FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2014, 309 (29), 41–52

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EVALUATION OF EFFECTIVENESS OF MUNICIPAL WASTEWATER TREATMENT IN COMPARISON WITH THE CLASSIFICATION OF THE CONDITION OF HOMOGENOUS SURFACE WATERS

OCENA EFEKTYWNOŚCI OCZYSZCZANIA ŚCIEKÓW KOMUNALNYCH W PORÓWNANIU Z KLASYFIKACJĄ STANU JEDNOLITYCH CZĘŚCI WÓD POWIERZCHNIOWYCH

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Streszczenie. Przedmiotem opracowania jest ocena stopnia oczyszczenia ścieków w komunalnej oczyszczalni ścieków w Nowogardzie na podstawie wartości następujących parametrów chemicznych i fizykochemicznych: zawiesina, biochemiczne zapotrzebowanie tlenu (BZT_5), chemiczne zapotrzebowanie tlenu (ChZT), ogólna zawartość azotu i fosforu. Do analizy wybrane zostały parametry charakteryzujące zanieczyszczenie ścieków, które w największym stopniu wpływają na stan odbiornika, do którego odprowadzane są ścieki. W procesie oczyszczania ścieków w oczyszczalni ścieków w Nowogardzie redukcja zanieczyszczeń, określonych przez zawartość w ściekach zawiesiny, fosforu ogólnego, azotu ogólnego i wskaźników BZT i ChZT, była powyżej 90%. Przyjmując kryteria podane w Rozporządzeniu Ministra Środowiska w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych z 2011 roku średnia zawartość zawiesiny w ściekach oczyszczonych w 2012 roku umożliwia zakwalifikować je do wód klasy I. Wartość stosunku ChZT : N w 2011 i 2012 roku wskazują na stabilizację składu chemicznego analizowanych ścieków oraz odpowiednie warunki do prawidłowego przebiegu procesu denitryfikacji podczas ich oczyszczania. Powyższe wyniki stanowią podstawę do oceny dużej stabilności odnośnie pracy analizowanej oczyszczalni ścieków w Nowogardzie.

Key words: biochemical oxygen demand, chemical oxygen demand, total nitrogen and phosphorus, total suspension, wastewater treatment.
Słowa kluczowe: azot ogólny, biochemiczne zapotrzebowanie na tlen, chemiczne zapotrzebowanie na tlen, fosfor ogólny, oczyszczanie ścieków, zawiesina ogólna.

INTRODUCTION

On the 5th of April 2011 the Notice of the Minister of Environment was issued announcing the revision of the national programme for municipal waste water treatment. It is predicted according to the Accession Treaty that from the 31st of December 2015 the provisions of the UE

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law will be fully in force in Poland. The basic instrument of implementation of the provisions of the Council Directive 91/271/EEC is the National Programme for Municipal Waste Water Treatment. The aim of this programme is to limit the discharge of insufficiently treated wastewater and the protection of the aquatic environment against their negative effects. The aim is to be accomplished by means of realisation of the investments included in the programme. The programme is a strategic document which evaluates the requirements and defines the actions to be taken in order to provide urban and rural agglomerations of population equivalent over 2000 with sewerage systems and municipal wastewater treatment plants (Monitor Polski 2011 r., nr 62, poz. 589).

The second document, which defines to what extent the pollution from municipal wastewater should be eliminated to the level not causing a risk for the environment when introduced to it, is the Regulation of the Minister of the Environment of 28 January 2009 amending the regulation on conditions to be met for the introduction of sewage into water or ground and on substances particularly harmful to the aquatic environment (DzU z 2009 r., nr 27, poz. 169).

In 2004 the Regulation of the Minister of Environment of 11 February was issued on the classification for presenting the condition of surface and underground waters, method of monitoring, interpreting the results and presenting the condition of the waters in question. This classification introduces the notion of quality classes: I, II, III, IV and V, and identifies admissible values of physiochemical and chemical indices of water for each of the classes (DzU z 2004 r., nr 32, poz. 284).

