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ASSESSING THE EFFICIENCY OF WASTEWATER TREATMENT PLANTS IN THE REMOVAL OF ANIONIC AND NONIONIC SURFACTANTS

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Introduction

Surfactants, so called surface-active agents are widely used for laundering, dishwashing, and household cleaning. Moreover, they are significantly used in industries (cosmetics, textiles, food, pharmaceuticals, microelectronic, mining, oil recovery, etc.). The most common used surfactant types in commercial detergent applications are anionic and nonionic. They find their way to water bodies either through discharge of Wastewater treatment plants (WWTPs) effluents or through infiltration where land application is employed as a method for disposal of effluent or of raw wastewater. The elimination of anionic and nonionic surfactants in WWTPs depends on the type of operation used; it is well known that in plants using activated sludge systems, removals higher than 98% are obtained. This paper presents the results focused on evaluating the operational efficiency of three important municipal treatment plants in Romania in terms of anionic and non-ionic surfactants removing.

Materials and methods

The samples for surfactant concentrations monitoring were collected in February and April 2022 from municipal WWTPs of three important cities of Romania: Iasi, Cluj and Bucharest. In addition, the concentrations of anionic and nonionic surfactants were performed in the surface waters - receivers of the treated effluents discharged by each treatment plant. The concentration of anionic surfactants was determined according to the Romanian standard (SR EN 903:2003) by spectrophotometric measurement of the blue complex formed with methylene blue active substance (MBAS) indicator, soluble in chloroform. Absorbance measurements were taken at 654 nm in 10 mm optical pathway flow cell with chloroform as blank. The calibration curve was made using as standard methyl ester of dodecyl benzene sulfonic acid (99% purity, Merck, Darmstadt, Germany). The concentration of nonionic surfactants was determined according to the Romanian standard (SR ISO 7875-2:1996) by UV spectrophotometric measurement of bismuth after separation with ethyl acetate, precipitation with reagent Dragendorff and solubilization of the precipitate. Absorbance measurements were taken at 263.5nm in 20 mm optical pathway flow cell with distilled water and methanol as blank. The calibration curve was made using as standard 4-Nonylphenyl-polyethylene glycol

non-ionic (Sigma-Aldrich, St. Louis, USA). The equipment used for analytical detection of surfactants was a spectrophotometer SHIMADZU (SHIMADZU, Japan).

Results and conclusions

The treatment process in a municipal wastewater treatment plant (WWTP) from Romania may include primary treatment - mechanical and physical-chemical removal of solid material and a secondary treatment – biological process with activated sludge and secondary settling. The surfactants content removal was investigated by measuring of anionic and nonionic surfactants concentrations in the influents and effluents of studied municipal WWTP's plants (Table 1 and Table 2). The amount of anionic and nonionic surfactants removed by the studied municipal WWTPs was calculated using the following formula: $Surfactant\ removal\ (\%) = [C_{IN} - C_{EF}] / C_{IN} \times 100$. Duplicates were tested for all types of samples using the same analytical techniques. The tables show the average values of the samples analysed in duplicate.

Table 1. Concentration and removal efficiency of anionic surfactants in WWTP

Municipal WWTPs	Sampling period	Anionic surfactants		
		Influent (C _{IN} mg/L)	Effluent (C _{EF} mg/L)	Removal efficiency (%)
Glina - Bucharest	February	3.86	0.91	76
	April	2.32	0.12	95
ApaVital - Iasi	February	0.62	<0.1*	84
	April	1.71	<0.1*	94
Apa Somes – Cluj-Napoca	February	16.21	10.28	37
	April	1.64	<0.1*	92

Table 2 Concentration and removal efficiency of nonionic surfactants in WWTP

Municipal WWTPs	Sampling period	Nonionic surfactants		
		Influent (C _{IN} mg/L)	Effluent (C _{EF} mg/L)	Removal efficiency (%)
Glina - Bucharest	February	3.59	0.83	77
	April	1.68	0.15	91
ApaVital - Iasi	February	0.55	<0.15**	73
	April	0.95	<0.15**	84
Apa Somes – Cluj-Napoca	February	0.18	<0.15**	-
	April	1.43	<0.15**	90

*0.1 – the quantification limit of the anionic surfactant test method

**0.15 – the quantification limit of the nonionic surfactant test method

The concentration of anionic surfactants in the WWTP influents showed a wide range varying from 0.62 mg/L to 16 mg/L, while the concentration of nonionic surfactants ranged from 0.18 to 3.59 mg/L. The concentration of anionic and nonionic surfactants in the WWTP effluents were below 1 mg/L, most of the recorded values were below the quantification limit of the analytical methods.

The concentration of anionic and nonionic surfactants determined for the receiving surface waters of municipal WWTP effluents were below the quantification limit of the analytical methods.

The present study highlighted relatively low concentrations of surfactants in the analysed wastewaters, as well as relatively high removal efficiencies (over 70%),

with a single exception recorded in February, in the WWTP of Cluj-Napoca. The legal regulations regarding the concentration of surface active compounds (anionic + nonionic) are addressed in the Government Decision no. 352/2005 (norms regarding wastewaters discharge conditions in WWTPs and the conditions of wastewater discharge in the aquatic environment): <25mg/L in the WWTP influent and <0.5 mg/L in the WWTP effluent. Our study results pointed out the efficient removal of anionic surfactants during the biodegradation process realized within municipal WWTP's from Romania and the limit values for their disposal in natural receivers are fully respected.

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