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Characteristics of Sludge Node Operation at Wastewater Treatment Plant in Żory

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1. Introduction

Proper operation of a wastewater treatment plant (WWTP) consists in achieving an appropriate level of the wastewater treatment and carrying out the technological process in accordance with the adopted technology. Therefore, it requires adapting the conducted wastewater treatment processes to the changing functional characteristics of the treatment plant elements, including inhomogeneous volume flow and the wastewater composition. Disruptions and disabilities in the operation of the wastewater treatment plant cause, that the increased amounts of pollutants are introduced into aquatic ecosystems. The by-product of the processes taking place at the wastewater treatment plant is, among others, the sewage sludge (Dymaczewski et al. 1997). According to the Polish regulations (Dz. U. 2019 item 701), the municipal sewage sludge is defined as the "coming from the wastewater treatment plants sludge from the anaerobic digesters and other installations used for the treatment of the municipal wastewater, and other wastewater with a composition similar to the composition of the municipal wastewater". In turn, indirectly, as a result of running processes of the sludge treatment, there are produced leachates from the sludge dewatering processes. The leachates are characterized by varying in time load of pollutants, especially nitrogen and phosphorus compounds. The issue of leachates is a key problem in terms of returning into the technological line the additional load of nitrogen, phosphorus and organic carbon. In addition, they are a factor with a potentially very large negative impact on the effects of nitrogen removal in the main treatment line (Gajewska & Pempkowiak-Obarska 2008). In connection with the above, in the work an analysis was prepared of the functioning of the sewage sludge part of the wastewater treatment plant in Żory, in the years 2015-2017.

2. Objective of the work

The subject of the study was the analysis of data regarding the functioning of the sewage sludge part of the wastewater treatment plant in Żory. The study included analysis of the functioning of the sewage sludge part of the Żory wastewater treatment plant in the period from 2015 to 2017. The assessment of work of this part of the wastewater treatment plant was based on results of the physical and chemical parameters of sludges and leachates after the dewatering process.

3. General characteristics of the object

The wastewater treatment plant in Żory is located in the Silesian Voivodship, on the left bank of the River Ruda, at 43 + 450 km of its course. In terms of technology, the treatment plant is divided into two parts: wastewater and sewage sludge. The wastewater is treated using the mechanical and biological methods along with anaerobic treatment of the sludge. The wastewater treatment is carried out using the low-load sludge technology based on the classical, 3-stage Bardenpho system, referred to as the A2/O system (Figure 1). According to the assumptions of the process, the wastewater along with the activated sludge flows sequentially through a chamber or a separate anaerobic (non-oxygen), anoxic (hypoxic) and aerobic (oxygen) zone (Heidrich & Witkowski 2005). In the three-phase type A2/O system, both organic phosphorus and total nitrogen are removed from the wastewater.

The excessive sludge from the secondary settling tanks after compaction on a belt compactor is directed to anaerobic digesters, where it is fermented together with the raw sludge from the primary settling tank in the process of mesophilic fermentation at 38°C. The hydraulic retention time (HRT) amounts to 20-21 days. The chambers are heated by spiral heat exchangers through recirculation of the sludge contained in them. Mixing in the anaerobic digesters is carried out by means of mechanical agitators, and the mixing process is additionally supported by the pump system for recirculation. The sludge from the anaerobic digester (AD) is discharged using the overflow pipeline to a two-chamber retention basin of the digested sludge, equipped with agitators. The next stage of processing the sludge is its dewatering on the belt press. The dewatered sludge is stored under a roofed place of temporary sludge collection and then directed for further management.

The functioning anaerobic digesters are equipped with installations for collecting biogas, which after the desulphurisation and drainage process is used for the production of electricity and heat in cogeneration units. The biogas produced in the fermentation process is collected in the shell gas tank, and its excess is burned in a torch.

The projected average daily capacity of the treatment plant amounts to $Q_{d,avg.}$ = 9 596.0 m^3/d, while the maximum daily capacity is $Q_{d,max}$ = 19 200.0 m^3/d. The equivalent number of inhabitants was defined at the level 69 791 PE.