In 2010 the Regulation of the Minister of Environment was issued on the classification for presenting the condition of homogenous surface water and environmental quality standards for priority substances (DzU z 2011 r., nr 257, poz. 1545). This regulation gives special consideration to biological and hydro-morphological elements. Values regarding the chemical and physiochemical parameters are usually given only for the first two classes. Therefore, the assessment of the effectiveness of municipal wastewater treatment plant by comparing obtained data with that included in the aforementioned regulation gives better evaluation of the degree of wastewater purification.

The aim of this study is to assess the degree of wastewater purification in the municipal wastewater treatment plant in Nowogard on the basis of the following chemical and physiochemical parameters: suspension, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and total contents of nitrogen and phosphorus. The analysis is based on the selected parameters of pollution of wastewater which to the greatest degree affect the condition of the receiver to which wastewater is discharged. The aim of this study is also to assess stability of the analyzed treatment despite the uneven flow of sewage

MATERIAL AND METHODS

Location of the wastewater treatment plant

Nowogard is a city located in the north-west of Poland, in Zachodniopomorskie Voivodeship in the eastern part of Goleniów County, 64 km to the north-east of Szczecin. According to data of the Central Statistical Office in 2010 (Mały Rocznik Statystyczny Polski 2012) the city was inhabited by 16816 residents.

The municipal wastewater treatment plant is located in the north-west periphery of the city in Zamkowa Street. The wastewater treatment plant in Nowogard is operated by Water and Sanitary Service Company Ltd. in Nowogard.

Treatment was built in 1972. Expansion and modernization of the wastewater treatment plant started 1993 and was put into operation in 1996. The modernized technological system built bioreactor and used the second stage biological treatment based on activated sludge low loaded. Also performed two new secondary clarifiers and sand grit. Currently the wastewater treatment plant includes: transported wastewater disposal station, wastewater grating, two horizontal grit chambers, raw wastewater pumping station, two Imhoff tanks, installation for dosing of PIX coagulant, three-phase bioreactor, two secondary sedimentation radial tanks and sludge treatment facility.

In front of the raw wastewater pumping station there is a measuring channel where the daily raw wastewater effluent flow is measured. Because of the combined character of the wastewater system in Nowogard, the amount of influent and treated wastewater fluctuates wildly which periodically causes difficulties with maintenance and can result in disturbances in the operation of the wastewater treatment plant. Water and Sanitary Service Company Ltd. in Nowogard has the relevant permit required by Water Management Act for operating the wastewater treatment plant and discharging wastewater to Wojcieszyński Channel and further to the Sąpólna river. This river runs through Nowogard Plain and is a left-bank tributary of the Ukleja river. The length of the watercourse is 60.08 km and the area of the basin is 87.7 km². The name “Sąpólna” was introduced in 1948 in the place of the previous German name “Zampel” (Monitor Polski 1948 r., nr 78, poz. 692).

On the basis of the permit required by Water Management Act valid for the wastewater treatment plant, the admissible concentrations of pollutants are as follows: total suspension – 35 mg $\cdot$ dm^{-3}, BOD_5 – 15 mg O_2 $\cdot$ dm^{-3}, COD_{Cr} – 125 mg O_2 $\cdot$ dm^{-3}, total nitrogen – 15 mg N $\cdot$ dm^{-3}, total phosphorus – 2 mg P $\cdot$ dm^{-3}.

Methodology of analysis

The analyses of the physiochemical and chemical parameters of wastewater were done in a laboratory of Water and Sanitary Service Company Ltd. in Nowogard. The laboratory has the accreditation certificate issued by Polish Centre for Accreditation – No AB 828.

The contents of total suspension in wastewater was calculated using the gravimetric method with the use of filtration with fibreglass drain (PN-EN 872:2007). Biochemical oxygen demand (BOD_5) was marked using electrochemical method (PN-EN 1899-1:2002) and chemical oxygen demand (COD_{Cr}) by spectrophotometric method (PN-ISO 15705:2005). The spectrophotometric method was also used to mark the concentration of total nitrogen and phosphorus (Procedura badawcza PB-04 issue 1 of 20.11.2006 and PB-02 issue 1 of 14.11.2006). In the processing of the obtained results the variance analysis and confidence half-intervals calculated with the use of Tukey’s test at the significance level $\alpha = 0.05$ (Statistica 07 software) were used. The following parameters were adopted: I – years (Y) and II – time of the analysis (T).

