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ANALYSIS OF SEWAGE SUSCEPTIBILITY TO BIODEGRADATION ON AN EXAMPLE OF SEWAGE TREATMENT PLANT IN WODZISŁAW ŚLĄSKI

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Abstract

The paper presents an analysis of sewage susceptibility to biodegradation on an example of sewage treatment plant in Wodzisław Śląski in the Śląskie province. For this purpose, dependencies between selected indices of domestic sewage pollution were applied. Descriptive statistics of the respective indices rations COD/BOD_5, BOD_5/TN, BOD_5/TP were presented. Moreover, an analysis was conducted on the composition of raw sewage flowing into the treatment plant, pre-treated sewage and sewage leaving the studied treatment plant. The analysis was carried out on the basis of three basic indices of sewage pollution (BOD_5, COD and total suspended solids) and two biogenic indices (total nitrogen and total phosphorus). Tests on the sewage composition were conducted in the years 2010-2015. Basic descriptive statistics were compiled for the values of the studied indices of sewage pollution and the obtained results were interpreted. On the basis of collected material it may be said that sewage reaching the treatment plant in Wodzisław Śląski revealed a good susceptibility to biodegradation, whereas the BOD_5/TN and BOD_5/TP ratios were below the optimum value.

Keywords: sewage biodegradation, sewage composition, sewage treatment plant

INTRODUCTION

Sewage treatment plants still remain a present-day problem of many legal, economic and technical regulations. When entering the European Union structures, Poland undertook to observe the regulations concerning water and sewage management (Directive 1991). The main document in this area is The Waste Water Directive. This document was the basis for establishing the National Programme for Municipal Waste Water Treatment in Poland (KPOŚK 2003). One of its provisions states that the agglomerations where the population equivalent number (PE) is at least 2 000 must be equipped with combined sewer systems ending at sewage treatment plants (Miernik and Młyński 2014a; Miernik and Młyński 2014b; Chmielowski et al. 2015, Młyński et al. 2016). Owing to the provisions of the document it is possible to estimate the progress of works connected with construction of new treatment plants and modernization of the existing ones. The reference to the size of the agglomeration was presented in the Regulation (2014). One should remember that according to the provisions in the Waste Water Directive, Poland undertook to ensure a good status of waters until 2015. A considerable portion of works in the area has been completed, but not all appointed tasks were fully realized. Therefore, every effort should be made to improve the composition of sewage discharged from city agglomerations in Poland. Efficiently functioning sewer systems must be constructed, which would drain sewage to collective sewage treatment plants (Mikołajczyk and Krajewski 2014, Bugajski et al. 2017, Kaczor et al. 2017). Sewer agglomerations comprise a sewer system or systems which drain untreated sewage to the collective sewage treatment plants. The composition of sewage reaching the treatment plant is greatly diverse (Bugajski et al. 2016, Chmielowski 2013, Mazur et al. 2016, Nowak et al. 2016, Wąsik et al. 2016). Sewage biodegradability is a crucial issue. It may be determined by the ratio of selected indices of sewage pollution (COD/BOD_5, BOD_5/TN, BOD_5/TP). Analysis of selected pollution indices in sewage outflow from the sewer agglomeration in Wodzisław Śląski in view of susceptibility to biodegradation was conducted in the presented paper.

AIM AND SCOPE OF WORK

The aim of the paper was an analysis of raw and mechanically treated sewage susceptibility to biodegradation. Descriptive statistics of individual indices: COD/BOD_5, BOD_5/TN and BOD_5/TP were presented. Moreover, raw sewage was divided into five groups depending on the concentration of a respective pollution index. The values of sewage pollution indices were determined for sewage flowing into, pre-treated and flowing out of the treatment plant in Wodzisław Śląski in the Śląskie province. The analysis was conducted on the basis of three main indices of sewage pollution (BOD_5, COD and total suspended solids) and two biogenic indices (total nitrogen and total phosphorus). Analyses of the sewage composition were conducted in the years 2010-2015. Basic descriptive statistics of the examined sewage pollution indices values were compiled and the obtained results were interpreted.