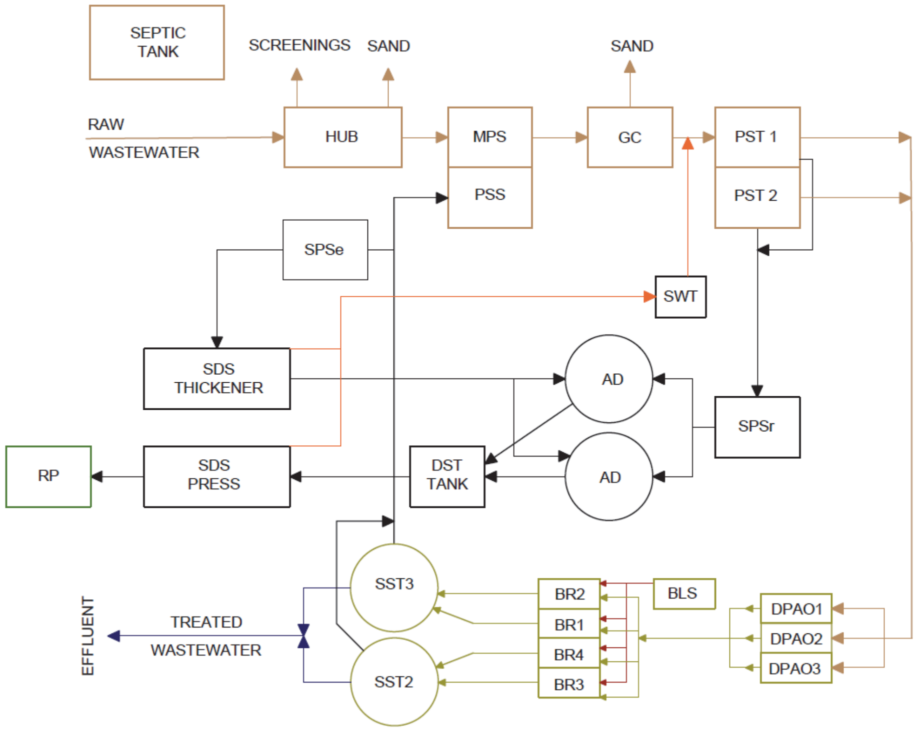

Fig. 1. Block diagram of the wastewater treatment plant in Żory. Source (Own materials of PWiK Żory 2018; Zdebik et al. 2018)
Meaning of symbols: HUB – sand separator with screen, MPS – main pump station, PSS – pump station for the recirculated sludge, GC – grit chamber, PST – primary settling tank, DPAO – dephosphatation chamber, BLS – blower station, BR – biological reactor, SST – secondary settling tank, SPSr – raw sludge pump station, SPSe – excessive sludge pumping station, AD – anaerobic digester, DST – digested sludge tank, SDS – sludge digestion station, RP – roofed place, SWT – supernatant storage tank

Average daily inflow of raw wastewater to the treatment plant in the years 2015-2017 amounted ca. 8 177.0 m^3/d. The data regarding the quantity and quality of wastewater flowing into the wastewater treatment plant in the years 2015-2017 are presented in Table 1. It was found that the hydraulic load and pollutants loads in the wastewater inflow conditions, in the rainless periods, did not exceed the assumed design parameters Analysing the annual distribution of the BOD_5 load, which amounted to 2 444 kg/d, it was lower by 1 743.0 kg /d than the design parameters. The total phosphorus load was lower than the assumed design parameters, while in the case of total nitrogen, the assumed load of these pollutants was exceeded. With reference to the design values, the total nitrogen load was higher by 114.3 kg/d. A observable increase in the nitrogen load in raw wastewater may be caused by an increased amount of inflowing wastewater in a certain month. Another of the reasons could be the low temperature of the raw wastewater (Brzezińska 2011). For example in 2016 it was 8.7°C.

Table 1. Comparison of design and actual parameters of the wastewater flowing into the WWTP in the years 2015-2017. Own study based on (Own materials of PWiK Żory 2018)

Parameter	Design parameters	Actual parameters
PE*	69 791	44 283
$Q_{d,avg.}$, m^3/d	9 596.0	8 177.0
BOD_5, kg/d	4 187.0	2 444.0
COD, kg/d	8 375.0	5 825.5
TSS, kg/d	4 536.0	3 266.3
TN, kg/d	768.0	882.3
TP, kg/d	126.0	119.0

