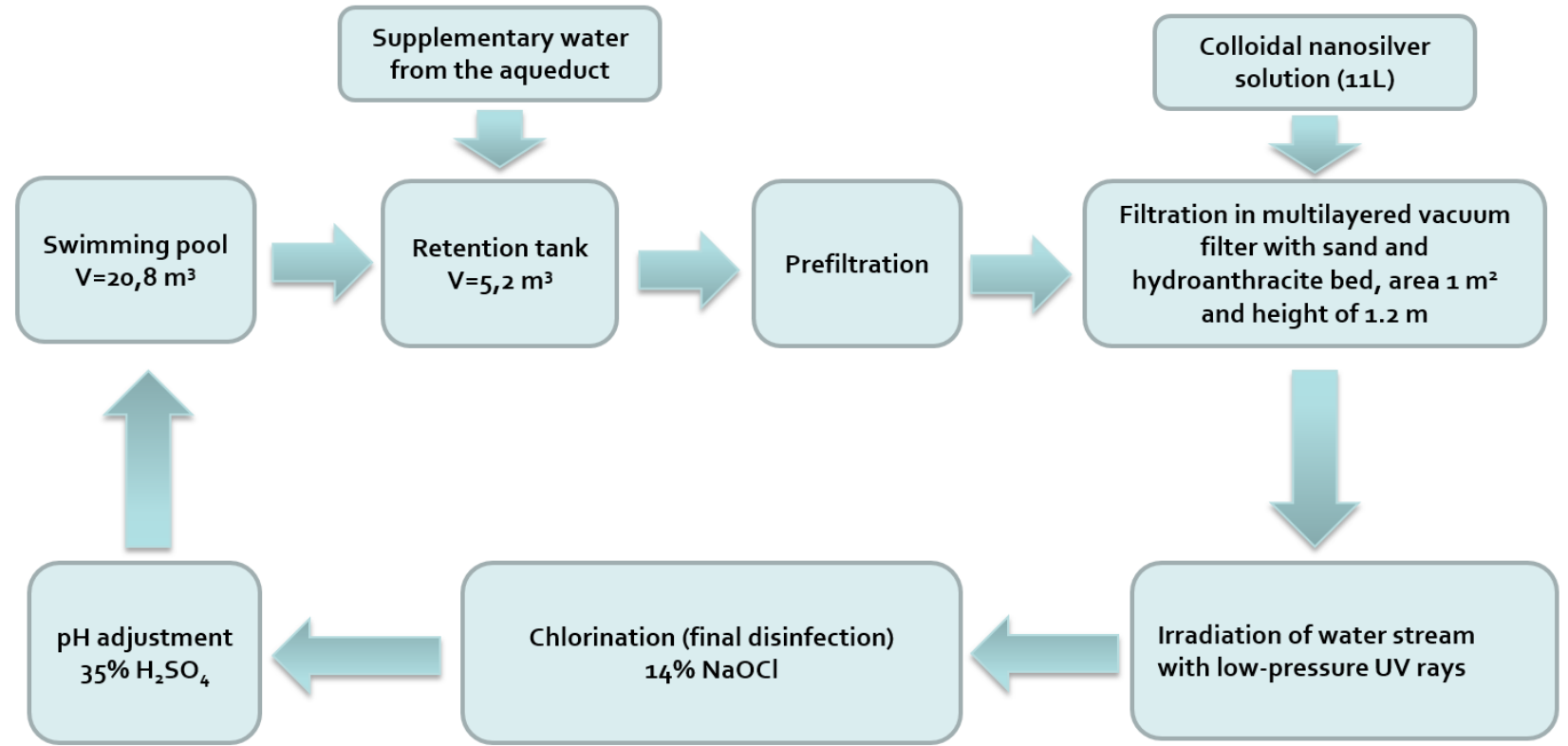
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Introduction

- The main aim of this work is to present possibility of applying a colloidal solution of nanosilver in a closed circuit of swimming pool water treatment.
- The applied nanosilver solution is characterized as having a very high biocidal effect, with no negative impact on the human and animal body, or the environment.
- Silver nanoparticles are known as excellent antimicrobial agents and therefore they could be used as alternative disinfectant agents for the disinfection of drinking water or recreational water (O'Brien et al. 2010; Zang 2013; Tugulea et al. 2014; Yang 2017).
- In the tested swimming pool, during morning hours, there are physiotherapy sessions for patients suffering from various injuries. In the afternoon, there are swimming lessons for infants and their parents.
- Strict requirements regarding swimming pool water (WHO 2006; DIN 19643, 2012; Decree of the Health Minister 2015) caused traditional and one-stage filtration systems to be insufficient (Lee et al. 2010; Cheema et al. 2017, Chowdhury et al. 2014, Wyczarska-Kokot 2014).