DESCRIPTION OF THE STUDIED FACILITY

Sewage treatment plant called Karkoszka II is situated in Wodzisław Śląski in the Wodzisław county in the Śląskie province. It a mechanical-biological sewage treatment plant with integrated system of nitrogen and phosphorus removal. The investigated sewage-treatment plant is located in Wodzisław Śląski, Wodzisław district, Silesian province (Fig. 1).

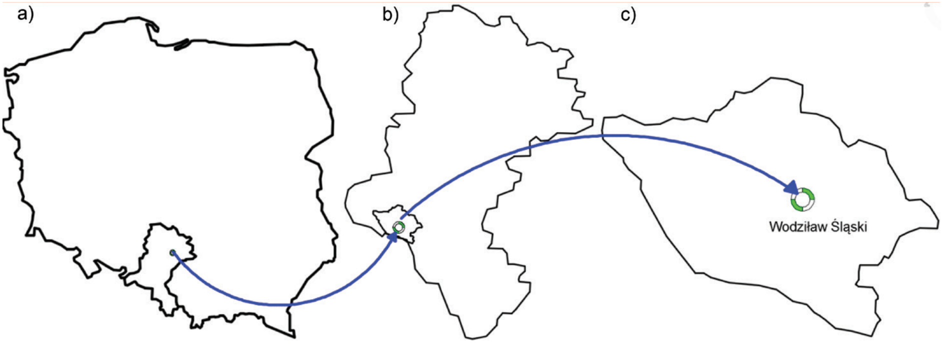

Figure. 1. The facility location in Poland (a), Silesian province (b), Wodzisław district (c); source: own elaboration (Chmielowski et al. 2017)

The sewer system is 313.4km long, of which sanitary sewer system is 300.2 km long (95.8%) and the combined sewer system makes up the remaining 13.2 km. The receiving waters for the treated sewage is Leśnica watercourse, the right bank tributary to the Szotkówka watercourse, which in turn flows into the Olza river – a right bank tributary of the Odra river. Karkoszka II sewage treatment plant may discharge treated sewage into the Leśnica river on the basis of water permit no. WOŚ.6223-13/08. The permit was issued by the Wodzisław authorities on 29 August 2008 and remains in force until 29 August 2018. The document allows for discharging municipal sewage after treatment to the receiving waters to the maximum volume of 15000 $m^3 \cdot d^{-1}$. The share of industrial sewage in municipal wastewater may be maximum 1152 $m^3 \cdot d^{-1}$. In compliance with the water permit the treatment plant is allowed to discharge treated sewage in to the receiving waters with the following highest values of pollution indices:

BOD_5 – 15 $mgO_2 \cdot dm^{-3}$, COD_{Cr} – 125 $mgO_2 \cdot dm^{-3}$, total suspended solids – 35 $mg \cdot dm^{-3}$, total nitrogen – 15 $mgN \cdot dm^{-3}$, total phosphorus – 2 $mgP \cdot dm^{-3}$.

According to the report of National Programme for Municipal Waste Water Treatment (Krajowy Program… 2003) the actual number of Wodzisław Śląski agglomeration is 59325, of which 56125 (94.6%) are sewer system users. There are 285 household sewage treatment plants operating in the agglomeration area, which are treating domestic sewage from 1140 inhabitants. The amount of municipal sewage generated in the agglomeration equals 3614.9 thousand m^3 per year. The designed throughput of the treatment plant is 15000 $m^3 \cdot d^{-1}$. Total population equivalent number is 93649, of which 11906 is the population equivalent from industry. The rest is the number of inhabitants connected to a sewer system. According to the Water Quality Impact Assessment (2008) the share of accidental waters has been estimated at 20%. The values of the treatment plant hydraulic loading for respective conditions were presented in Table 1.

Table 1. Permissible amount of sewage inflow to a treatment plant (Pozwolenie wodno-prawne 2008)

Parameter	Symbol	Unit	Value
Average daily sewage inflow for dry weather	$Q_{dśr}$	$m^3 \cdot d^{-1}$	15000
Maximum hourly inflow for dry weather	Q_{hmax}	$m^3 \cdot h^{-1}$	1438
Maximum rain inflow to the mechanical part	Q_{dmech}	$m^3 \cdot h^{-1}$	2641
Maximum rain inflow to the biological part	Q_{dbiol}	$m^3 \cdot h^{-1}$	2042

Technological arrangement of the appliances constituting the treatment plant in Wodzisław Śląski was presented in Figure 2.