*Population Equivalent

4. Analysis of functioning of the sewage sludge part

Table 2 shows the characteristics of the sludge produced in the various stages of its processing. The properties of sludge generated in the wastewater treatment process at WWTP Żory are typical for municipal wastewater treatment plants (Bień 2007) and for this characteristics of sewage sludges and wastewaters the wastewater treatment plant has been designed. The physico-chemical properties of the sediments were similar to the designed values. However, due to increasing amount of sewage sludges, their value exceeded the designed values which resulted in partial overloading of sewage sludges equipment. The raw sludge from the primary settling tanks was characterized by hydration of 96.27% and the volatile solids of 2.83%. The thickened waste sludge had lower hydration (at the level of about 94%). The volatile solids amounted to about 4.5%. The lowest content of the volatile solids was characteristic for the digested sludge (1.68%). The last stage of the sewage sludge treatment is the dewatering process.

Thanks to this process, the sludge obtained the dry matter content of around 20.4% in the analysed period.

Table 2. Characteristics of the specific types of sludge according to design and operational data from 2015-2017. Based on (Own materials of PWiK Żory 2018)

Sludge			
Raw	Thickened	Digested	Dewatered
Daily sludge volume, m^3/d (operational data / design data)			
64.08 / 67.00	49.01 / 53.00	113.09 / 110.00	11.98 / 10.00
Moisture content, %			
96.27 / 97.50	94.12 / 95.00	97.34 / 97.50	79.58 / 78.00
Dry matter content, %			
3.70 / 2.50	5.88 / 5.00	2.66 / 2.50	20.42 / 22.00
Organic matter content, %			
2.83 / n.d.*	4.48 / n.d.	1.68 / n.d.	14.09 / n.d.

n.d. – no data

The data regarding the average daily balance of sludge was used to assess the load of process equipment in the sewage sludge line. The analysis of the data presented in Table 3, i.e. the differences between the designed and the current state, indicates changes in regime of the equipment operation in the sewage sludge part of the treatment plant.

In the technological line of the sludge processing it was omitted the hydrolyser, which was out of service by the end of 2017. In the analysed period (2015-2017), two instead of three secondary settling tanks were used. The time of the wastewater retention in the secondary settling tanks, calculated on the base of the average daily volume of the wastewater ($Q_{d,avg.}$ = 8 177.0 m^3/d), including their capacity, increased from the designed value of 7.8 h to 9.14 h. The excessive sludge thickener, with the assumed 24-hour excessive sludge amount of 270.4 m^3/d, works approx. 5.4 h/day, i.e. longer than assumed in the project (4.9 h/day). For an average HRT, calculated on the base of the average daily amount of the excessive thickened sludge (48.0 m^3/d) and raw sludge (64.1 m^3/d), reaching the WKF, the hydraulic retention time is on average 21 days, i.e. 5 days shorter than in the design assumptions for the WKF chambers.

Table 3. Comparison of the designed capacity with the actual cycle of work of the sludge processing equipment. Based on (Own materials of PWiK Żory 2018)

Device	Parameter	Unit	Design parameter	HRT
			Value	
Hydrolyzer	Capacity	m^3	196	-
Primary settling tank	Capacity	m^3	2x400	
	Mean retention time	h	1.3	1.2
Secondary sedimentation tank	Capacity	m^3	3x1556	2x1556
	Mean retention time	h	7.8	9.14
	Diameter	m	3x25	
Thickener	Output	m^3/h	50	
	Mean work time	h/d	4.9	5.4
Mixed sludge storage tank	Capacity	m^3	14.5	
	Fill time	h	b.d.	7.3
Anaerobic digester	Capacity	m^3	2x1200	
	HRT	d	26.6 (summer) 25.4 (winter)	21.0 (avg.)
Post-fermentation storage tank	Capacity	m^3	300	
	Sludge retention time	d	6.4-7.8	2.6
Filter press	Output	m^3/h	5-10	
	Mean work time	h/d	4.1	11.9
Supernatant water storage tank	Capacity	m^3	1100	
	Retention time	d	6.3 (winter) 7.7 (summer)	16.4 (avg.)

