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CHEMICAL OXYGEN DEMAND FRACTIONATION OF REJECT WATER FROM MUNICIPAL WASTEWATER TREATMENT PLANT

FRAKCJE CHEMICZNEGO ZAPOTRZEBOWANIA NA TLEN WÓD OSADOWYCH Z MIEJSKIEJ OCZYSZCZALNI ŚCIEKÓW

Abstract: This study presents results of chemical oxygen demand fractionation measurement of reject water from municipal wastewater treatment plant in Malaga (Spain). Analyzed reject water is a high-strength wastewater, internally generated at WWTP during sewage sludge treatment. Additionally, in many cases the reject water is recycled to the main stream of WWTPs without any treatment. Because of high concentrations of nitrogen and phosphorus as well as organic matter, those sludge liquors could significantly effect on WWTPs operation. In this research, the samples of reject water were obtained from following installations: centrifuge dewatering, centrifuge thickening, gravity thickener and sludge dryer. The respirometric method was applied to determine biodegradable COD fractions. In case of reject water form sludge dryer, gravity thickener as well as centrifuge dewatering the obtained results of COD fractionation indicated that the organic matter of wastewater is mostly biodegradable, this fraction was ranged from 63.6 to 88.6 of total COD. Whereas, the reject water from centrifuge thickening was characterized by significant share of inert fractions, 86.9 of total COD.

Keywords: COD fraction, organic matter, reject water, side-stream wastewater, respirometry

Introduction

Currently, the chemical oxygen demand (COD) fraction has become an indispensable tool for the characterization of wastewater and expression of model components [1, 2]. The COD fractionation often replaced biological oxygen demand (BOD), volatile solids (VS) and total organic carbon (TOC) as the parameter to describe organic matter presented in wastewater [3-5]. The total COD is divided due to rate of degradation, in ASM1 (Activated Sludge Model no. 1) is distinguished following fractions: readily biodegradable (S_S) and slowly biodegradable (X_S) (biodegradable organic matter) as well as soluble inert COD (S_I) and particulate inert COD (X_I) (non-biodegradable organic matter) [5, 6]. The biodegradable fractions (S_S and X_S) could be absorbed by organisms and metabolized for energy and synthesis. However, the slowly biodegradable substrate firstly should be hydrolyzed by exocellular enzymes of bacteria [2, 7]. The soluble inert COD passes through the system without influencing the biochemical processes in the reactor. Whereas, the particulate inert fraction (X_I) is mostly accumulated in the activated sludge and removed from the system with waste sludge [4, 8]. Generally, the COD fraction has been applied in modeling of the microbial processes in activated sludge as well as control purposes [2].

This study presents results of chemical oxygen demand fractionation measurements of reject water from municipal wastewater treatment plant in Malaga (Spain). Recently, more attention has been focused on the issue of return flows. Those streams mostly include

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removed liquid phase from processes such a thickening, anaerobic digestion, chemical conditioning as well as dewatering of sewage sludge. This high-strength wastewater also called as side-stream may contain significant concentrations of nitrogen, phosphorus and organic matter [9, 10]. Additionally, in many cases the reject water is recycled into the main stream of WWTPs without any treatment, which could cause several problems on WWTP operation. Most significant of those issues are biological process disturbances connected with substrate unequilibrium, overloading of bioreactor which can led to increase of operational as well as maintenance costs [11, 12].

Materials and methods

As a materials in presented research was used reject water obtained from following installations: centrifuge dewatering, centrifuge thickening, gravity thickener and sludge dryer of the MWWTP situated in Malaga (Spain). To determine COD fractions the freshly collected samples were used, maximally 2 hours after sampling.

The tests were conducted using respirometer BM-T (Surcis). The equipment consisted of three parts: batch reactor (volume 1.0 dm^3) thermostatic unit and computer with software. The respirometer's chamber was equipped with a stirring and aeration systems as well as dissolved oxygen probe and the pH electrode. It recorded directly two fractions: total biodegradable (C_S) and readily biodegradable (S_S).

The respirometer was inoculated with activated sludge from biological reactor. This sample was aerated over 24 hours before the measure to reach the endogenous respiration. For all measurements the temperature was maintained at 20.0 ± 0.1ºC. In order to eliminate oxygen consumption due to nitrification about 10 min before the analysis 10 cm^3 solution of allylthiourea (ATU) was added to respirometer's chamber. The measurement was carried out in accordance with the procedure given by Surcis.