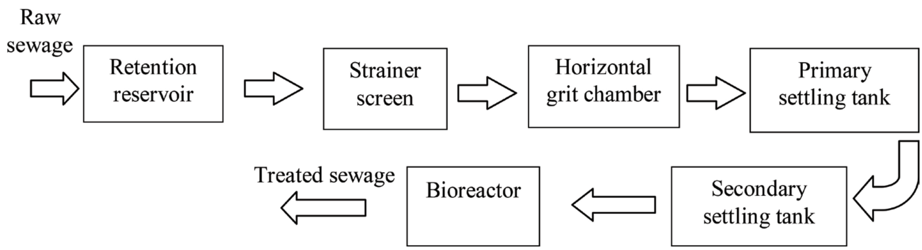

Figure 2. Simplified technological scheme of the sewage treatment plant in Wodzisław Śląski

METHODS

The paper presents an analysis of pollution indices values for raw sewage inflow to the treatment plant, mechanically treated sewage and biologically treated sewage discharged into the receiving waters. Sewage samples were collected once a month, according to standards PN-74/C-04620/11 and PN-EN 25667-2:1999. The following methods were applied to assess the studied indices: BOD_5 – manometric method, COD_{Cr} – dichromate method, total suspended solids – gravimetric method, total nitrogen and total phosphorus – by spectrophotometer. Sewage samples were analyzed in an accredited laboratory. A total of 236 measurement series were conducted for each raw and treated sewage and 41 for biologically treated sewage. The following basic descriptive statistics were determined for the analyzed pollution indices of raw sewage, biologically and mechanically treated sewage: mean value ($\overline{X}$), median (m_e), minimum value (X_{min}), maximum value (X_{max}), standard deviation (σ), coefficient of variation (V_{zm}) and range (R_o). An attempt was made to determine raw sewage susceptibility to biodegradation by means of establishing the basic descriptive statistics for the ratios of selected sewage pollution indices: COD/BOD_5, BOD_5/TN, BOD_5/TP. Susceptibility to biodegradation was determined for raw and mechanically treated sewage. In the paper, raw sewage was divided to groups according to their pollutant concentrations. The basis for determining the values of intervals for respective groups were results of studies conducted by Henze (1982, 1992, 2002) and Chmielowski et al. (2016). Considering the composition of analyzed sewage, five main groups were identified: group 1 – highly concentrated sewage, group 2 – concentrated sewage, group 3 – medium concentrated sewage, group 4 – diluted sewage, group – 5 very diluted sewage. The division of sewage to groups was made for the following pollution indices: BOD_5, COD_{Cr}, total suspended solids, total phosphorus and total nitrogen.

Table 2. Division of raw sewage into groups according to the concentrations of analyzed indices (Chmielowski et al. 2016)

Index name	Raw sewage concentration groups				
	Group 1 highly concentrated sewage	Group 2 concentrated sewage	Group 3 medium concentrated sewage	Group 4 diluted sewage	Group 5 very diluted sewage
BOD_5	$x_i \geq 450$	$450 > x_i \geq 300$	$300 > x_i \geq 200$	$200 > x_i \geq 125$	$x_i < 125$
COD_{Cr}	$x_i \geq 800$	$800 > x_i \geq 635$	$635 > x_i \geq 425$	$425 > x_i \geq 265$	$x_i < 265$
Total suspended solids	$x_i \geq 500$	$500 > x_i \geq 375$	$375 > x_i \geq 245$	$245 > x_i \geq 155$	$x_i < 155$
Total nitrogen	$x_i \geq 90$	$90 > x_i \geq 65$	$65 > x_i \geq 40$	$40 > x_i \geq 25$	$x_i < 25$
Total phosphorus	$x_i \geq 16$	$16 > x_i \geq 12$	$12 > x_i \geq 8$	$8 > x_i \geq 5$	$x_i < 5$

The division of sewage used in the paper and basing on individual pollution indices concentrations was applied after Chmielowski et al. 2016. Table 2 shows the division of raw sewage into groups – due to their concentration.

