CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

No. 2 2007

24-HOURS VARIATION OF AMOUNT AND CONTENTS OF WASTEWATER FLOWING TO TREATMENT PLANT IN ZIELONA GÓRA

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The article describes daily variations of influents in the aspect of their volume and composition in the sewage treatment plant of Zielona Gora. With a method of direct measurements the flow rate and the concentration of pollutants in the sewage have been marked. Based on the research results the cumulative curves of the flow duration and daily pollutant loads as well as lines of daily loads variations in raw sewage have been worked out.

Keywords: wastewater, contamination loads, variation of contents of wastewater

1. INTRODUCTION

Knowledge of changes in quantity of produced wastewater and contamination loads is necessary in order to design and operate the wastewater treatment plant. In engineer's practice there are two methods of solving this problem. At the stage of new systems design a method of unitary coefficients is widely used, whereas at the stage of systems modernization and optimisation a method of direct measurements is commonly applied. Characterising changes in contents and amounts of wastewater is a difficult task.

Permanent measurement of flow intensity and concentration of contamination entails considerable expenses. Owing to this, engineering solutions and scientific research apply some simplifications in order to determine contamination loads. If samples of wastewater are taken in proportion to the volume of the wastewater, and then decanted to one common sample, then contamination load contained in this sample will be proportional to the load flown in with wastewater. Concentration in a sample obtained in such a way will be similar to the average concentration from a time period and it is called representative concentration.

Tests of non-uniformity of quantity and contents of wastewater should cover a longer period, taking into account not only hourly „peaks" during 24 hours but also daily „peaks" during a year. Flowing through the treatment plant facilities, the wastewaters are averaged both in quantity and contents. Separate containers (settling tanks, active sediment chambers, etc.) act like buffer containers [1,2].

The paper presents changes in quantity and contents of wastewater flowing to the treatment plant in Zielona Góra during 24 hours. Intensity of flow and contamination concentration were determined using direct measurements. The tests results made it possible to determine curves of accumulated frequencies for flow intensities and contamination loads as well as to draw lines for 24 hour variations in changes of contamination loads included in raw wastewater.

2. SCOPE OF TESTS

The tests covered municipal wastewater flowing to "Łącza" treatment plant in Zielona Góra. Zielona Góra is a city of almost 120 thousand inhabitants, occupying the area 58 km^2. The wastewater carried to the plant is mostly household wastewater but also wastewater produced by supermarkets and wastewater produced by small plants. „ŁĄCZA" wastewater treatment plant – central wastewater treatment plant for Zielona Góra is located about 7 km north of the town and west from Łężyca village. The plant output of $Q_{śrd}$=51225m^3/d was designed in a system of mechanical-biological wastewater treatment with biological dephosphatation, de-nitrification and nitrification as well as chemical precipitation of phosphor. Contents of raw wastewater flowing to the plant was analysed in time-proportional samples taken each two hours, during consecutive days from Monday to Friday, during the time between 22.04. to 26.04.2002. The tests were performed using time autosampler, which dosed 200 cm^3 of wastewater to separate containers each two hours (starting from 8:00 a.m.). Simultaneously, the flow intensity of the wastewater flowing into the plant within two hours was measured.

Scope of analytical control of wastewater contents included: dry residue, suspended matter, dissolved substances, electrolytic conductivity, pH, BOD_5, COD, total phosphor, total Kjeldahl nitrogen, organic nitrogen, $N–NH_4$.

3. RESULTS OF TESTS

Figure 1 presents changes in wastewater flowing to the plant and in figure 2 shows the summary amount of wastewater brought within 24 hours. The measurements were registered automatically, values were measured in two-hour in-

tervals. The tests carried out show that changes in quantity and contents of wastewater form a series of certain periodicity.