The inert as well as the slowly biodegradable fractions were based on following calculations:

$$X_S = C_S - S_S \ [\mathrm{mg \cdot dm^{-3}}] \tag{1}$$

$$S_I = S_T - S_S \ [\mathrm{mg \cdot dm^{-3}}] \tag{2}$$

$$X_I = C_I - S_I \ [\mathrm{mg \cdot dm^{-3}}] \tag{3}$$

where: S_I - soluble inert COD substrate [mg·dm^{-3}], S_T - total soluble COD [mg·dm^{-3}], X_I - particulate inert substrate [mg·dm^{-3}], X_S - slowly biodegradable organic matter [mg·dm^{-3}].

In order to estimate (S_T) the total soluble COD, the samples of wastewaters were filtered through 0.45 μm filter, then the chemical oxygen demand was measured. All chemical oxygen demand analyses were performed with Hach Lange UV - VIS DR 5000 using Hach analytical methods.

Results and discussion

The results of presented study are shown in Table 1. The concentrations of total and soluble COD were differed over a wide range. The average value of total COD was

2110.0 mg·dm^{-3} and varied within a range of 86.8 to 8660.0 mg·dm^{-3}. The highest value was observed in case of sludge dryer, whereas the lowest result in centrifuge thickening. The soluble COD concentrations were differed in the range of 39.1 to 7850.0 mg·dm^{-3}, with a mean value of 1618 mg·dm^{-3}.

Table 1

Estimated chemical oxygen demand fractions of reject water from different facilities

		C_T	C_S	S_S	X_S	S_I	X_I
		[mg·dm^{-3}]		[%]			
centrifuge dewatering	average	1406.8	660.5	46.0	17.5	8.7	27.8
	min	991.0	371.0	21.2	5.5	0.1	10.0
	max	1869.0	905.0	71.1	31.5	23.3	43.5
	SD	460.0	251.0	20.8	10.9	11.1	17.1
centrifuge thickening	average	114.2	59.8	11.1	1.9	42.3	44.5
	min	86.8	39.1	8.3	0.1	21.5	32.5
	max	151.0	94.9	12.4	4.0	53.0	65.4
	SD	32.1	24.4	1.9	1.8	14.4	14.7
gravity thickener	average	978.8	483.0	51.7	11.9	3.8	32.5
	min	543.0	215.0	40.2	7.5	0.2	21.4
	max	1355.0	693.0	68.3	18.0	8.7	41.4
	SD	333.7	201.8	13.0	4.5	4.5	10.3
sludge dryer	average	5940.0	5270.0	83.9	4.8	17.4	5.4
	min	3220.0	2690.0	79.8	3.7	2.7	5.7
	max	8660.0	7850.0	87.9	5.9	3.8	10.6
	SD	3846.7	3648.7	5.8	1.6	29.6	7.5

In case of reject water from sludge dryer, gravity thickener as well as centrifuge dewatering the obtained results of COD fractionation indicated that the organic matter of wastewater is mostly biodegradable, this fraction was ranged from 63.6 to 88.6 of total COD.