ANALYSIS OF RESULTS AND DISCUSSION

Table 3 presents basic descriptive statistics for pollution indices in raw sewage entering the sewage treatment plant in Wodzisław Śląski.

Table 3. Basic descriptive statistics for pollution indices in raw sewage flowing into to the treatment plant in Wodzisław Śląski

Descriptive statistics	Symbol	Sewage pollution index				
		BOD_5 [$mgO_2 \cdot dm^{-3}$]	COD_{Cr} [$mgO_2 \cdot dm^{-3}$]	Total suspended solids [$mg \cdot dm^{-3}$]	Total nitrogen [$mgTN \cdot dm^{-3}$]	Total phosphorus [$mgTP dm^{-3}$]
Mean value	$\overline{X}$	267.88	633.09	531.01	83.24	9.76
Median	m_e	260.00	618.00	526.00	80.40	9.18
Minimum value	X_{min}	80.00	248.00	44.00	29.40	1.40
Maximum value	X_{Max}	540.00	1995.00	1432.00	260.00	25.60
Standard deviation	σ	80.38	195.25	205.48	26.95	3.45
Coefficient of variance	V_{zm}	0.30	0.31	0.39	0.32	0.35
Range	R_o	460.00	1747.00	1388.00	230.60	24.20
Number of samples	N	236	237	237	235	236

Basing on the data in Table 3 it may be stated that mean BOD_5 value for raw sewage was not high reaching 267.88 $mgO_2 \cdot dm^{-3}$. Considering the division into groups of sewage concentrations, the value is in group 3 – medium concentrated sewage. Standard deviation on the level of 80.83 $mgO_2 \cdot dm^{-3}$ may suggest a considerable variability of the sewage inflow composition. The reason may be the inflow of infiltration and accidental waters characterized by low values of

BOD_5 index. The issue was already addressed by other authors (Kaczor 2006, Kaczor 2009, Kaczor 2011, Kaczor et al. 2013). On the other hand, high values of this index might be influenced by liquid wastes supplied by gully emptier fleet. Transported sewage reveals very high indices of pollution. The range of BOD_5 values was high and over the whole studied period reached 460.00 $mgO_2 \cdot dm^{-3}$. Similar values were obtained during testing the quality of sewage inflow from the agglomeration sewer system in Kolbuszowa Dolna (Chmielowski et al. 2016). The next analyzed index was $COD_{Cr,}$ whose mean value was 633.09 $mgO_2 \cdot dm^{-3}$ and regarding sewage concentration, it belongs to group 2 – concentrated sewage. The index value revealed a considerable variability, with a range of 1747.0 $mgO_2 \cdot dm^{-3}$. Values similar to the mentioned above were reported by other authors (Chmielowski et al. 2016, Krzanowski and Wałęga 2004, Sikorski 1989, Sikorski 1994a, Sikorski 1994b). Mean concentration of total suspended solids in raw sewage was high – 531.01 $mgO_2 \cdot dm^{-3}$, which allows to classify it to the first group of concentration – highly concentrated sewage. The reason for such high values of total suspended solids in raw sewage may be food leftovers and ground organic waste introduced to the sewer system. Increasingly greater number of households have sinks equipped with food leftovers crushers and in result crushed organic parts get into the sewer system instead to the municipal waste container. Beside the basic indices of sewage pollution, analyzed was also the content of biogenic indices (total nitrogen and total phosphorus). Mean concentration of total nitrogen was registered on the level of 83.24 $mgTN \cdot dm^{-3}$ and total phosphorus 9.76 $mgTPdm^{-3}$. Thus, mean concentrations of total nitrogen were in group 2 of sewage concentration (concentrated sewage). Considering the available references (Jóźwiakowski and Pytka 2010, Chmielowski et al. 2012) it may be concluded that sewage flowing into the treatment plant in Wodzisław Śląski had high pollutant concentrations characterized by a considerable variability of the values of analyzed pollution indices.