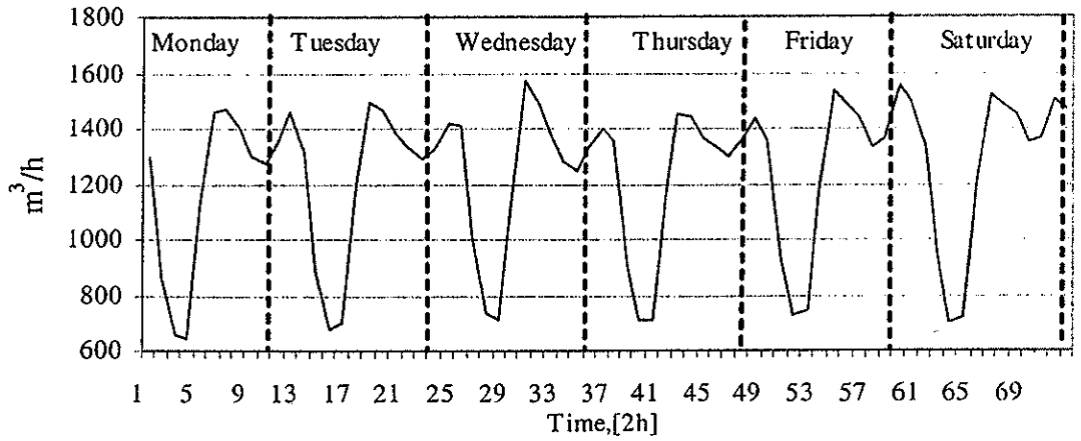


Fig. 1. Changes in amount of wastewater flowing in 24 hours

In the measurement period analysed, that is from Monday to Saturday, the smallest wastewater flow (below the average flow) was observed in morning hours (6:00 a.m. – 8:00 a.m.), the biggest at noon (12:00 noon – 2:00 p.m.) and during late evening (10:00 p.m. –1:00 a.m.). The amount of inflowing wastewater increased within four hours from 10:00 a.m. to 2:00 p.m. from the minimum value (about 65 % of the average flow) to the maximum value (about 139 % of average flow). The smallest amount of inflowing raw wastewater was observed on Monday (643 m^3/h) between 4:00 a.m. and 6:00 a.m., and the biggest on Wednesday (1,568 m^3/h) between 10°° and 12°°. The difference between these values is 144 % in relation to the minimum flow.