RESULTS AND DISCUSSION

Characteristics of discharged wastewater

The average daily effluent of wastewater from wastewater treatment plant was 3853 m³. The other parameters given in kg per 24-hours amounted to: total suspension – 52.0, BOD_5 – 38.5, COD – 131.0, total nitrogen – 15.8, total phosphorus – 4.81 (www.wios.szczecin.pl).

Suspension

Total suspension in wastewater characterizes the amount of solid substance composed of organic and inorganic compounds.

The contents of suspension in raw wastewater supplied to the wastewater treatment plant varied in both years and ranged from 130.0 to 484.0 mg · dm^{-3}. As a result of wastewater treatment process, the contents of suspension amounted to the range from 9.7 to 58.0 mg · dm^{-3} (Table 1). Comparison of the data from the two years shows that effectiveness of wastewater treatment was higher in 2012 when the suspension was eliminated from wastewater in 94.8% and with the exception of October its amount did not exceed the admissible standards given in the Regulation of the Minister of Environment (DzU z 2009 r., nr 27, poz. 169). Classification of wastewater discharged in 2012 in terms of suspension contents and on the basis of the limit values of water quality index and surface water quality classes according to the Regulation of the Minister of the Environment of 2004 (DzU z 2004 r., nr 32, poz. 284) marks wastewater as belonging to I, II and II class depending on the results from individual months.

Table 1. The contents of suspension in raw and treated wastewater in the years 2011 and 2012 (mg · dm^{-3})

Tabela 1. Zawartość zawiesiny w ściekach surowych i oczyszczonych w 2011 i 2012 roku (mg · dm^{-3})

Year – Rok 2011				Year – Rok 2012				Average reduction in 2 years Średnia redukcja w dwóch latach (%)
Date Data	Wastewater – Ścieki		Reduction Redukcji (%)	Date Data	Wastewater – Ścieki		Reduction Redukcji (%)	
	raw świeże	treated oczysz-czone			raw świeże	treated oczysz-czone		
20.01	232.5	50.0	78.5	23.01	137.0	14.6	89.3	83.9
10.02	152.0	58.5	61.5	29.02	346.0	18.8	94.6	78.1
01.03	167.0	23.6	85.9	23.03	430.0	13.0	97.0	91.5
07.04	313.0	20.2	93.5	13.04	171.3	34.7	79.7	86.6
25.05	298.0	38.6	87.0	10.05	1706.0	14.3	99.2	93.1
24.06	231.0	26.4	88.6	05.06	244.0	18.0	92.6	90.6
26.07	160.0	13.6	91.5	05.07	223.0	16.5	92.6	92.1
25.08	258.0	26.8	89.6	02.08	130.0	20.0	84.6	87.1
22.09	484.0	11.4	97.6	06.09	172.0	9.7	94.4	96.0
26.10	284.3	20.8	92.7	31.10	156.0	34.0	78.2	85.5
25.11	211.3	50.8	76.0	09.11	394.0	25.0	93.7	84.9
15.12	463.4	25.6	94.5	20.12	163.8	18.4	88.8	91.7
Average Średnia	271.0	30.5	85.9	Average Średnia	373.6	19.7	94.8	88.4
$LDS_{0,05}$ $NIR_{0,05}$	Y* – n.s.**; T*** – n.s.; V% = 3.50							

* – Years – Lata.
** – n.s. – no signification – nie istotne.
*** – Time – Czas.

Mean suspension content in 2012 (19.7 mg · dm^{-3}) classifies wastewater as class II (DzU z 2004 r., nr 32, poz. 284). Adopting the criteria given in the Regulation of the Minister of Environment on the classification of the condition of homogenous surface waters of 2011 (DzU z 2011 r., nr 257, poz. 1545), the mean contents of suspension in treated wastewater in 2010 classifies it as belonging to class I.

A study on the effectiveness of communal wastewater treatment plants located in Wielkopolska by Przybyła et al. (2009) indicates that according to regulations as in force at present the concentration of suspension in discharged wastewater should not exceed 35 ÷ 40 mg · dm^{-3}, and the minimum level of elimination of pollution should be over 90% – overall, the requirements were met in case of the wastewater treatment plants in question.