Due to the fact that the amount of mixture of the sludge directed to fermentation has increased, in the future it should be considered possibility of expanding the system with an additional WKF chamber, or a system of thermal sludge hydrolysis. The possible retention time in the digested sludge tank, calculated taking into account the current data on the amount of the digested sludge, is shorter than the assumed time (6.4-7.8 d) and amounts to 2.6 d. Near three-fold increase in the average working time of the belt press was found (from 4.1 h/d to 11.9 h/d). This value was determined on the base of the average daily amount of the digested sludge and the maximum capacity of the equipment (10 m^3/h). In turn, the possibility of retaining leachates in the tank of the supernatants is greater than the designed one (about 7 d) and amounts to 16.4 d. The increase in the amount of wastewater flowing into the treatment plant and the related increase in the amount of generated sludge have an impact on the presented discrepancies between the designed and the actual state. The belt press and the digested sludge tank are particularly loaded in the system. The constantly increasing amount of sludge generated in the wastewater treatment plant may cause overloading of the technological system of sludge processing and, as a consequence, deterioration of the digested and dewatered sludge parameters.

5. The effect of pollutant loads in the leachates on the efficiency of work in the main technological line

The source of pollutants supplied to the main technological line, in addition to these coming from the municipal wastewater flowing into the WWTP, make the leachates generated after dewatering of the sludges, coming from the fermentation process. The leachates from dewatering of the sludge are a key problem in the aspect of returning to the production process of an additional nitrogen load, also phosphorus and organic compounds. The issue of pollutant load in the leachates is a factor with a potentially very large negative effect on the results of TN (Total Nitrogen) removal in the main treatment line. On the basis of data regarding the qualitative composition of the raw wastewater, initially treated and the leachates, it was determined their potential impact on the efficiency of pollutant decomposition in the biological reactors (Table 4). In the WWTP Żory the amount of arising leachates is not measured, therefore for further analysis it was adopted the target value specified in the construction and executive design of 2006, made by the Consulting Inżynieria Technologia, which is presented in Table 5.

The digested sludge produced in the WWTP Żory is dewatered by the filter belt press. During dewatering of sludges, the formed leachates are discharged by gravitation into the supernatant storage tank. For this need it was adapted the object previously functioning as the Imhoff settler. To the supernatant storage tank there are also directed waters from the emergency overflow of the digested sludge tanks, leachates from the temporary sludge repository and the rinsing water. From the leachate storage tank the leachates are discharged through a gate valve with electric drive, enabling regulation of the runoff to the inflow into the wastewater treatment plant.

Table 4. Quality assessment of the raw wastewaters, wastewaters after the primary settling tank and leachates coming from the filter presses in the years 2015-2017. On the base of (Own materials of PWiK Żory 2018)

Parameter	Unit	Raw wastewater	Wastewater after primary settling tank	Leachates from filter press	Treated wastewater
TN	mg/dm^3	107.9 σ = 21,78	75.9 σ = 18,42	664.8 σ = 221,73	14.7 σ = 3,36
N_{NH4}		82.5 σ = 23,40	61.7 σ = 15,06	592.6 σ = 215,01	1.3 σ = 4,20
TP		14.6 σ = 6,17	8.2 σ = 3,35	197.7 σ = 105,39	0.2 σ = 0,65
PO_4		39.2 σ = 18,94	39.1 σ = 199,44	*nt.*	*nt.*
COD		712.4 σ = 169,64	548.0 σ = 79,73	386.9 σ = 168,74	52.0 σ = 40,82
BOD_5		297.9 σ = 95,30	243.0 σ = 59,08	66.4 σ = 75,00	5.0 σ = 2,84
TSS		399.4 σ = 122,87	263.0 σ = 71,74	1100.9 σ = 1008,10	13.9 σ = 16,41
BOD_5/TN	-	2.8	3.2	0.1	0.3
COD/TN		6.6	7.2	0.58	3.5
COD/BOD_5		2.39	2.26	5.83	10.40

nt. – not tested, TN – Total Nitrogen, TP – Total Phosphorus,
TSS – Total Suspended Solids

Table 5. The amount of effluents from the filter presses. Source (Consulting Inżynieria Technologia 2006)

Parameter	Unit	Value	
		Summer	Winter
Amount of leachates	m^3/d	65.8	68.8
Individual amount of rinsing water	m^3/h	10.0	10.0
Amount of rinsing water	m^3/d	77.4	81.0
Total amount of leachates	m^3/d	143.3	149.8

On the base of data from the period of 2015-2017, an analysis of the qualitative composition of the leachates, produced during dewatering of the digested sludge on the filter presses, was conducted.