Materials and Methods

Water treatment system in the tested swimming pool



Materials and Methods

Sampling points

Samples of pool water for the control of water quality variation in the treatment cycle were taken from 5 points:

- from pool basin (**SP**),
- retention tank (**RT**)
- just before filter (**BF**),
- just after filter but before UV lamp (**AF**)
- from water supply system replenishing water lost from swimming pool circuit (**WS**).



Guidance for the quality of swimming pool water

The water samples were subjected to bacteriological and physicochemical analyses that measured basic control parameters of pool water quality.

The obtained tests results were compared against the recommendations of:

- Guidelines for safe recreational water environments. Vol.2: Swimming pools and similar environments, WHO 2006.
- DIN 19643. Water treatment for swimming and bathing pools, 1997 and 2012 (German).
- ZHK NIZP-PZH. Recommendations on sanitary and hygienic requirements for swimming pools and water quality in pools for babies and children from 6 months to 3 years old, 2012 (Poland).
- Decree of the Health Minister on the requirements for water in swimming pools, 2015 (Poland).

Results and Discussion

Bacteriological parameters of water quality in tested pool circuit

Parameter	SP				RT				BF				AF				WS				Recommended value in SP [1-5]
	1	1	1	0	18	5	0	0	42	1	12	2	$2.5 \cdot 10^3$	$5.7 \cdot 10^2$	$2.8 \cdot 10^3$	$2.6 \cdot 10^3$	4	0	0	23	
Total plate count in 36°C after 48 hours (CFU/1ml)	1	1	1	0	18	5	0	0	42	1	12	2	$2.5 \cdot 10^3$	$5.7 \cdot 10^2$	$2.8 \cdot 10^3$	$2.6 \cdot 10^3$	4	0	0	23	<100
Coliform bacteria of the fecal type (CFU/100ml)	<5	0	0	0	<5	0	0	0	<5	0	0	0	<5	0	0	0	<5	0	0	0	0
<i>Escherichia coli</i> (CFU/100ml)	<5	0	0	0	<5	0	0	0	<5	0	0	0	<5	0	0	0	<5	0	0	0	0
<i>Legionella sp.</i> (CFU/100ml)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	14	4	0
<i>Pseudomonas aeruginosa</i> (CFU/100ml)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coagulase-positive staphylococci (CFU/100ml)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-

Results and Discussion

Physical and chemical parameters of water quality in tested pool circuit:
pH,
Redox



The parameters of water quality in the pool basin were compliant with the requirements in this regard.

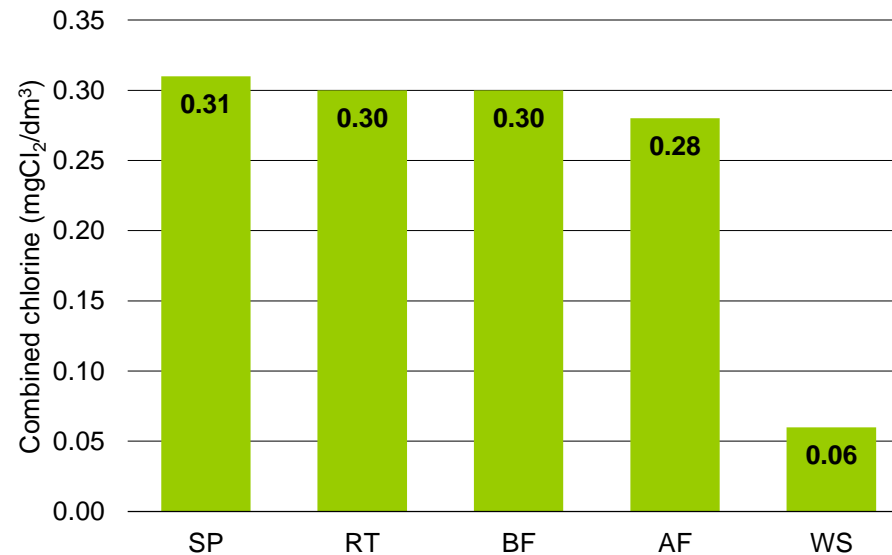
Water pH in every collection point was within the required range, i.e. 6.5÷7.6

The redox values further confirmed the effectiveness of protecting the pool water against bacteriological contamination.

The required minimum in SP is 750 mV.

