

ANALYTICAL CONTROL OF THE NUTRIENTS AND DETERGENTS REMOVAL IN MUNICIPAL WASTEWATER TREATMENT PROCESSES♦

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Abstract: The paper presents studies regarding the efficiencies of the removal process for ammonia, nitrites, phosphorus and detergents, in the Constanța city municipal wastewater treatment plant, during 2007. The pollutants mean concentrations in the effluent, in the studied period, have been according to the imposed limits, but some slightly higher values have been noticed for ammonia during July – October and for total phosphorus during January - March, September and December. The obtained results show that during 2007 high removal efficiencies for ammonium nitrogen (84.79%) and detergents (95.96%) have been obtained but low percentages for phosphorus (47.01%), showing that some operational measures should be taken, in order to improve the removal performances.

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Keywords: *municipal wastewater treatment, ammonia, detergents, nitrites, phosphorus, removal efficiency*

INTRODUCTION

In order to protect the natural receiving waters, the effluents are treated by various wastewater treatment processes before their discharge. The discharge of large volumes of treated wastewater that contains low concentrations of chemical constituents may still lead to an excessive input of nutrients in a receiving water body, thus, leading to a water quality problem. Regulations have progressively diversified the tolerable discharge levels to accord with the objectives for receptor waters quality, established by the authorities in charge of water and wastewater management [1-3]. Moreover, the reuse of water represents an environmental challenge [4].

Wastewater is not just sewage. The domestic waters used in homes or social units (restaurants, daily nurseries, institutions), going down the drains or into the sewage collection system is considered wastewater. This includes water from baths, showers, sinks, dishwashers, washing machines, and toilets. Small businesses and industries often contribute with discharging large amounts of wastewater to the sewage collection systems others have their own wastewater treatment systems. In combined municipal sewage systems, waters from storm drains is also added to the municipal wastewater stream. Thus sewage pollutants are a complex mix of mineral and organic materials, including small and large particles that are dissolved, float or are in suspension. Wastewater treatment plants operate at a critical point of the water cycle, helping nature to defend itself of excessive water pollution. Most treatment plants are based on primary treatment processes (physical removal of floatable and settleable solids) as well as secondary treatment processes (biological removal of dissolved solids) [5-6]. In order to evaluate the pollutants removal efficiencies accurate and sensitive analytical methods are used [7].

The municipal wastewater treatment plant (WWTP) Constanța Sud has an important mission for the pollutants removal, in order to reduce the discharged effluent quantity in the Black Sea. Previous studies reported the suspended solids (*TSS*), total extractable in ether petroleum (*EP*), chemical oxygen demand by potassium dichromate (*CODCr*), biochemical oxygen demand in five days (*BOD₅*) removal efficiencies [8] and the assessment of biological phosphorus removal possibilities [9].

The aim of this study is to present original results concerning the removal efficiencies related to detergents, ammonia, nitrites and phosphorus from municipal WWTP Constanța Sud, during 2007.

MATERIALS AND METHODS

Studies were performed on a modern municipal WWTP in Romania, located on the Black Sea coast, which processes about 3,200 L·s⁻¹ of effluent from Constanța city, including sewage (60%) and industrial wastewater (food industry and processing,

constructions, petroleum products distribution etc.). Stages of the treatment processes used at the municipal WWTP Constanța Sud, Romania (Figure 1) include:

- **Primary treatment** based on: screening for large objects removal (stones, sticks); grid chamber; sedimentation tanks (sand separators, settling tanks); settleable solids are settled out and pumped away, while oils float to the top and are skimmed off; often these tanks include or are followed by a flotation step to optimize the separation of particles with density lower than water.
- **Secondary treatment** based on: biological treatment processes, where microorganisms convert nonsettleable solids to settleable solids; sedimentation typically follows, allowing the settleable solids to settle out; biochemical reactions take place between substratum (represented by wastewater containing organic pollutants, as carbon source for bacterium) and the reactive substance (aerobic or anaerobic biological sludge).