The analysis of the presented data shows that in the leachates there is a high content of ammonium nitrogen, total phosphorus, as well as periodically very high content of the total suspended solids. The maximum measured concentration of the total suspended solids during this period amounted to 3627.0 mg/dm^3, ammonium nitrogen 935.4 mg/dm^3, total phosphorus 668.2 mg/dm^3. The leachates after the filter presses were characterized by similar concentration of the COD as in the raw wastewaters. This value was on average 683.0 mg O_2/dm^3 in the raw wastewaters, and 386.9 mg O_2/dm^3 in the leachates. On the other hand, the value BOD_5 of the leachates coming from the presses was 4.5 times smaller than in the raw wastewaters and almost 4 times smaller than in the wastewater after the primary settling tank. Accordingly, the value of the ratio COD/BOD_5 was 5.83, indicating that there are recycled to the main technological line the hardly biodegradable organic substances that reduce effectiveness of the biological decomposition processes. The leachates discharged from the filter presses are a source of the secondary pollutants returned to the technological line of the wastewater treatment plant.

High content of the nitrogen and phosphorus compounds and a relatively small amount of organic compounds cause that the leachates have a significant contribution to the inflow of pollutants load into the biological part and under conditions of deficiency of organic compounds in the raw wastewaters, they can affect the inhibition of the biological process of the wastewater decomposition. The above observations have been confirmed in the studies carried out, among others, by (Fux et al. 2002; Janus & van der Roest 1997). For example, in the wastewater treatment plant in Minworth (England), the concentration of the total suspended solids was from about 220.0 to 2340.0 mg/dm^3, and $N\text{-}NH_4$ from 450 to 750 mg/dm^3. In turn, in the leachates coming from the Luggage Pot (Australia) treatment plant, the concentration of the ammonium nitrogen amounted from 943.0 to 1710.0 mg/dm^3, and the total suspended solids from 95.0 to 6132.0 mg/dm^3.

Next, it was estimated the value of load of the pollutants supplied to the technological wastewater treatment line (Table 6). The daily quantity of the leachates was determined on the base of the data contained in Table 5. The average value from the summer-winter period was assumed to be equal 146.6 m^3/d.

Table 6. Loads of pollutants in the wastewater in the years 2015-2017.
Source (Own materials of PWiK Żory 2018)

Wastewater	Parameter	Value [kg/d]		
		Average	Max.	Min.
Raw wastewater	TN	859.5	1334.3	474.0
	N_{NH4}	691.7	1802.6	284.1
	TP	106.4	266.5	24.4
	COD	5591.0	8930.9	2979.7
	BOD_5	2488.5	4174.9	843.2
	TSS	2979.7	7244.6	1514.4
After primary settling tank	TN	621.3	1105.1	137.5
	N_{NH4}	505.1	894.7	90.9
	TP	67.1	190.7	0.00
	COD	4485.9	5689.3	2709.6
	BOD_5	1989.2	3266.2	1219.7
	TSS	2152.9	4346.77	826.8
Leachates from filter press	TN	97.45	156.86	12.31
	N_{NH4}	86.87	137.14	6.10
	TP	28.98	97.96	1.32
	COD	56.72	158.33	5.39
	BOD_5	9.73	50.72	2.79
	TSS	161.39	531.72	4.40
Treated wastewater	TN	120.30	253.70	96.57
	N_{NH4}	11.05	463.70	0.81
	TP	1.63	36.00	0.08
	COD	6.35	2659.80	204.6
	BOD_5	40.92	122.76	0.08
	TSS	113.76	1980.52	57.29

Based on the conducted analyses. it was found that the leachates coming from the filter presses carried a significant load of total phosphorus. which constitutes on average 27.2% of the total load flowing into the treatment plant. as well as total suspension and total nitrogen. which maximum load is respectively 5.4% and 11.3% of the total load flowing into the treatment plant. On the other hand. the COD and BOD_5 load constitutes only a small part of the raw wastewater load. i.e. below 1% (Figure 6).

The unfavourable COD/BOD_5 ratio of the supernatants inflowing to the main technological line causes periodical deterioration of the efficiency of nitrogen compounds removal in the wastewater treatment plant. This is due to the poor load of organic pollutants flowing into the wastewater treatment plant. The denitrification process works best when the BOD_5/TN ratio is higher than 4.0, while the very low value of this parameter in the supernatants inhibits the growth of denitrifying bacteria, which reduces the effectiveness of nitrogen compounds elimination. The increased amount of total suspended solids in supernatants entering into the primary settling tank increases its hydraulic load and negatively affects the degree of pollutants removal.