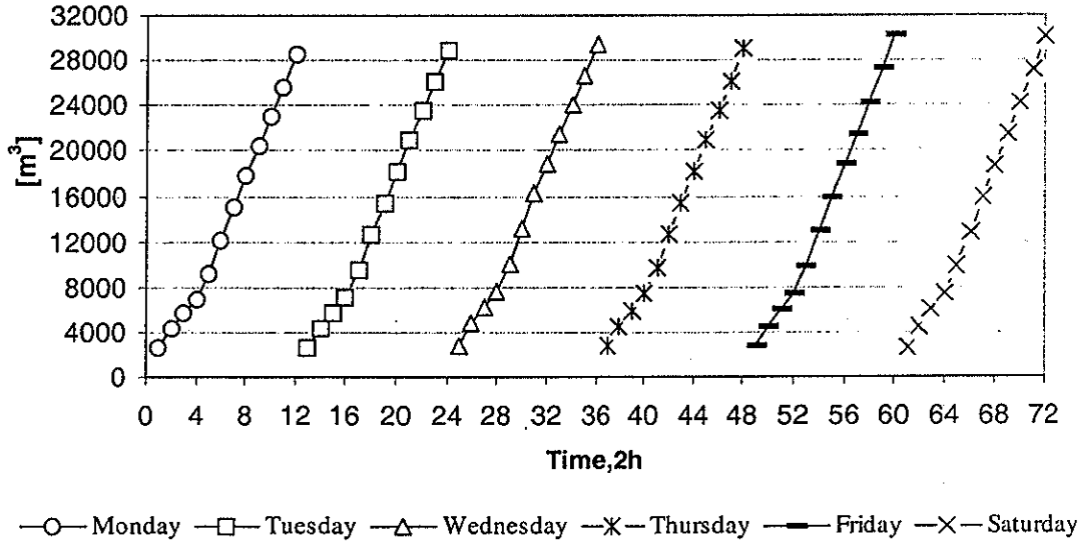


Fig. 2. Amount of wastewater flowing to the plant within 24 hours

The analysis of data obtained in figures 1 and 2 enables to state that the course of changes in quantity of wastewater flowing into the plant is characterised by big repeatability (dry weather). Basing on the measurement obtained it was concluded that day of the week does not influence the amount of inflowing wastewater. The smallest amount of wastewater run into the plant in 24 hours was observed on Monday – it was 28,574 m^3/d, and the maximum inflow of wastewater in the tested period occurred on Friday – 30,326 m^3/d.

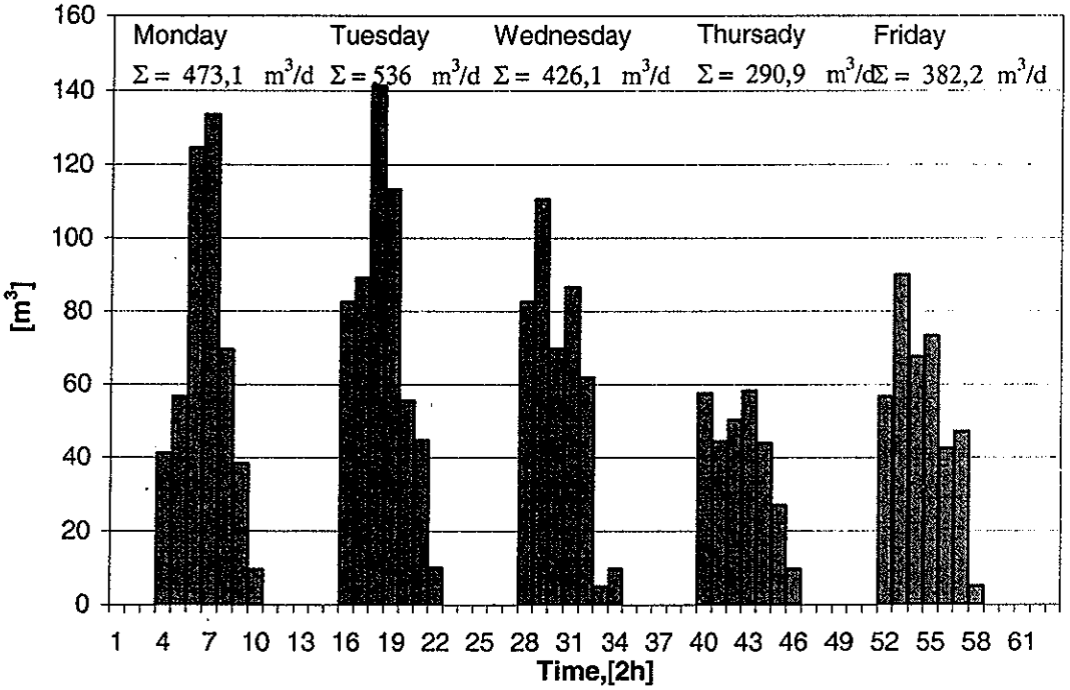


Fig. 3. 24 hour changes in quantity of the wastewater transported in.

Bigger changes (fig.3) were observed for wastewater transported in sewage removal trucks. The biggest amount was transported on Monday and Tuesday. The difference between the maximum and the minimum amount of wastewater was about 100 %. The biggest frequency of transported wastewater discharge was observed between 12:00 noon and 2:00 p.m.

Figure 4 illustrates 24-hour changes of BOD_5 and COD in wastewater flowing into the plant are presented.

For the five day period under analysis the course of the changes of COD is almost analogical with the value of BOD_5. Except for Wednesday, when the additional increase of COD during the night was observed, COD in the whole period varied from 200 gO_2/m^3 to 1160 gO_2/m^3, and BOD_5 from 16.4 gO_2/m^3 to 372 gO_2/m^3.