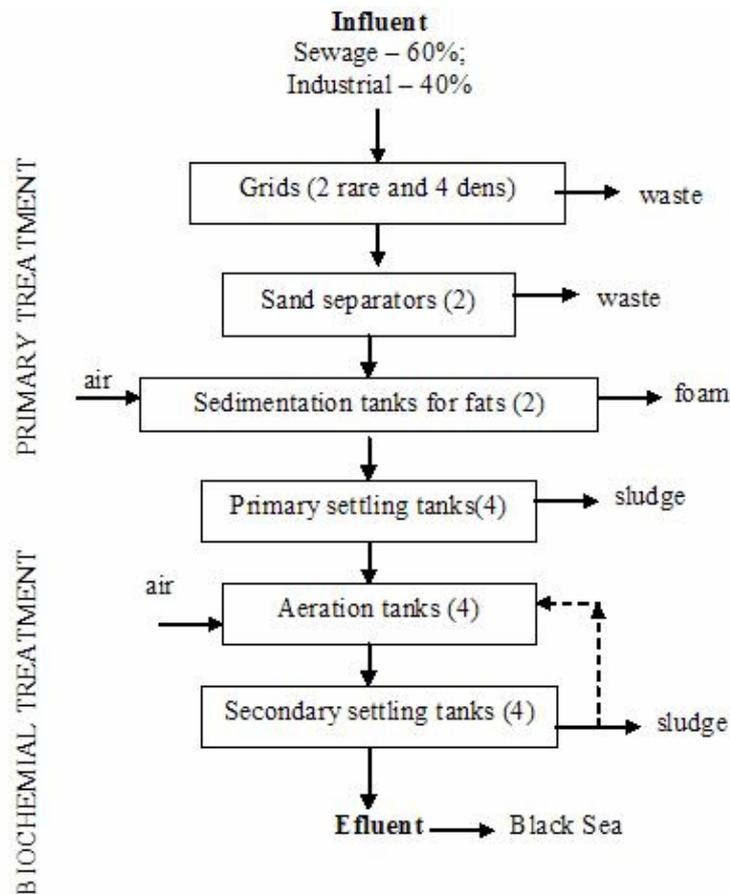


Figure 1. Stages of the municipal WWTP Constanța Sud

To verify the evolution of the wastewater treatment removal efficiencies, influent and effluent samples were collected and analyzed. The used analytical methods have been those imposed by national and international regulations. The following equipments for samples preparation were used: Bloc Digest 6-Selecta for total phosphorus mineralization; mineralization unit Buchi K 424 for total nitrogen Kjeldahl, distillation units Buchi 339 and Behr Laborator – Technik for ammonia.

The ammonia concentration was determined by distillation of the sample into a solution of boric acid and titration of the resulting basic species with hydrochloric acid. The others analytical parameters (nitrites, total phosphorus, detergents) were analyzed by molecular absorption spectrometry using a UV-VIS GBS CINTRA 5 spectrometer. For all parameters concentration determination, momentary samples have been analyzed, the analyses being performed immediately after sampling. Three individual measurements were performed and the mean values are reported. All reagents used were analytical reagent grade.

The relationship determine the removal efficiency (Ef), is expressed by equation 1:

$$Ef(\%) = 100 (I - E) / I \quad (1)$$

where I and E are the pollutant concentrations in the effluent and influent, respectively. The imposed values for the studied parameters in effluents and effluents of wastewaters and the removal efficiencies, according to the Romanian regulations are presented in table 1.

Table 1. *The imposed wastewater pollutant concentrations and overall treatment removal efficiencies*

Quality parameter	Concentration, [mg·L ⁻¹]		Removal efficiency, [%]
	Influent *NTPA 002	Effluent *NTPA 001	
Ammonia	30	2-3	90.0 - 93.3
Nitrites, mg·L ⁻¹	-	1-2	-
Total Nitrogen Kjeldahl (TNK), mg·L ⁻¹	-	10-15	-
Detergents, mg·L ⁻¹	25	0.5	98.0
Total Phosphorus, mg·L ⁻¹	5.0	1-2	60.0 – 80.0

*NTPA – Limits by Romanian regulations [15]

RESULTS AND DISCUSSION

Usually, the nutrients (total nitrogen and phosphorus) are removed especially in the biochemical treatment stage, but there is a slight nutrient removal in the mechanical stage too.

In figures 2 and 3 the nutrient concentrations evolution of WWTP Constanța Sud effluent in 2007 are plotted.

The ammonia, nitrites, TNK and total phosphorus mean concentrations in the effluents in the studied period have been in concordance with the imposed limits, but some slightly higher values have been noticed for ammonia and TNK during July – October and for total phosphorus during January - March, May, September and December.

Figure 4 shows the evolution of the detergents concentrations in the Constanța Sud WWTP effluent in 2007. All the measured values for detergents are lower than those imposed by national regulations.