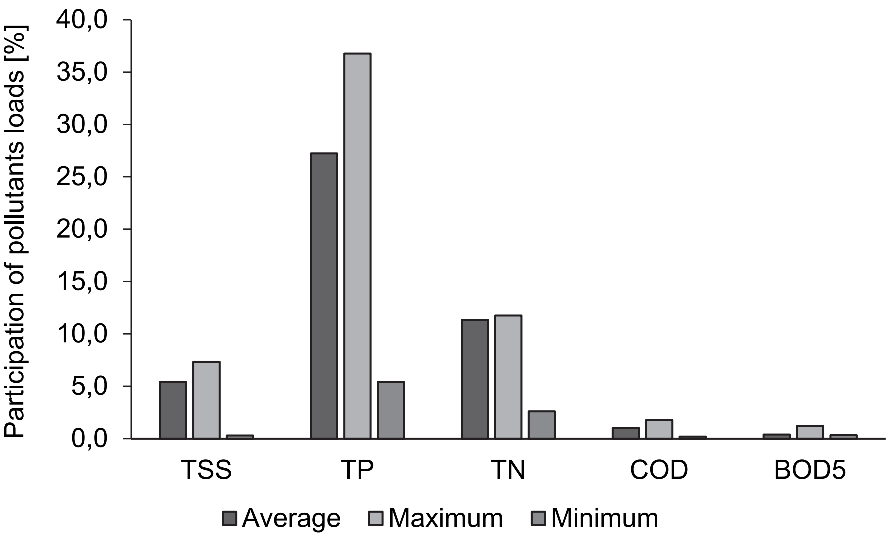

Fig. 2. Percentage relation of the pollutants load in the leachates. coming from dewatering. to the total load in the raw wastewater. Own study based on (Own materials of PWiK Żory 2018

Despite the adverse impact of the leachates quality on the efficiency of biological wastewater treatment, the quality of the wastewater discharged to the receiver meets the requirements set out in the conditions of the water permit. The organic pollutants load expressed as COD is reduced by about 92%, BOD_5 by over 98%, while totals suspended solids by about 96%. Similarly, high removal efficiency is observed for phosphorus compounds, which are reduced by almost 99%. Total phosphorus concentrations in treated wastewater range from 0 to 0.2 mg P/dm^3, while the permissible value is 2 mg P/dm^3. The wastewater treatment plant is also characterized by quite good efficiency of removing total nitrogen. In this case, the removal efficiency is on average of 83%. In periods, when leachates with particularly unfavourable composition flow into the main technological line, the efficiency of ammonium nitrogen removal is 75% compared to nearly 99% reduction in other periods of work (Zdebik et al. 2018).

Due to the large and time-varying load of pollutants which characterize leachates. especially those of general nitrogen. total phosphorus and suspended matter. consideration should be given to the treatment of the leachates before returning them to the technological wastewater treatment line. Due to the high content of nitrogen and phosphorus compounds and unfavourable C:N and C:P ratio. which cause that this type of wastewater is difficult to biodegrade. discharging the leachate waters in the case of a deficit. the inflow of easily biodegradable organic compounds in the wastewater may cause a reduction in the effectiveness of biogenic compounds removal (nitrogen and phosphorus compounds) in the biological process of the wastewater treatment. There are several methods for reducing pollutants found in supernatants. These include physico-chemical methods, e.g. ammonia stripping, ion exchange, chlorination, struvite precipitation and biological methods, including modern and effective activated sludge processes such as the DEMON, BABE, SHARON and SHARON-ANAMMOX processes (Barbusiński 2016; Dereszewka & Cytawa 2016). Due to the high content of nitrogen compounds in the supernatants, it is advisable to pre-treat them in the deammonification process. The deammonification process involves nitrogen removal by partial nitrification and ANAMMOX technology in SBR reactor under strict pH control (Wett 2007).