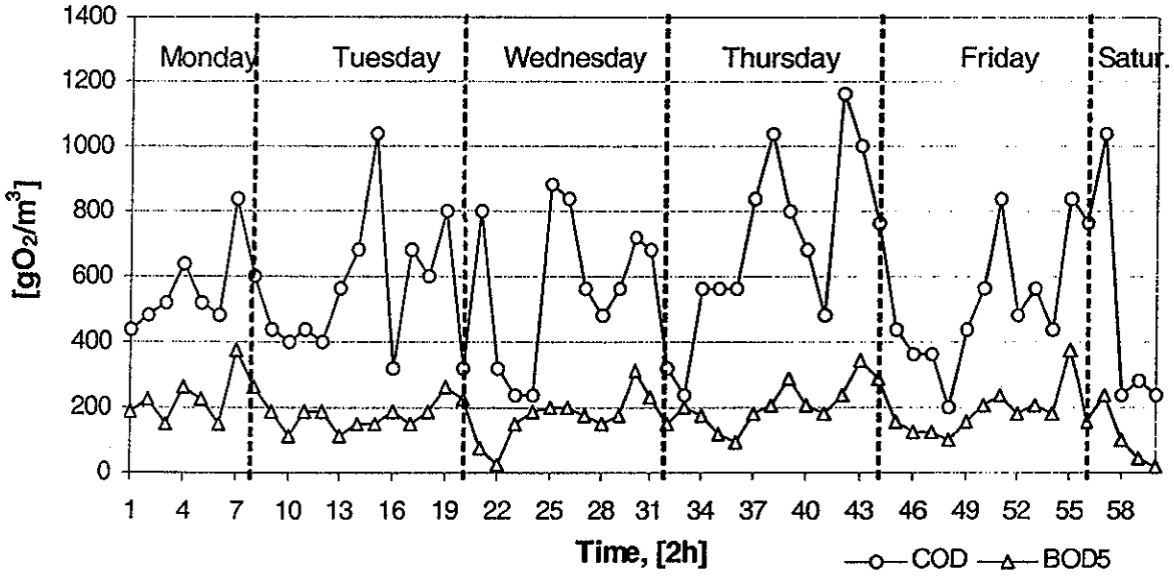


Fig. 4. Changes in BOD_5 and COD in wastewater

Figure 5 presents is the course of changes in concentration of separate forms of nitrogen. $N–NH_4$ concentration was relatively stable and was, on the average, 45.35 $gN\text{-}NH_4/m^3$. Whereas changes in organic nitrogen and total Kjeldahl nitrogen concentration were characterised by 24-hour periodicity.