Biochemical oxygen demand – BOD_5 (mg O_2 · dm^{-3})

Biochemical oxygen demand is a contractual index determining the amount of oxygen needed for oxidation of organic compounds by microorganisms. The value of BOD_5 index in raw wastewater ranged from 200 to 591 mg O_2 · dm^{-3}. As a result of wastewater treatment in most cases the values of BOD_5 decreased to a dozen or so (mg O_2 · dm^{-3}), and the mean percentage of reduction from the period of two years was 96.7% (Table 2). The assessment of wastewater discharged in 2011 in terms of BOD_5 and on the basis of the limit values of surface water quality index according to the Regulation of the Minister of Environment of 2004 classifies them as belonging to class V, whereas in 2012 the value of BOD_5 of the analysed wastewater classifies it as water of class IV (DzU z 2004 r., nr 32, poz. 284). The Regulation of the Minister of Environment of 2011 on the classification of the condition of homogenous surface waters (DzU z 2011 r., nr 257, poz. 1545), gives BOD_5 values regarding only classes I and II and their range (to 6 mg O_2 · dm^{-3}) is smaller than that of wastewater in question.

Table 2. The contents of BOD_5 in raw and treated wastewater in the years 2011 and 2012 (mg O_2 · dm^{-3})
Tabela 2. Zawartość BZT_5 w ściekach surowych i oczyszczonych w 2011 i 2012 roku (mg O_2 · dm^{-3})

Year – Rok 2011				Year – Rok 2012				Average reduction in 2 years Średnia redukcja w dwóch latach (%)
Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	
20.01	320.0	19.0	94.1	23.01	226.0	6.0	97.3	95.7
10.02	200.0	22.0	89.0	29.02	454.0	8.6	98.1	93.6
01.03	213.0	10.0	95.3	23.03	591.0	8.4	98.6	97.0
07.04	580.0	11.0	98.1	13.04	276.0	14.3	94.8	96.5
25.05	508.0	8.0	98.4	10.05	237.0	12.5	94.7	96.6
24.06	338.0	10.0	97.0	05.06	271.0	11.0	95.9	96.5
26.07	491.0	11.7	97.6	05.07	257.0	5.2	98.0	97.8
25.08	357.0	3.9	98.9	02.08	242.0	6.0	97.5	98.2
22.09	516.0	4.0	99.2	06.09	303.0	4.1	98.6	98.9
26.10	297.0	8.0	97.3	31.10	254.0	5.4	97.9	97.6
25.11	390.0	41.0	89.5	09.11	310.0	5.6	98.2	93.9
15.12	408.0	7.0	98.3	20.12	401.0	6.8	98.3	98.3
Average Średnia	384.7	13.0	96.6	Average Średnia	318.5	7.8	97.5	96.7
$LDS_{0,05}$ $NIR_{0,05}$	Y* – n.s.**; T*** – n.s. V% = 3.00							

* – Years – Lata.
** – n.s. – no signification – nie istotne.
*** – Time – Czas.

Chemical oxygen demand – COD_{Cr} (mg $O_2 \cdot dm^{-3}$)

Chemical oxygen demand COD_{Cr} is a contractual index determining the amount of oxygen used to oxidise organic and selected inorganic compounds in wastewater. The most commonly used oxidant in terms of wastewater analysis is potassium dichromate. In raw wastewater the values of COD index ranged greatly from 454.0 to 1156.0 mg $O_2 \cdot dm^{-3}$. In 2012 the diversification of the concentration of wastewater regarding COD was smaller. For example, a study concerning the effectiveness of communal wastewater treatment plants located in Wielkopolska by Przybyła et al. (2009) states that COD values were more varied and ranged from 2478 to almost 7500 mg $O_2 \cdot dm^{-3}$. As a result of wastewater treatment in most cases the values of COD decreased to several dozens (mg $O_2 \cdot dm^{-3}$), and the mean percentage of reduction from two years was 93.2% (Table 3).