MECHANICALLY TREATED SEWAGE

Additional analysis was conducted for the value of the studied indices for pre-treated sewage (after the mechanical part), as presented in Table 4.

Table 4. Basic descriptive statistics for pollution indices in sewage treated mechanically in the sewage treatment plant in Wodzisław Śląski

Descriptive statistics	Symbol	Sewage pollution index				
		BOD_5 [$mgO_2 \cdot dm^{-3}$]	COD_{Cr} [$mgO_2 \cdot dm^{-3}$]	Total suspended solids [$mg \cdot dm^{-3}$]	Total nitrogen [$mgTN \cdot dm^{-3}$]	Total phosphorus [$mgTPdm^{-3}$]
Mean value	$\overline{X}$	155.00	405.88	155.05	74.41	8.33
Median	m_e	150.00	384.00	109.50	69.20	8.02
Minimum value	X_{min}	60.00	210.00	15.00	39.80	3.20
Maximum value	X_{Max}	480.00	805.00	808.00	171.00	18.00
Standard deviation	σ	71.73	119.49	142.94	25.45	3.38
Coefficient of variance	V_{zm}	0.46	0.29	0.92	0.34	0.41
Range	R_o	420.00	595.00	793.00	131.20	14.80
Number of samples	N	41	41	40	39	41

BIOLOGICALLY TREATED SEWAGE

Biologically treated sewage was the last group subjected to the quality analysis, as presented in Table 5.

Low values of BOD_5 values may be stated on the basis of data in Table 5. Mean value of this index was 8.29 $mgO_2 \cdot dm^{-3}$, at the permissible value of 25 $mgO_2 \cdot dm^{-3}$. Even the maximum value from among all 234 collected and analyzed samples did not exceed the permissible value, reaching only 15.00 $mgO_2 \cdot dm^{-3}$. Therefore, it may be said, that the processes occurring in the sewage treatment plant, particularly in the multi-chamber reactor have good conditions. The range between the minimum and maximum value of this index was low – only 14.00 $mgO_2 \cdot dm^{-3}$. Similarly, low value of standard deviation (3.34 $mgO_2 \cdot dm^{-3}$) evidences stable functioning of the treatment plant and its very good exploitation. It is similar in case of the second analyzed index – COD_{Cr}, where its mean value was calculated on the level of 38.00 $mgO_2 \cdot dm^{-3}$. Also in this case, the permissible value (125 $mgO_2 \cdot dm^{-3}$) was not exceeded, whereas the maximum 83.10 $mgO_2 \cdot dm^{-3}$ was registered. Analysis of the data from the sewage treatment plant in Kolbuszowa Dolna yielded similar results (Chmielowski et al. 2016). Total suspended solids were the subsequent analyzed index, for which mean value was on the level of 17.56 mg $\cdot dm^{-3}$. Like in the case of oxygen indices, also for total suspended solids no exceeded permissible values were registered, whereas the maximum value reached the admissible level of 35.0 $mgO_2 \cdot dm^{-3}$. Beside the indices from the basic group, the analyses covered also the indices from the biogenic group. High concentrations of total nitrogen were registered in treated sewage (on average 15.41 $mgTN \cdot dm^{-3}$), which denoted a slightly exceeded permissible value (15 $mgTN \cdot dm^{-3}$). On the other hand, the maximum value for this index over the studied period was 85.10 $mgTN \cdot dm^{-3}$. Elevated values of total nitrogen in treated sewage were noted mainly in winter months (from December to March), characterized by the low air temperature and sewage in the reactor. Bacteria involved in the nitrification and denitrification processes are sensitive to low temperatures.