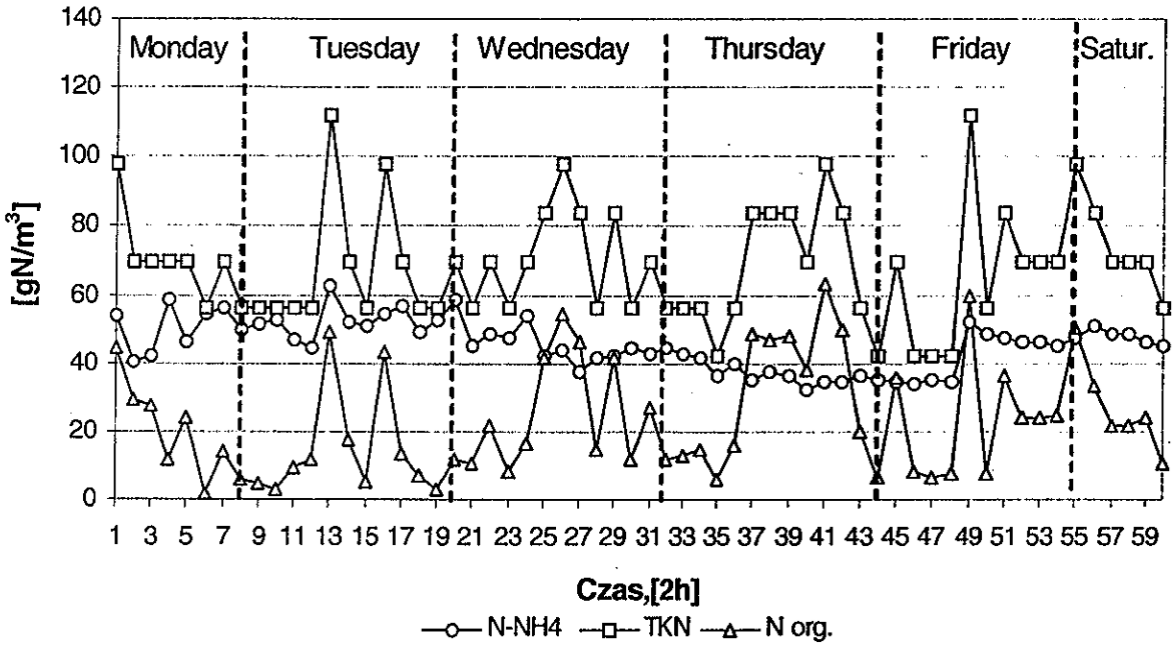


Fig. 5. Changes in concentration of nitrogen compounds in wastewater

Figure 6 illustrates changes in general phosphor concentration in wastewater. Large 24 hour changes of this parameter were observed. Concentration of phosphor in wastewater changed from 2 gP/m^3 to 20 gP/m^3. When considering

24 hour periodicity, high concentration was found at noon, whereas the lowest at night. Average phosphor concentration was of 6.39 gP/m^3.

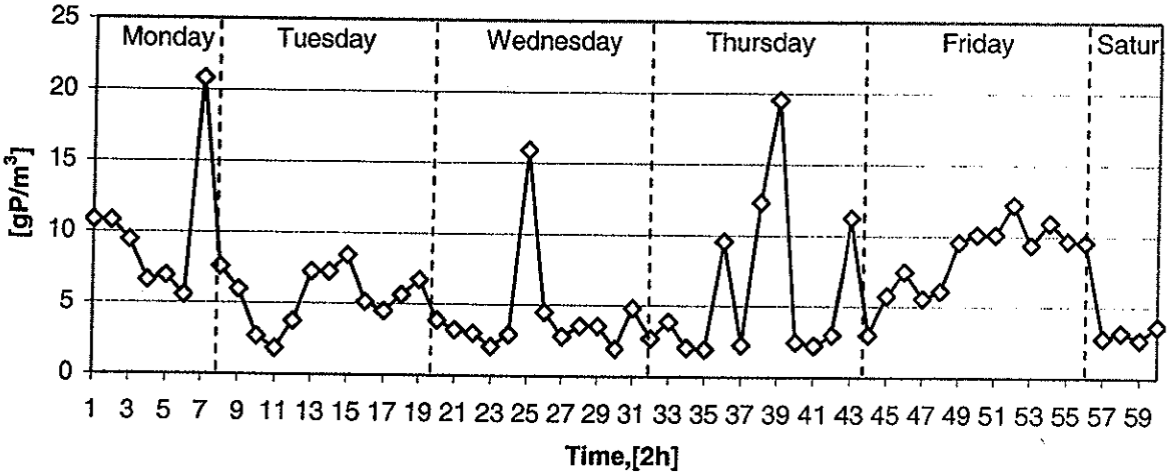


Fig. 6. Changes in total phosphate concentration in wastewater

Analysing the course of changes in the value of particular indicators, it was found out that the occurrence of their minimum and the maximum values on successive days of measurements can be characterized by hour periodicity. No influence of days of the week on concentration value was found. On four successive days, from Tuesday to Friday, these values were comparable.