Table 3. The contents of COD in raw and treated wastewater in the years 2011 and 2012 (mg $O_2 \cdot dm^{-3}$)
Tabela 3. Zawartość ChZT w ściekach surowych i oczyszczonych w 2011 i 2012 roku (mg $O_2 \cdot dm^{-3}$)

Year – Rok 2011				Year – Rok 2012				Average reduction in 2 years Średnia redukcja w dwóch latach (%)
Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	
20.01	699.0	74.0	89.4	23.01	712.0	30.0	95.8	92.6
10.02	454.0	89.0	80.4	29.02	905.0	26.0	97.1	88.8
01.03	633.0	46.0	92.7	23.03	899.0	45.0	95.0	93.9
07.04	1043.0	38.0	96.4	13.04	596.0	75.0	87.4	91.9
25.05	1156.0	60.0	94.8	10.05	938.0	76.0	91.9	93.4
24.06	641.0	61.0	90.5	05.06	649.0	89.0	86.3	88.4
26.07	536.0	41.0	92.4	05.07	853.0	25.0	97.1	94.8
25.08	776.0	33.0	95.7	02.08	598.0	52.0	91.3	93.5
22.09	1113.0	37.0	96.7	06.09	469.0	37.0	92.1	94.4
26.10	743.0	52.0	93.0	31.10	565.0	50.0	91.2	92.1
25.11	698.0	150.0	78.5	09.11	635.0	32.0	95.0	86.8
15.12	989.0	56.0	94.3	20.12	600.0	52.0	91.3	92.8
Average Średnia	790.1	61.4	92.2	Average Średnia	701.6	40.4	94.2	93.2
$LDS_{0,05}$ $NIR_{0,05}$	Y* – n.s.**; T*** – n.s.; V% = 6.40							

* – Years – Lata.
** – n.s. – no signification – nie istotne.
*** – Time – Czas.

The assessment of wastewater discharged in 2011 and 2012 in terms of COD and on the basis of the limit values of surface water quality index according to the Regulation of the Minister of Environment of 2004 classifies them as belonging to class VI and V (DzU z 2004 r., nr 32, poz. 284). The Regulation of the Minister of Environment of 2011 on the classification of the condition of homogenous surface waters (DzU z 2011 r., nr 257, poz. 1545), gives COD values regarding only classes I and II which are higher in comparison with data of 2004 and their range (to 30 mg $O_2 \cdot dm^{-3}$) is smaller than that of wastewater in question.

Total nitrogen content (mg N · dm^{-3})

Total nitrogen and phosphorus are eutrophication indices which characterize the level of wastewater pollution to the greatest extent. Nitrogen in wastewater is mainly contained in organic compounds an in the form of ammonium salts. Elimination of nitrogen is one the most important issues in the process of wastewater treatment (Kłodowska et al. 2013).

Kulikowska et al. (2009) states that the denitrification process occurs without disruptions if the ratio COD:N is at the level of 5–10. The value of the ratio COD : N in the analysed wastewater in both years was 7.6 which points to stabilisation of the chemical composition of wastewater in question and to adequate conditions for denitrification process. The contents of nitrogen in raw wastewater in both years was on the similar level and in the range from 70.8 to 169.0 mg N · dm^{-3}. As a result of wastewater treatment nitrogen was eliminated in 90%. Treated wastewater in most of the times contained nitrogen below 10 mg N · dm^{-3} (Table 4).

Table 4. The contents of total nitrogen in raw and treated wastewater in the years 2011 and 2012 (mg N · dm^{-3})

Tabela 4. Zawartość azotu ogólnego w ściekach surowych i oczyszczonych w 2011 i 2012 roku (mg N · dm^{-3})

Year – Rok 2011				Year – Rok 2012				Average reduction in 2 years Średnia redukcja w dwóch latach (%)
Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	
20.01	70.8	14.5	79.5	23.01	81.1	9.3	88.5	84.0
10.02	74.6	15.5	79.2	29.02	94.6	8.5	91.0	85.1
01.03	82.3	8.8	89.3	23.03	115.5	14.6	87.4	88.4
07.04	103.6	11.7	88.7	13.04	94.0	15.6	83.4	86.1
25.05	169.0	6.4	96.2	10.05	88.8	14.8	83.3	89.8
24.06	121.2	7.4	93.9	05.06	82.8	9.7	88.3	91.1
26.07	115.0	9.3	91.9	05.07	83.1	7.9	90.5	91.2
25.08	90.0	8.9	90.1	02.08	79.9	8.5	89.4	89.8
22.09	96.2	9.4	90.2	06.09	84.4	7.1	91.6	90.9
26.10	125.1	8.2	93.4	31.10	132.0	8.2	93.8	93.6
25.11	105.8	7.0	93.4	09.11	92.7	8.3	91.0	92.2
15.12	91.9	8.1	91.2	20.12	85.9	5.7	93.4	92.3
Average Średnia	103.8	9.6	90.8	Average Średnia	92.9	9.8	89.0	89.5
$LDS_{0,05}$ $NIR_{0,05}$	Y* – n.s.**; T*** – n.s.; V% = 5.10							

* – Years – Lata.
** – n.s. – no signification – nie istotne.
*** – Time – Czas.