In the case of sludge dewatering process, a common problem arising during the exploitation of sewage sludge dewatering equipment is the precipitation of hard sediment of ammonium magnesium phosphate ($(NH_4)Mg(PO_4)\cdot 6H_2O$), also known as struvite. Struvite is a mineral with a characteristic crystalline structure, which is formed by regular PO_4^{3-} tetrahedrons, deformed $Mg(H_2O)_6^{2+}$ octahedrons and NH_4^+ group bonded through hydrogen bonds. Struvite precipitation is also possible under controlled conditions, eg. in reactors such as the Struvia™, Crystalactor®, PhosnixUnitaka®, PEARL® or PHOSPAQ™. The precipitated struvite is a product of commercial values due to its very good fertilizing properties. Due to the poor solubility in water, minerals contained in struvite (i.e. nitrogen, phosphorus, magnesium) are released slowly and gradually. In granular form, it can be applied to the soil in amounts significantly exceeding the dose of conventional fertilizers used, without overdosing (Czajkowska & Siwiec 2011).

6. Conclusions

The results of the carried out tests and the assessment of operation of the wastewater treatment plant. including the centre of the sludge treatment. allow to present the following conclusions:

- The quality of sewage sludges was characterized by similar chemical composition and physical properties to the sludge design characteristics. Daily sludge volume from the wastewater treatment plant was higher than according to the designed values wjich resulted in overloading of some sewage sludge processing equipment.
- Performed calculations. checking the efficiency of individual equipment. showed that the existing excessive sludge thickening system does not have sufficient capacity and was designed for other values of concentrations of pollutants in the sludge and the leachates stream.
- On the base of analyses and own calculations it was found that the charge of pollutants introduced from the leachates into the technological system affects the final concentration of total nitrogen in the treated wastewaters.
- In order to increase the efficiency of nitrogen removal in the main technological line. it is proposed to introduce the deammonification process of the leachates coming from the sludge dewatering. to reduce the load of ammonium nitrogen entering the biological part of the treatment plant. After the deammonification process. it will be possible to use the struvite precipitation process.
- Despite the observable. increasing concentrations of pollutants and the amount of treated wastewater. the plant meets the requirements for the quality of the wastewater discharged to the receiver. as required by the conditions of the water permit and in the Regulation of the Minister of the Environment.

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Abstract

The purpose of this work was to analyze work of the sludge part of the wastewater treatment plant in Żory. During the analysed period (years 2015-2017) the wastewater treatment plant in Żory worked in conditions typical for the municipal facilities. The characterization of the sludge generated in the wastewater treatment process has also shown that the sludge properties are typical for the municipal wastewater treatment plants. Based on the data provided by the PWiK Sp. z o. o. in Żory. the characteristics of the technological process were made. This characteristics in a detailed way includes the sludge part of the treatment plant. The analysis of the functioning of the sludge part was performed and the influence of the pollutants load in leachates on the effectiveness of work in the main technological line was characterized. Studies on the functioning of the sludge part showed discrepancies between the design status of the wastewater treatment plant and the real state. This is due to the increasing amount of the wastewater flowing into the treatment plant and the associated increase in the amount of the occurring sludge. The belt press and the digested sludge tank are particularly loaded. The belt press works for about 11.9 h/d with assumed 4.1 h/d. In turn. the residence time of the sludge in the digested sludge tank is about 3 times shorter than assumed. Despite the observed. increasing concentrations of pollutants and the amount of treated wastewater. the plant meets the legal requirements regarding the quality of the wastewater discharged to the receiver by the water-legal permit and the Regulation of the Minister of the Environment. Based on the results of laboratory tests of the wastewater and leachates generated in the process of dewatering on the filter presses. their impact on the efficiency of treatment in the main technological line was characterized. The amount of leachates in relation to the amount of the wastewater flowing into the treatment plant was 1.8%. The leachates had high content of ammonium nitrogen. total phosphorus and total suspended solids. The average concentrations of these parameters were: S_{NNH4} = 592.6 mg/dm^3, S_{Nog} = 664.8 mg/dm^3, S_{Pog} = 197.7 mg/dm^3 and S_{Zog} = 1100.9 mg/dm^3. The average values of BOD_5 and COD indices were S_{BOD5} = 66.4 mg/dm^3, and S_{COD} = 386.9 mg/dm^3. The leachates coming from the filter presses carried a significant load of total phosphorus. which constituted on average 27.3% of the total load flowing into the treatment plant. as well as the total suspension and total nitrogen. which maximum load constituted 7.3% (Z_{og}) and 11.8% (N_{og}) of the total load flowing into the treatment plant. The ratio of COD/BOD_5 indices of pollutants of the leachates from the presses was 5.83. which indicated the introduction of hardly biodegradable compounds into the main technological line. In order to increase the efficiency of nitrogen removal in the main technological line it was proposed the implementation of deammonification process of the leachates from the sludge dewatering. aiming to reduce the ammonium nitrogen load. introduced to the biological part of the treatment plant.