4. SUMMARY

Basing on five day measurements of flow intensity and contamination concentration in wastewater, lines of 24 hour changes of contamination loads were determined, being a graphical representation of distribution of load changes of the analysed indicator during 24 hours. The Knowledge of 24 hour lines of BOD_5, COD, total Kjeldahl nitrogen load changes, general phosphor is particularly important for operation of the wastewater treatment plant. Figure 7 presents distribution of load changes during 24 hours for BOD_5, COD, total Kjeldahl nitrogen and $P_{gen.}$.

Analysing the course of 24 hour lines of changes in loads of contamination indicators in raw wastewater their distinct repeatability is observed. The occurring deviations and differences in singular measurement points probably result form analytical errors or random changes of wastewater composition.

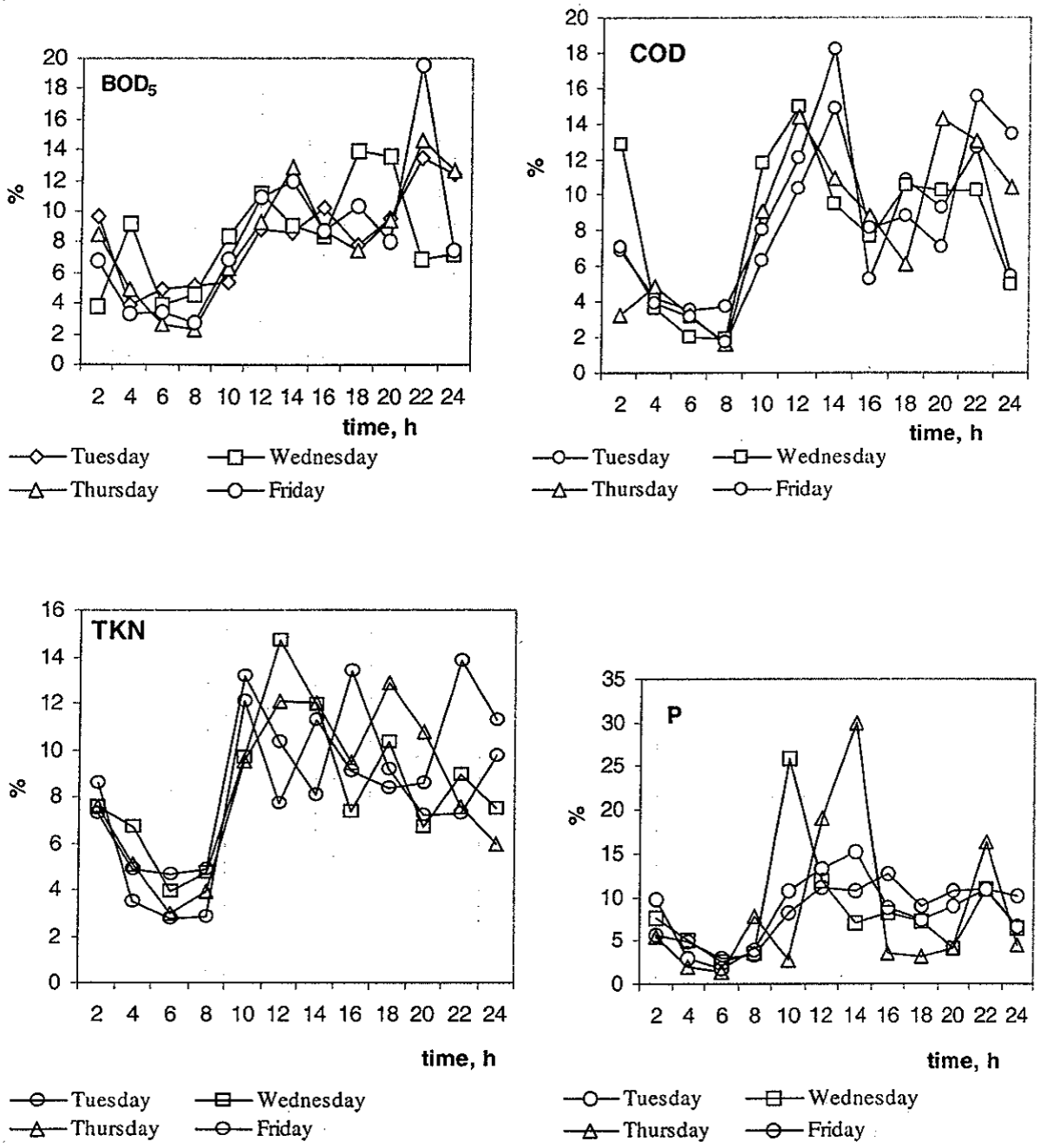