Results and Discussion

Physical and chemical parameters of water quality in tested pool circuit:
Free chlorine,
Combined chlorine

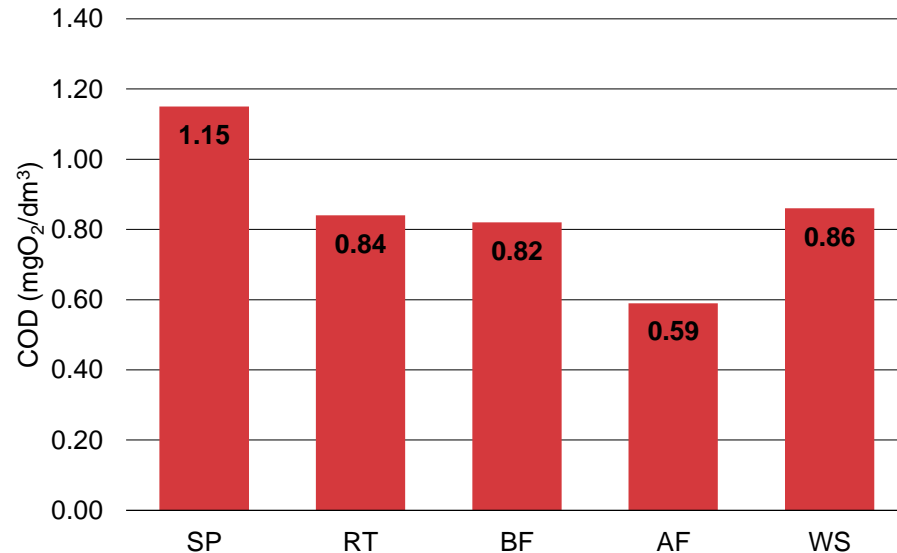
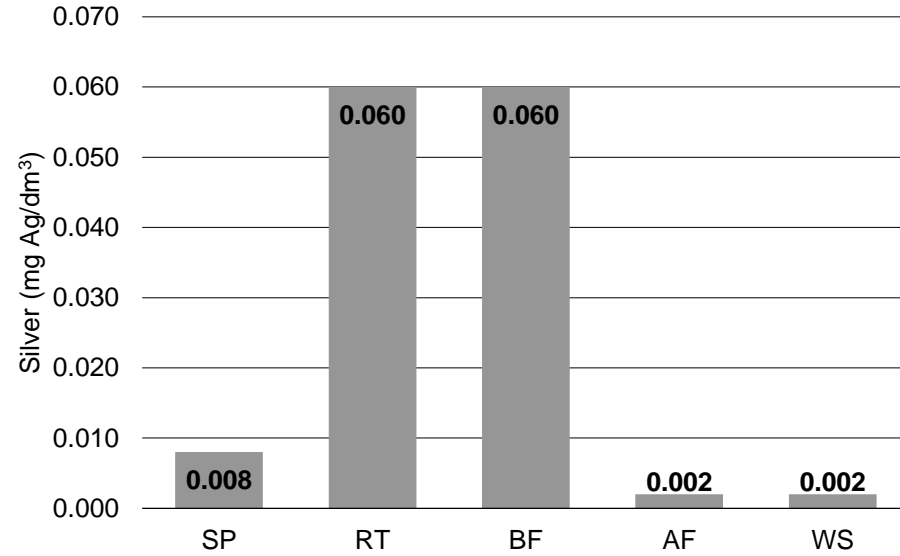


A systematic decrease in free chlorine concentration was observed in water samples taken from the subsequent parts of the pool circuit (filtering the water through a filtration bed with an anthracite layer decreased it by 88.6%). The required range in SP is 0,3÷0.6 mgCl₂/L.

Due to the adverse effects on the bathers, the permissible content of combined chlorine in pool water according to WHO and DIN 19643 is 0.2 mgCl₂/L, and according to Decree of the Health Minister of Poland is 0.3 mgCl₂/L. There were no complaints from the bathers when the concentrations of combined chlorine in water in the pool basin exceeded the concentrations stipulated in DIN19643, on average, by 0.11 mgCl₂/L.