The assessment of treated wastewater discharged in 2011 and 2012 in terms of nitrogen content and on the basis of the limit values of water quality index according to the Regulation of the Minister of Environment of 2004 classifies them as belonging to class II and III (DzU z 2004 r., nr 32, poz. 284). The Regulation of the Minister of Environment of 2011 on the classification of the condition of homogenous surface waters (DzU z 2011 r., nr 257, poz. 1545), gives total nitrogen content values regarding only classes I and II and they are higher in comparison with values from 2004. Mean total nitrogen contents in treated wastewater in both years classifies it as belonging to class II.

Total phosphorus content (mg P · dm^{-3})

Phosphorus is present in wastewater in the form of phosphates, polyphosphates and organic compounds. In the process of wastewater treatment part of phosphorus is accumulated by microorganisms contained in wastewater as well as precipitated in the form of sparingly soluble compounds (Wysocka et al. 2013).

The results of laboratory analyses indicate high effectiveness of phosphorus compounds elimination. The concentration of phosphorus in treated wastewater was much lower than their admissible content which is 2.0 mg P · dm^{-3}. Total phosphorus content in treated wastewater in both years was on the similar level and within the range from 0.47 to 1.70 mg P · dm^{-3}, and on average 0.82 and 0.89 mg P · dm^{-3} (Table 5). The assessment of treated wastewater discharged in 2011 and 2012 in terms of total phosphorus content and on the basis of the limit values of water quality index according to the Regulation of the Minister of Environment of 2004 classifies them as belonging to class IV (DzU z 2004 r., nr 32, poz. 284). The Regulation of the Minister of Environment of 2011 on the classification of the condition of homogenous surface waters (DzU z 2011 r., nr 257, poz. 1545), gives total phosphorus content values regarding only classes I and II, corresponding to those from 2004 and their range (to 0.4 mg P · dm^{-3}) is lower than that of the wastewater in question.

Table 5. The contents of total phosphorus in raw and treated wastewater in the years 2011 and 2012 (mg P · dm^{-3})

Tabela 5. Zawartość fosforu ogólnego w ściekach surowych i oczyszczonych w 2011 i 2012 roku (mg P · dm^{-3})

Year – Rok 2011				Year – Rok 2012				Average reduction in 2 years Średnia redukcja w dwóch latach (%)
Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	Date Data	Wastewater Ścieki raw świeże	Wastewater Ścieki treated oczysz-czone	Reduction Redukcji (%)	
20.01	8.8	0.99	88.8	23.01	9.33	0.47	95.0	91.9
10.02	7.9	1.08	86.3	29.02	10.70	0.92	91.4	88.9
01.03	8.6	0.54	93.7	23.03	12.30	0.43	96.5	95.1
07.04	12.2	0.66	94.6	13.04	9.88	1.10	88.9	91.8
25.05	21.7	0.94	95.7	10.05	11.07	1.70	84.6	90.2
24.06	11.4	0.66	94.2	05.06	10.20	0.55	94.6	94.4
26.07	8.5	0.61	92.8	05.07	10.30	0.51	95.0	93.9
25.08	10.9	0.80	92.7	02.08	9.00	1.20	86.7	89.7
22.09	12.8	0.55	95.7	06.09	12.70	0.79	93.8	94.8
26.10	12.9	0.67	94.8	31.10	13.67	1.32	90.3	92.6
25.11	12.5	1.52	87.8	09.11	12.07	0.94	92.2	90.0
15.12	11.3	0.78	93.1	20.12	13.30	0.78	94.1	93.6
Average Średnia	11.6	0.82	92.9	Average Średnia	11.20	0.89	92.1	92.5
$LDS_{0,05}$ $NIR_{0,05}$	Y* – n.s.**; T*** – n.s.; V% = 1.50							

* – Years – Lata.
** – n.s. – no signification – nie istotne.
*** – Time – Czas.