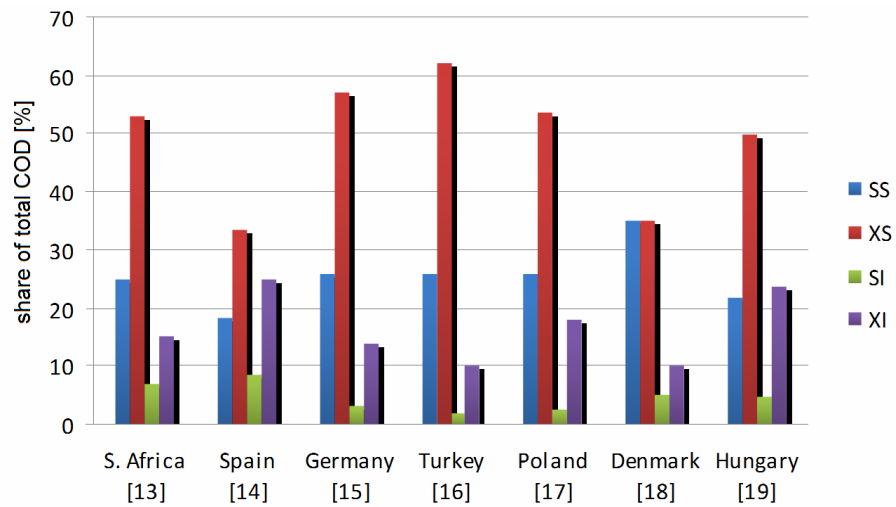

Fig. 1. The summary of COD fractions in raw wastewater from various countries

The presented results for reject water from centrifuge dewatering and gravity thickener were comparable. Those samples were characterized by significant percentage of readily biodegradable faction, 46% for centrifuge dewatering and 51.7% for gravity thickener. The similar data was also observed in case of slowly biodegradable substrate, 17.5 and 11.9% of total COD, respectively. The highest value of biodegradable fractions was obtained in wastewater from sludge dryer 88.7%, of which 83.9% was a readily biodegradable component. The results show that those samples contain a relatively low fraction of slowly biodegradable COD, with a mean value of 11.4 of total COD, compared to data reported at the literature and depictured at Figure 1 for raw wastewater (X_S between 33-62 of C_T) [13-19]. Whereas, the non-biodegradable fractions were dominated in case of sample from centrifuge thickening, the average value was 42.3% for soluble inert fraction and 44.5% for the particulate inert fraction. In raw wastewater inert fractions (soluble and particulate) might contain up to 33 of total COD [14]. A significant share of non-biodegradable fraction in the influent could interfere the biological treatment.

Additionally, the obtained results of COD fractionation were characterized by significant standard deviation, which could be attributed to changing influent quality as well as the process efficiency.

Summary and conclusions

Although flow of reject water is relatively small, it could affected on wastewater treatment plant efficiency. Furthermore, this high-strength wastewater is returned to influent of wastewater treatment plants. In this study, the results of chemical oxygen demand fractionation of reject water from municipal wastewater treatment plant in Malaga (Spain) were presented.

In case of reject water form sludge dryer, gravity thickener as well as centrifuge dewatering the obtained data of COD fractionation indicated that the organic matter of wastewater is mostly biodegradable, this fraction was ranged from 63.6 to 88.6 of total COD. Whereas, the reject water from centrifuge thickening was characterized by significant share of inert fractions, 86.9 of total COD.

The result of this research could be applied in modelling activated sludge systems as a part of influent characterization as well as for designing separate treatment of those returned streams.

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FRAKCJE CHEMICZNEGO ZAPOTRZEBOWANIA NA TLEN WÓD OSADOWYCH Z MIEJSKIEJ OCZYSZCZALNI ŚCIEKÓW

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Abstrakt: Artykuł przedstawia wyniki badań udziału poszczególnych frakcji chemicznego zapotrzebowania na tlen w wodach odprowadzanych z urządzeń przeróbki osadów w miejskiej oczyszczalni ścieków w Maladze (Hiszpania). Analizowane wody osadowe można scharakteryzować jako silnie zatężone ścieki generowane wewnątrz oczyszczalni, powstałe w efekcie prowadzonych procesów technologicznych - głównie obróbki osadów. W wielu stosowanych obecnie układach technologicznych tego typu wody zawracane są na początek głównego ciągu technologicznego oczyszczalni. Jednakże ze względu na bardzo wysokie stężenia związków zawierających azot, fosfor oraz węgiel organiczny odcieki te mogą znacząco wpływać na realizowane procesy oczyszczania. Podczas badań prowadzonych w ramach niniejszego opracowania próbki analizowanych wód procesowych

pobierane były z następujących urządzeń gospodarki osadowej: wirówki odwadniającej, wirówki zagęszczającej, zagęszczacza grawitacyjnego oraz suszarni osadów. Za pomocą metody respirometrycznej określony został udział frakcji biodegradowalnych w całkowitym chemicznym zapotrzebowaniu na tlen analizowanych próbek. W przypadku wód osadowych po suszarni osadów, zagęszczaczu grawitacyjnym oraz wirówki odwadniającej uzyskane wyniki analizy frakcyjnej ChZT wskazują na znaczny udział substancji biodegradowalnych - zakres od 63,6 do 88,6% całkowitego ChZT. Natomiast odcieki z wirówki zagęszczającej charakteryzują się znacznym udziałem substancji niebiodegradowalnych - udział frakcji inertnych wynosił 86,9% ChZT całkowitego.

Słowa kluczowe: frakcje ChZT, materia organiczna, wody odpadowe z przeróbki osadów, respirometria