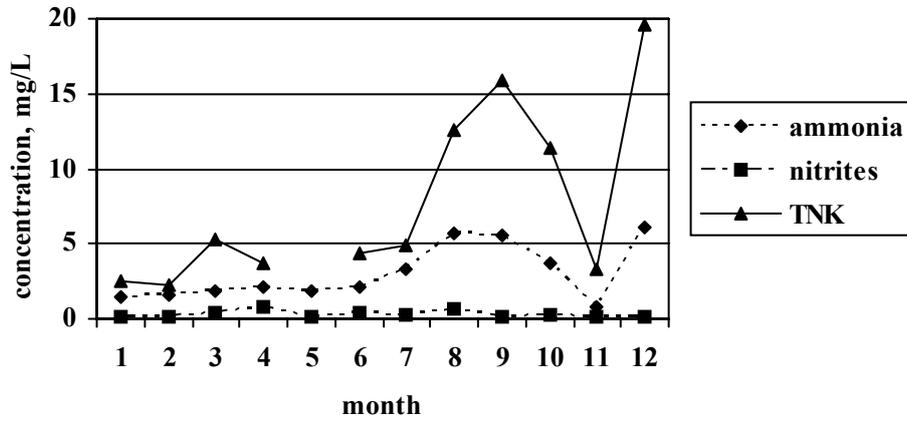


Figure 2. Ammonia, nitrites and TNK mean concentrations evolution in Constanța Sud WWTP effluent in 2007

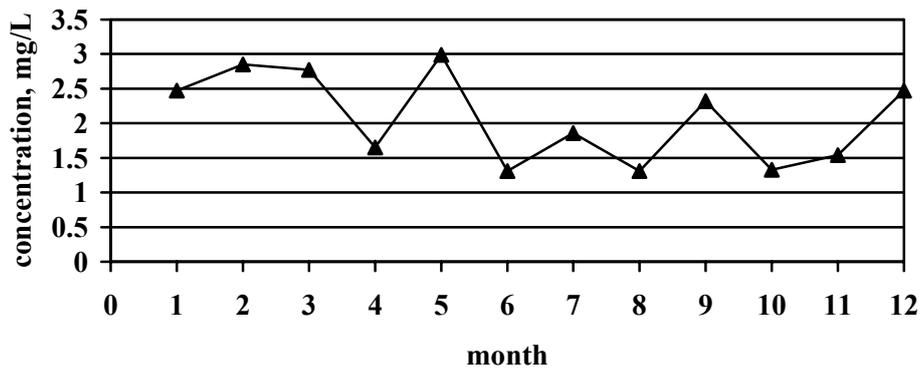


Figure 3. Total phosphorus mean concentrations evolution in Constanța Sud WWTP effluent in 2007

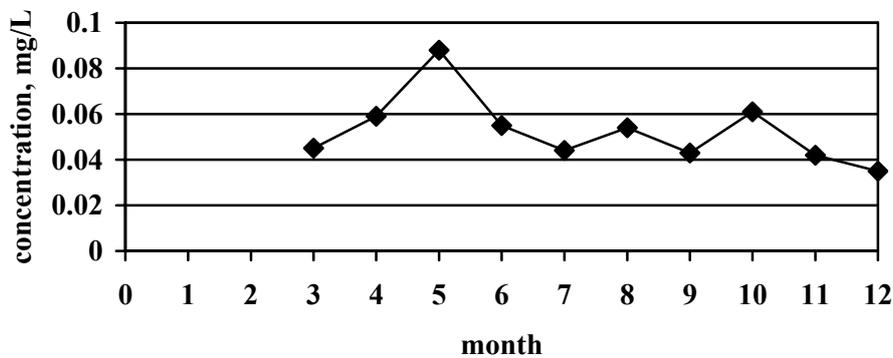


Figure 4. Detergents mean concentrations evolution in Constanța Sud WWTP effluent in 2007

The removal efficiencies for nitrogen and phosphorus compounds monthly averages evolution in 2007 are presented in figures 5 and 6. In the case of ammonia, the removal efficiencies have been in the range of 67-95% and of the total phosphorus 1-68%. During the summer months better performances for phosphorus was observed, due to the increased microorganisms' activities, but only in June, August, October and November the imposed values have been achieved.

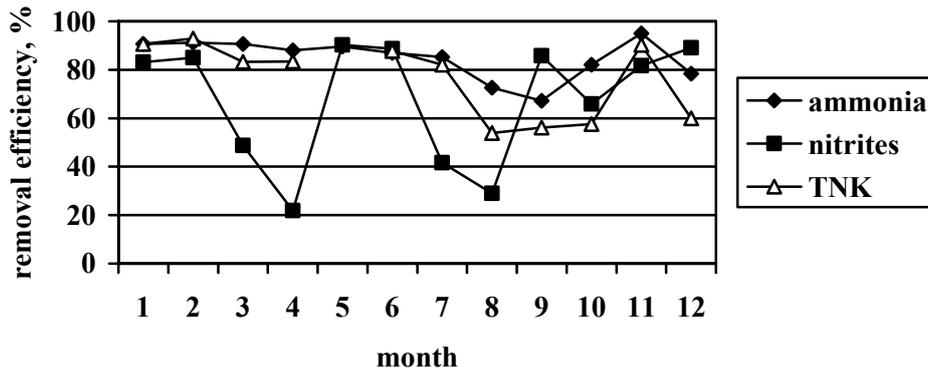


Figure 5. Ammonia, nitrites and TNK monthly mean removal efficiencies evolution in Constanța Sud WWTP in 2007