Fig. 7. Lines of 24 hour changes of loads BOD_5, COD, total nitrogen, phosphorus in wastewater

Basing on 24 hour lines of changes in contamination loads overload coefficient τ was determined as a quotient of maximum load and average 24 hour load. The calculated values are presented in table 1.

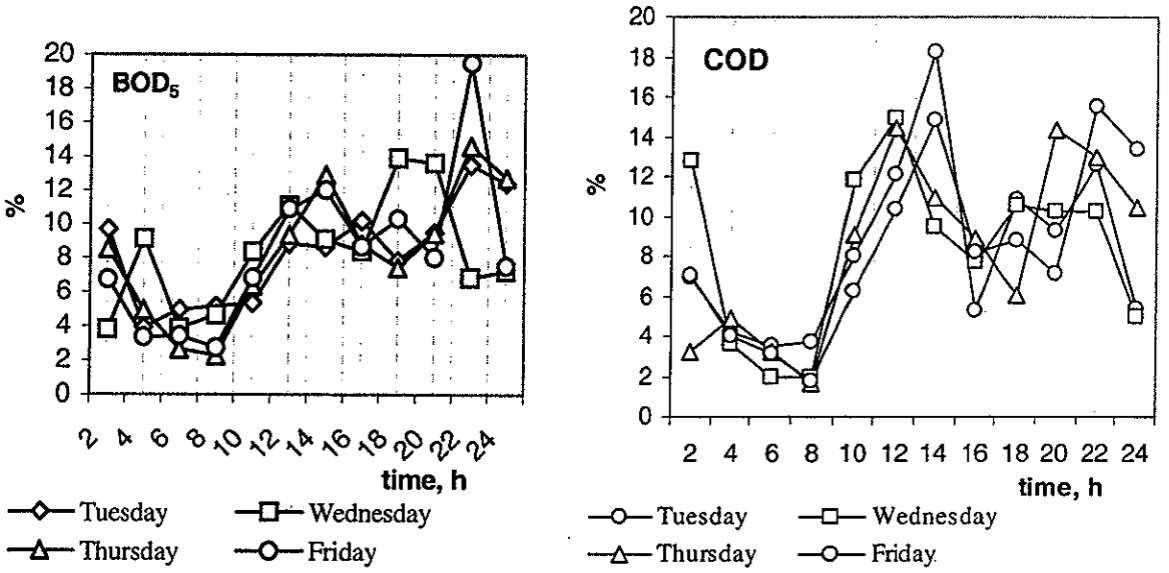
Table1. Overload coefficients τ_x

Day	$\tau_{suspension}$	τ_{BOD5}	τ_{COD}	τ_{TKN}	τ_P
Tuesday	1,66	1,62	2,17	1,59	1,81
Wednesday	3,45	1,67	1,79	1,76	3,77
Thursday	2,50	1,75	1,72	1,43	3,56
Friday	3,27	2,58	1,85	1,64	1,49

For particular contamination indicators values of overload indicators change within the range from 1.49 to 3.56 and correspond with publication data (value 1.5-3) [1,2]. Overload coefficients are used for interpreting results of chemical analysis of raw wastewater while designing devices and modelling processes of biological treatment of wastewater [1,2].