SUMMARY

1. In wastewater treatment process in the plant in Nowogard the reduction of pollution determined by the contents of suspension, total phosphorus, total nitrogen, BOD and COD indices was over 90%.

2. The classification of treated wastewater in the years 2011 and 2012 in terms of the contents of the analysed indices and on the basis of limit values of water quality index of the Regulation of the Minister of Environment of 2004 classifies it as belonging to class I, II, IV and V depending on the given parameter.

3. Adopting the criteria included in the Regulation of the Minister of Environment of 2011 on the classification of the condition of homogenous surface waters, the mean suspension content in treated wastewater in 2012 classifies it as water of class I.

4. The values of COD:N ratio in the years 2011 and 2012 indicates stabilisation of the chemical composition of analysed wastewater and adequate conditions for denitrification process during wastewater treatment.

5. The lack of significant differences between the levels of reduction of pollution (suspension, total phosphorus, total nitrogen, BOD and COD indices) in the time of sampling and in the years under analysis as well as their low coefficients of variation (1.5–6.4) indicating high accuracy of statistical analyses demonstrate high stability of the operation of the wastewater treatment plant in Nowogard.

REFERENCES

Kłodowska I., Rodziewicz J., Janczukowicz W., Filipkowska U. 2013. Wpływ procesu elektrochemicznego na stężenie azotu ogólnego i ortofosforanów w odpływie z reaktora z unieruchomiona błoną biologiczną [Effect of Electrochemical Process on the Concentration of Total Nitrogen and Orthophosphates in the Outflow from the Reactor with Immobilized Biofilm]. Rocznik Ochrona Środowiska, Ann. Set Environ. Protect., T. 15, cz. 15. 1952–1964. [in Polish.]

Kulikowska D., Drzewicki A., Tomczykowska M. 2009. Intensyfikacja procesu denitryfikacji ścieków na przykładzie oczyszczalni w Tyrowie. Śr. Czas. Techn. Wydaw. Politechniki Krakowskiej. Z 11. 111–120. [in Polish.]

Mały Rocznik Statystyczny Polski 2013. Wydaw. Główny Urząd Statystyczny Warszawa [Concise Statistical Yearbook of Poland 2013 ed. Central Statistical Office Warsaw 2013]. [in Polish.]

Monitor Polski 1948 r., nr 78, poz. 692. Rozporządzenie Ministrów Administracji Publicznej i Ziem Odzyskanych z dnia 1 października 1948 o przywróceniu i ustaleniu urzędowych nazw miejscowości [Regulation of Ministers of Public Administration and the Recovered Territories on October 1, 1948 to restore and establish official names of places]. [in Polish.]

Monitor Polski 2011 r., nr 62, poz. 589. Obwieszczenie Ministra Środowiska z dnia 5 kwietnia 2011 r. w sprawie ogłoszenia aktualizacji krajowego programu oczyszczania ścieków komunalnych [The Notice of the Minister of Environment on the 5th of April 2011 was issued announcing the revision of the national programme for municipal waste water treatment]. [in Polish.]

PN-EN 1899-1. 2002. Jakość wody – Oznaczanie biochemicznego zapotrzebowania tlenu po n dniach (BZTn) – Część 1: Metoda rozcieńczania i szczepienia z dodatkiem allilotiomocznika [Determination of biochemical oxygen demand after n days (BOD) – Part 1: Method of dilution and vaccination with the addition of thiosinamine]. [in Polish.]

PN-ISO 15705. 2005. Norma ISO 15705. Jakość wody – Oznaczanie indeksu chemicznego zapotrzebowania tlenu [Water quality - Determination of the chemical oxygen demand index]. [in Polish.]

PN-EN 872:2007 + Ap1. 2007. Oznaczanie zawiesin. Metoda z zastosowaniem filtracji przez sączki z włókna szklanego [Water quality – Determination of suspensions. Method by filtration through glass fiber filters]. [in Polish.]