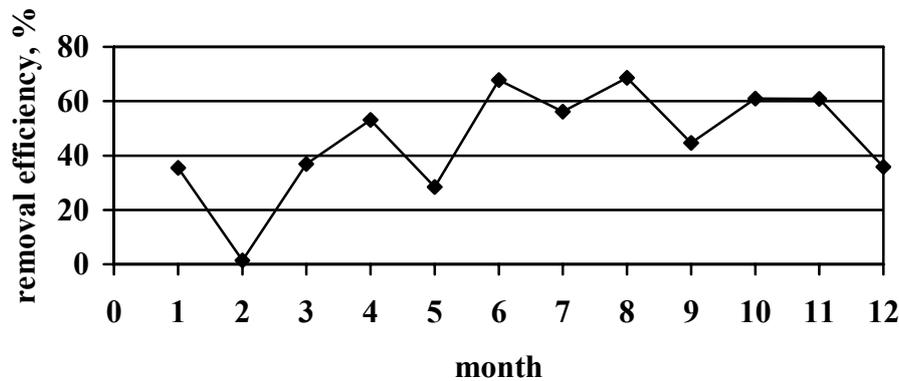


Figure 6. Total phosphorus monthly mean removal efficiencies in Constanța Sud WWTP in 2007

Detergents removal in Constanța Sud WWTP, the monthly average values in March - December 2007 were in the range of 93-97%, lower than those imposed (Figure 7).

The annual average values of the removal efficiencies in 2007 for ammonia, nitrites, phosphorus and detergents are presented in table 2.

The obtained results show that in 2007 high removal efficiencies for ammonium nitrogen and detergents have been obtained but in the case of phosphorus there must be taken some operational measures in order to improve the removal performances of the treatment plant. The analytical control of the pollutants contained in the influents and effluents could have an important role in this improvement.

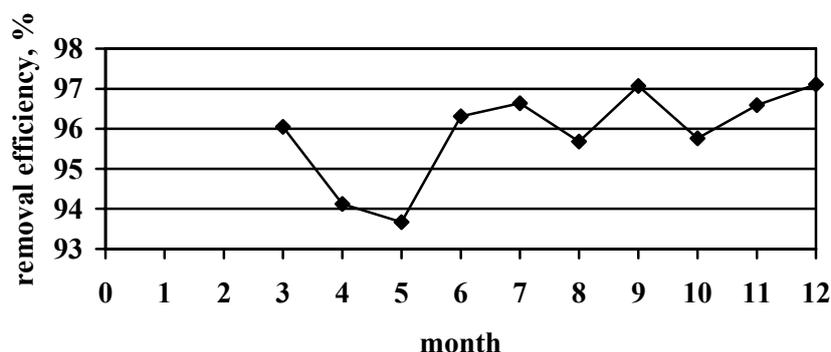


Figure 7. Detergents monthly mean removal efficiencies in Constanța Sud WWTP in 2007

Table 2. Removal efficiencies for ammonia, nitrites, phosphorus and detergents in the sewage treatment processes from “Constanța Sud” treatment plant in 2007 (mean values)

Quality parameter	Concentration, [mg.L ⁻¹]		Removal efficiency, [%]
	Influent	Effluent	
Ammonia	19.21	3.01	84.33
Nitrites	1.093	0.479	56.67
TNK	31.71	7.80	76.17
Total phosphorus	3.85	2.04	47.01
Detergents	1.29	0.05	95.96

The obtained results show that in 2007 high removal efficiencies for ammonium nitrogen and detergents have been obtained but in the case of phosphorus there must be taken some operational measures in order to improve the removal performances of the treatment plant. The analytical control of the pollutants contained in the influents and effluents could have an important role in this improvement.

CONCLUSIONS

This paper presents monthly average values of the removal efficiencies during one year, for nutrients in the municipal WWTP Constanța Sud, Romania. Overall obtained efficiencies were: ammonia 67-95%, nitrites 21-90%, TNK 53-92%, phosphorus 1-68%, and detergents 93-97%. The actual performances of the treatment processes used in the WWTP could be improved with the aid of the analytical control, by the use of the most suitable operational treatment technologies, to the influent content.

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