Results and Discussion

Physical and chemical parameters of water quality in tested pool circuit:
Silver,
COD



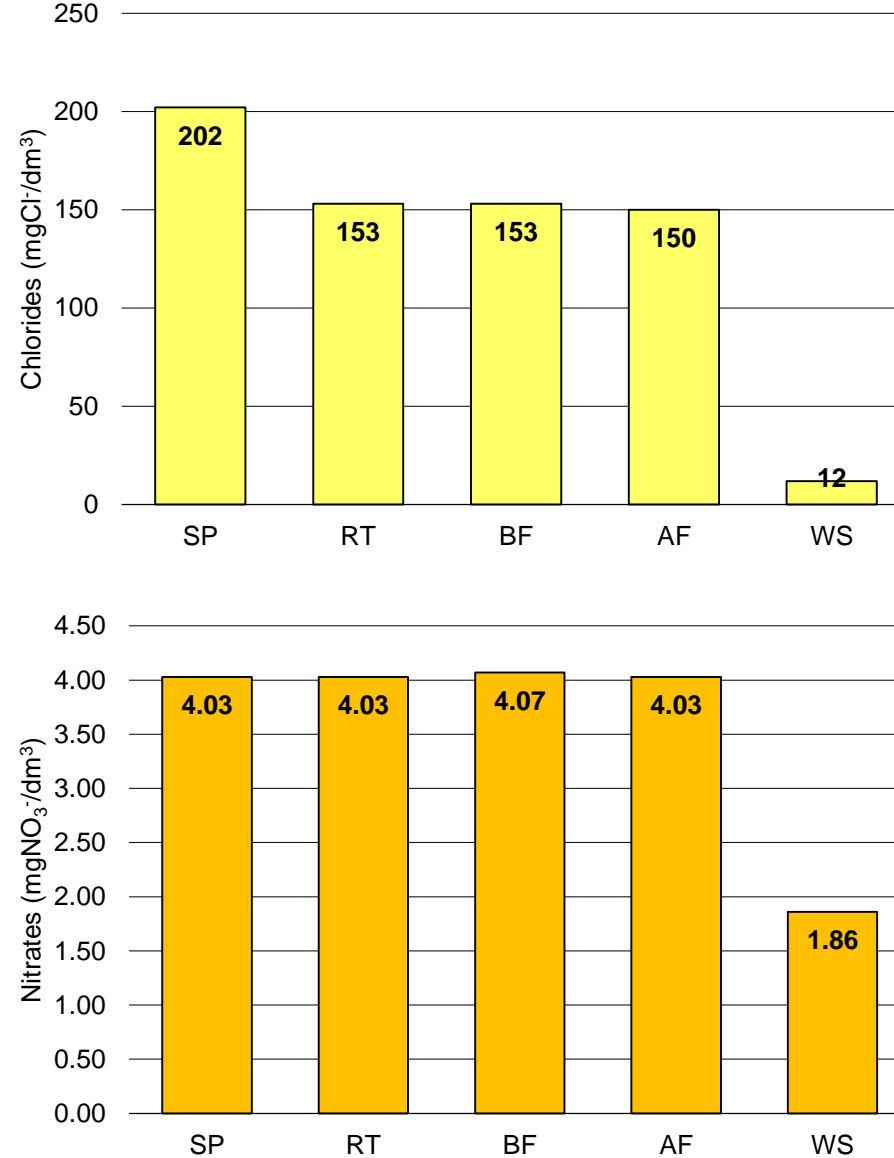
The low levels of silver in pool water samples about 0.008 mg/L did not cause a risk to the health of bathers. Silver concentrations up to 0.1 mg/L may be tolerated in the case of silver salts to maintain the bacteriological quality of drinking water.

During the tests, in the majority of samples, oxidisability index (COD) was below 1.0 mgO₂/L and the permissible value is 4*mgO₂/L.

* Difference in COD values in swimming pool water and COD in water supplementing circulation system.

Results and Discussion

Physical and chemical parameters of water quality in tested pool circuit:
Chlorides,
Nitrates



The systematic increase of chlorides and nitrates in SP during the filtration cycle indicated that an insufficient amount of water was taken into the pool circuit.

The permissible value in SP for chlorides is 250 mgCl⁻/L and for nitrates is 20 mgNO₃⁻/L.

Conclusions

- The performed tests indicate the effectiveness of the proposed pool water treatment system incorporating dosing of nanosilver colloidal solution, vacuum filter with multilayered bed, and irradiating the circuit water with UV light.
- Despite the use of the colloidal solution of nanosilver, as bacteriostats product, it was found that favorable conditions for the development of bacterial colonies were present in the bed. The anthracite and sand filtration bed facilitated the growth of bacteria which then were washed out to the filtrate.
- Although CFU of bacteria in the filtrate samples was high, water from the pool basin contained only 1 CFU/1mL (permissible number: 100 CFU/1mL). Thus, the two-step disinfection (UV + NaOCl) was sufficient to ensure safe bath.

Acknowledgments

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