Table 5. Basic descriptive statistics for pollution indices in sewage treated biologically in the sewage treatment plant in Wodzisław Śląski

Descriptive statistics	Symbol	Sewage pollution index				
		BOD_5 [$mgO_2 \cdot dm^{-3}$]	COD_{Cr} [$mgO_2 \cdot dm^{-3}$]	Total suspended solids [$mg \cdot dm^{-3}$]	Total nitrogen [$mgTN \cdot dm^{-3}$]	Total phosphorus [$mgTPdm^{-3}$]
Mean value	$\overline{X}$	8.29	38.00	17.56	15.41	0.77
Median	m_e	9.00	37.00	18.00	13.70	0.60
Minimum value	X_{min}	1.00	22.00	2.00	4.55	0.03
Maximum value	X_{Max}	15.00	83.10	35.00	85.10	1.96
Standard deviation	σ	3.34	6.63	8.41	10.38	0.54
Coefficient of variance	V_{zm}	0.40	0.17	0.48	0.67	0.70
Range	R_o	14.00	61.10	33.00	80.55	1.93
Permissible value	X_{per}	15.00	125.00	35.00	15.00	2.00
Number of samples	N	234	239	239	239	239

SEWAGE SUSCEPTIBILITY TO BIODEGRADATION

Basic descriptive statistics for selected indices of sewage pollution ratios in Wodzisław Śląski were presented in Table 6. While analyzing the obtained values, it may be stated that average value of COD/BOD_5 ratio for raw sewage in the studied multi-year period was 2.49. After sewage mechanical treatment, the ratio increased to an average value on the level of 2.91. Taking into consideration the literature data (Płuciennik-Koropczuk and Jakubaszek 2012, Klimiuk and Łebkowska 2008) this was medium-degradable sewage.

Table 6. Basic descriptive statistics for selected sewage pollution indices ratios in Wodzisław Śląski

Descriptive statistics	Symbol	COD_{Cr}/BZT_5 [-]		BOD_5/TN [-]		BOD_5/TP [-]	
		Raw sewage	Mechanically treated sewage	Raw sewage	Mechanically treated sewage	Raw sewage	Mechanically treated sewage
Mean value	$\overline{X}$	2.49	2.91	3.40	2.24	29.75	20.62
Median	m_e	2.29	2.81	3.26	2.27	28.02	20.47
Minimum value	X_{min}	1.03	1.18	0.64	0.60	9.90	5.74
Maximum value	X_{Max}	6.93	6.82	8.82	4.57	85.71	47.01
Standard deviation	σ	0.84	1.06	1.21	0.98	11.32	9.72
Coefficient of variation	V_{zm}	0.34	0.36	0.36	0.44	0.38	0.47
Range	R_o	5.90	5.65	8.19	3.97	75.81	41.27
Number of samples	N	236	41	234	39	235	41

Mean values of COD_{Cr} and BOD_5 for individual months over the 2010-2015 period were compiled in Figure 3.

It may be seen that sewage flowing into the treatment plant in Wodzisław Śląski revealed a good susceptibility to biodegradation. According to Henze (2002) COD/BOD_5 ratio below 2.2 classifies sewage as susceptible to biodegradation. For the raw sewage the highest mean value of COD/BOD_5 ratio was observed in April (3.0), whereas the lowest was determined for December (2.2). These values are close to optimal (below 2.2) sewage susceptibility to biodegradation. Slightly worse situation has been observed for mechanically treated sewage, where the highest mean value of COD/BOD_5 ratio was observed in

November (4.6), whereas the lowest was noted for December (2.2). The main biological processes occur in the biological reactor, therefore sewage susceptibility to biodegradation should be investigated in pre-treated sewage (after mechanical treatment). Analysis of the literature data (Płuciennik-Koropczuk and Jakubaszek 2012, Klimiuk and Łebkowska 2008) shows that sewage reaching the treatment plant is medium susceptible to pollutant biodegradation. Mean values of BOD_5/TN ratio in raw sewage in the individual months of the year were presented in Figure 4.