Key words:
wastewater treatment plant, activated sludge, sewage sludges, quality of the wastewater, leachate, sewage sludge management

Charakterystyka funkcjonowania węzła przeróbki osadów ściekowych na oczyszczalni ścieków w Żorach

Streszczenie

Celem niniejszej pracy była analiza pracy części osadowej oczyszczalni ścieków w Żorach. Oczyszczalnia ścieków w Żorach w analizowanym okresie (lata 2015-2017) pracowała w warunkach typowych dla miejskich obiektów komunalnych. Również charakterystyka osadów powstających w procesie oczyszczania ścieków wykazała. że właściwości osadów są typowe dla miejskich oczyszczalni ścieków. Na podstawie danych udostępnionych przez PWiK Sp. z o.o. w Żorach. dokonano charakterystyki procesu technologicznego. Charakterystyka w sposób szczegółowy uwzględnienia część osadową oczyszczalni. Dokonano analizy funkcjonowania części osadowej oraz scharakteryzowano wpływ ładunku zanieczyszczeń w odciekach na skuteczność pracy w głównym ciągu technologicznym. Badania dotyczące funkcjonowania części osadowej wykazały rozbieżności między stanem projektowym oczyszczalni ścieków. a stanem rzeczywistym. Wynika to z faktu zwiększającej się ilości ścieków dopływających na oczyszczalnię oraz związanym z tym przyrostem ilości powstających osadów. Szczególnie obciążone w układzie są prasa taśmowa oraz zbiornik osadu przefermentowanego. Prasa taśmowa pracuje przez około 11.9 h/d przy zakładanych 4.1 h/d. Z kolei czas przebywania osadów w zbiorniku osadu przefermentowanego jest około 3 razy krótszy od zakładanego. Pomimo obserwowanych. zwiększających się stężeń zanieczyszczeń oraz ilości oczyszczanych ścieków. oczyszczalnia spełnia wymagania prawne dotyczące jakości ścieków odprowadzanych do odbiornika nadane przez pozwolenie wodnoprawne oraz Rozporządzenie Ministra Środowiska. W opraciu o wyniki badań laboratoryjnych ścieków i odcieków powstałych w procesie odwadniania na prasach filtracyjnych. scharakteryzowano ich wpływ na skuteczność oczyszczania w głównym ciągu technologicznym. Ilość odcieków w stosunku do ilości ścieków dopływających do oczyszczalni wynosiła 1.8%. W odciekach stwierdzono wysoką zawartość azotu amonowego. fosforu ogólnego oraz zawiesiny ogólnej. Średnie stężenia wymienionych parametrów wynosiły: $S_{NNH4} = 592.6$ mg/dm^3, $S_{Nog} = 664.8$ mg/dm^3, $S_{Pog} = 197.7$ mg/dm^3 oraz $S_{Zog} = 1100.9$ mg/dm^3. Średnie wartości wskaźników BOD_5 oraz COD wynosiły $S_{BOD5} = 66.4$ mg/dm^3 i $S_{COD} = 386.9$ mg/dm^3. Odcieki z pras filtracyjnych niosły znaczny ładunek fosforu ogólnego. który stanowił średnio 27.3% całkowitego ładunku dopływającego do oczyszczalni oraz zawiesiny ogólnej i azotu ogólnego. których ładunek maksymalny stanowił 7.3% (Z_{og}) oraz 11.8% (N_{og}) całkowitego ładunku dopływającego do oczyszczalni. Stosunek wskaźników zanieczyszczeń COD/BOD_5 odcieków z pras wynosił 5.83. co wskazywało na wprowadzanie do głównego ciągu technologiczne związków trudno rozkładalnych. W celu zwiększenia efektywności usuwania azotu w głównym ciągu technologicznym zaproponowano implementację procesu deamonifikacji odcieków z odwadniania osadów w celu redukcji ładunku azotu amonowego wprowadzanego do części biologicznej oczyszczalni.

Słowa kluczowe:
oczyszczalnia ścieków, osad czynny, osady ściekowe, jakość ścieków, odciek, gospodarka osadowa