Procedura badawcza PB-02 wyd. 1 z dnia 14.11.2006, Polskie Centrum Akredytacji, Warszawa – Stężenie fosforu ogólnego. Metoda spektrofotometryczna [Research procedure PB-02 issue 1 of 14.11.2006, Polish Accreditation Centre, Warsaw, Poland – The concentration of total phosphorus. Spectrophotometric metod]. [in Polish.]

Procedura badawcza PB-04 wyd. 1 z dnia 20.11.2006, Polskie Centrum Akredytacji, Warszawa – Stężenie azotu ogólnego. Metoda spektrofotometryczna [Research procedure PB-04 issue 1 of 20.11.2006, Polish Accreditation Centre, Warsaw, Poland – The concentration of total nitrogen. spectrophotometric method]. [in Polish.]

Przybyła C., Bykowski J., Filipiak J. 2009. Efektywność funkcjonowania gminnych oczyszczalni ścieków [Technical Effectiveness of Municipal Wastewater Treatment Plants]. Rocz. Ochr. Śr., (Ann.I Set Environ. Protec.), Koszalin, T. 11, cz. 1. 231–239. [in Polish.]

Rozporządzenie Ministra Środowiska z dnia 28 stycznia 2009 r. zmieniające rozporządzenie w sprawie warunków, jakie należ spełnić przy wprowadzaniu ścieków do wód lub do ziemi, oraz w sprawie substancji szczególnie szkodliwych dla środowiska wodnego [Regulation of the Minister of the Environment of 28 January 2009 amending the regulation on conditions to be met for the introduction of sewage into water or ground and on substances particularly harmful to the aquatic environment]. DzU z 2009 r., nr 27, poz. 169. [in Polish.]

Rozporządzenie Ministra Środowiska z dnia 11 lutego 2004 r. w sprawie klasyfikacji dla prezentowania stanu wód powierzchniowych i podziemnych, sposobu prowadzenia monitoringu oraz sposobu interpretacji wyników i prezentacji stanu tych wód [Regulation of the Minister of Environment of 11 February 2004 was issued on the classification for presenting the condition of surface and underground waters, method of monitoring, interpreting the results and presenting the condition of the waters in question]. DzU z 2004 r., nr 32, poz. 284. [in Polish.]

Rozporządzenie Ministra Środowiska z dnia 9 listopada 2011 r. w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych [Regulation of the Minister of Environment of 9 November 2011 was issued on the classification for presenting the condition of homogenous surface water and environmental quality standards for priority substances]. DzU z 2011 r., nr 257, poz. 1545. [in Polish.]

Wysocka I., Kisielewska M., Rynkiewicz M.R., Konopka S. 2013. Usuwanie ortofosforanów ze ścieków syntetycznych o neutralnym i alkalicznym odczynie z wykorzystaniem metody roztwarzania metali i elektrokoagulacji [Orthophosphates Removal from Synthetic Neutral and Alkaline Wastewater Using the Electrocoagulation and the Metal Dissolution Methods]. Rocz. Ochr. Śr. (Ann. Set Environ. Protect.), T. 15, cz. 15. 2725–2737. [in Polish.]

www.wios.szczecin.pl, dostęp z dn. 1.03.2013.

Abstract. The aim of this study is to assess the degree of wastewater purification in the municipal wastewater treatment plant in Nowogard on the basis of the following chemical and physiochemical parameters: suspension, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and total contents of nitrogen and phosphorus. The analysis is based on the selected parameters of pollution of wastewater which to the greatest degree affect the condition of the receiver to which wastewater is discharged. In wastewater treatment process in the plant in Nowogard the reduction of pollution determined by the contents of suspension, total phosphorus, total nitrogen, BOD and COD indices was over 90%. Adopting the criteria included in the Regulation of the Minister of Environment of 2011 on the classification of the condition of homogenous surface waters, the mean suspension content in treated wastewater in 2012

classifies it as water of class I. The values of COD : N ratio in the years 2011 and 2012 indicates stabilisation of the chemical composition of analysed wastewater and adequate conditions for denitrification process during wastewater treatment. The lack of significant differences between the levels of reduction of pollution (suspension, total phosphorus, total nitrogen, BOD and COD indices) in the time of sampling and in the years under analysis as well as their low coefficients of variation (1.5–6.4) indicating high accuracy of statistical analyses demonstrate high stability of the operation of the wastewater treatment plant in Nowogard.