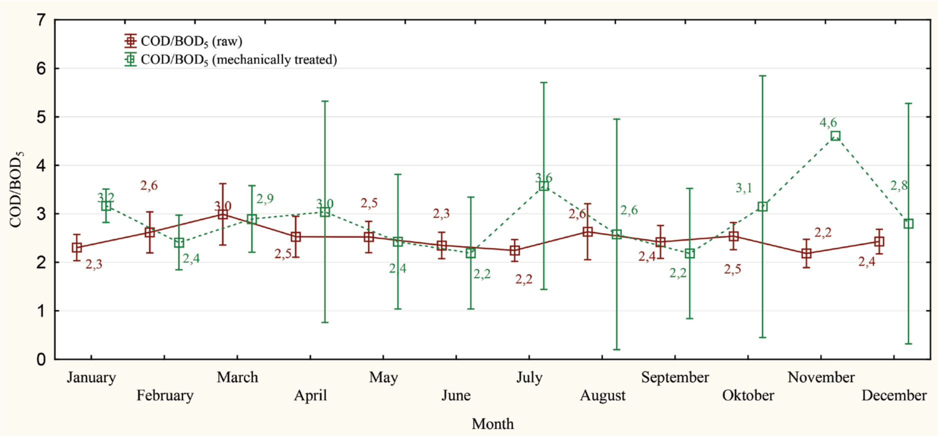

Figure 3. List of mean values of COD_{Cr} and BOD_5 ratios for individual months over the 2010-2015 period

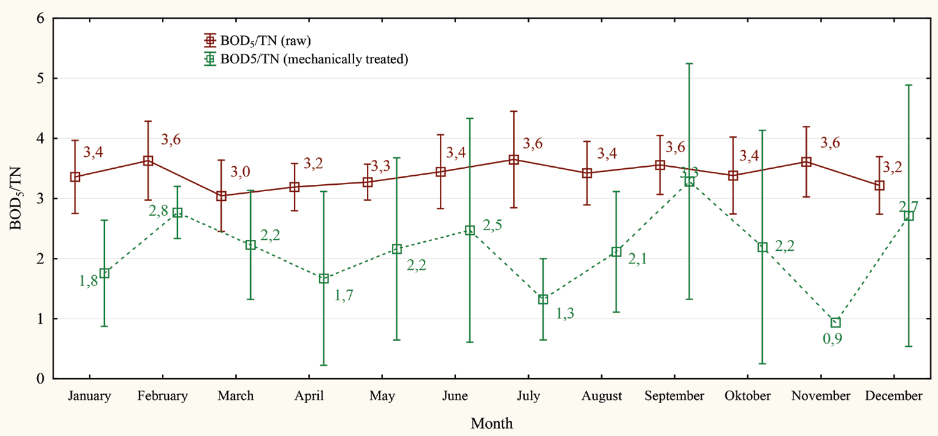

Figure 4. List of mean values of BOD_5/TN ratio in the individual months over the 2010-2015 period

While analyzing the data in Figure 4, it may be noticed that the sewage flowing into the treatment plant in Wodzisław Śląski had disadvantageous BOD_5 to total nitrogen ratio. According to the literature (Henze 2002), a preferable value of BOD_5/TN is higher than 5. For raw sewage, on average BOD_5/TN values fluctuated from 3.0 in March to 3.6 in July. These values were slightly below the recommended one (5.0). Therefore, it may be stated that raw sewage was characterized by little favourable BOD_5/TN ratio. The situation was even worse for pre-treated sewage (after mechanical treatment). Mean value of BOD_5/TN ratio fluctuated from 0.9 in November to 3.2 in September. A low susceptibility to nitrogen removal may be stated for the sewage flowing to the reactor. Mean values of BOD_5/TP ratio in raw sewage in the individual months of the 2010-2015 period were presented in Figure 5.

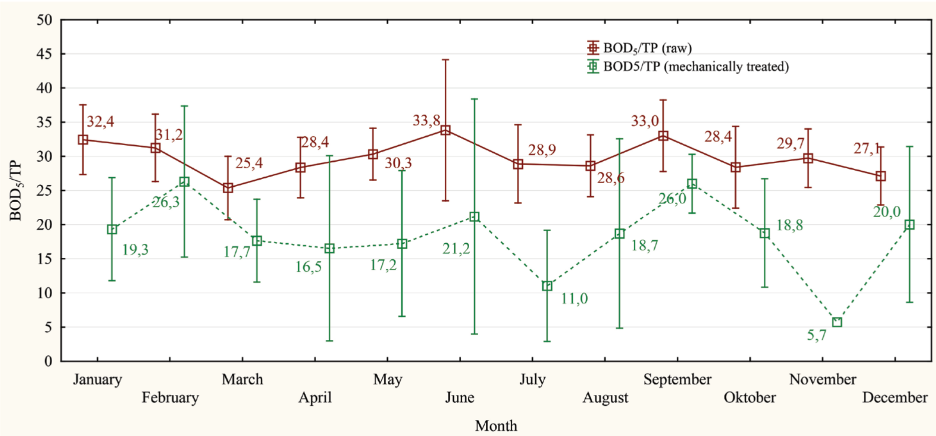

Figure 5. List of mean values of BOD_5/TP ratio in the individual months over the 2010-2015 period

The analysis of BOD_5/TP ratio revealed that raw sewage was characterized by its high value, on the level above the minimum recommended, i.e. 25. The highest value of BOD_5/TP ratio was registered in June (33.8), whereas the lowest in March (25.4). It was much worse in case of pre-treated sewage, where the values of BOD_5/TP ratio were noted on a much lower level. Removal of total phosphorus occurs mainly in the biological part of the treatment plant, so it is crucial that the proper proportions of organic carbon and phosphorus compounds be maintained in the sewage. Figure 5 shows clearly that to improve the situation, organic carbon compounds should be supplied from an external source after the mechanical part.

SUMMARY AND RESULTS

The analysis of pollution indices values of the sewage inflow and outflow from the sewage treatment plant in Wodzisław Śląski in Śląskie province was presented in the paper. The following conclusions and statements may be drawn on the basis of conducted analysis of the research results:

- Sewage susceptibility to biodegradation expressed by the COD/BOD_5 ratio was on a good level. On the other hand BOD_5/TN and BOD_5/TP ratios were below the optimum value. It may cause problems with nitrogen and biogenic compounds removal from sewage through biological processes. The confirmation may be seen in frequently exceeded admissible TN value in biologically treated sewage.
- In order to improve the situation, organic carbon compounds from external source should be added after the mechanical part, which would allow to maintain better proportions between phosphorus compounds in sewage before the biological part.
- Mean values of the analyzed indices in raw sewage were as follows: BOD_5 – 267.88 $mgO_2 \cdot dm^{-3}$, COD – 633.09 $mgO_2 \cdot dm^{-3}$, total suspended solids – 531.01 $mg \cdot dm^{-3}$, total nitrogen – 83.24 $mgTN \cdot dm^{-3}$ and total phosphorus – 9.76 $mgTPdm^{-3}$. These values are approximate to those stated in the literature on domestic sewage.
- Raw sewage flowing into the treatment plant in Wodzisław Śląski by a sewerage system revealed diversified values of the analyzed pollution indices. It has been evidenced by high values of range for individual indices: BOD_5 – 460.00 $mgO_2 \cdot dm^{-3}$, COD – 1747.00 $mgO_2 \cdot dm^{-3}$, total suspended solids – 1388.00 $mg \cdot dm^{-3}$, total nitrogen – 230.60 $mgTN \cdot dm^{-3}$ and total phosphorus – 24.,20 $mgTPdm^{-3}$. Such considerable range of values of analyzed indices in raw sewage may result on one hand from the inflow of accidental or infiltration waters to the sewer system, which cause dilution of domestic sewage, an on the other extremely high values of the indices may result from the presence of liquid wastes supplied by gully emptier fleet.
- Considering the raw sewage concentrations, the most common groups were: group 3 (medium concentrated sewage) due to BOD_5 and total nitrogen (TN), group 2 (diluted sewage) – due to COD and total phosphorus (TP) concentrations. High concentration of total suspended solids is worth attention, its mean value fell in the first group of concentration (highly concentrated sewage).
- Mean values of the analyzed indices in the treated sewage were as follows: BOD_5 – 267.88 $mgO_2 \cdot dm^{-3}$, COD – 633.09 $mgO_2 \cdot dm^{-3}$, total suspended solids – 531.01 $mg \cdot dm^{-3}$, total nitrogen – 83.24 $mgTN \cdot dm^{-3}$

and total phosphorus – 976 mg TPdm^{-3}. It should be considered that sewage leaving the treatment plant in Wodzisław Śląski was characterized by low values of pollution indices, which evidences properly occurring processes. Only total nitrogen value was exceeded several times during the investigated period.

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