Learning about 24 hour contamination loads enables static elaboration of data by determining accumulated frequency curves for analysed parameter, which are shown in fig. 8.

The analysis of the obtained relations leads to the conclusion that at any time of the day it is possible to read with a high accuracy with what percentage of 24 hour load the wastewater treatment plant is loaded. The value of 85 % of the average 24 hour load of particular types of contamination recommended for the plant design was carried to the plant until 8:00 p.m. – 10:00 p.m.



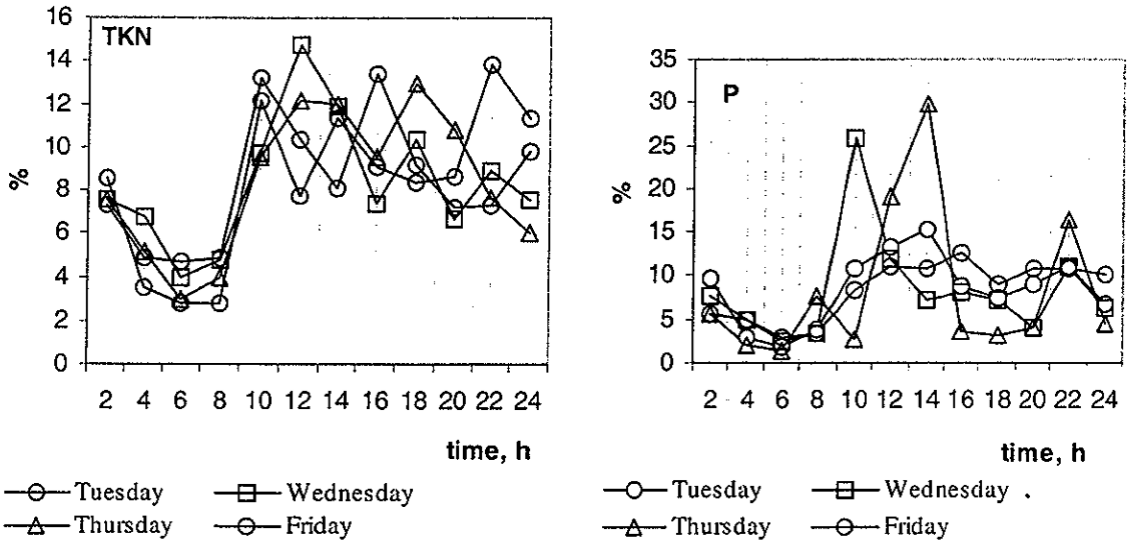


Fig. 8. Sums of loads of BOD_5, COD, general nitrogen, phosphor in wastewater

The most repetitive and possible to describe with line dependence is the distribution of BOD_5, COD and total Kjeldahl nitrogen load. Big differences occur in changes of phosphor loads.

5. CONCLUSIONS

Basing on the tests it has been concluded that:

- Changes in amount and contents of raw wastewater flowing to „Łącza" wastewater treatment plant in Łężyca form a time series characterized by periodicity.
- Day of the week (in analyzed period – from Monday to Saturday) does not affect considerably the quantity and quality of transported wastewater.
- Occurrence of the extreme concentration values of contamination indicators (minimum and maximum) is delayed (on the average - 2 – 3 h) as compared to the extreme concentration of wastewater flowing to the treatment plant in X, as a result of influence of collector system on wastewater composition.
- For analysed contamination indicators in raw wastewater: BOD_5, COD, total Kjeldahl nitrogen and general phosphor the determined overload coefficients change in the range of values from 1.49 to 3.56 and are comparable with data in publications.

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ZMIENNOŚĆ DOBOWA ILOŚCI I SKŁADU ŚCIEKÓW DOPŁYWAJĄCYCH DO OCZYSZCZALNI W ZIELONEJ GÓRZE

Streszczenie

W artykule przedstawiono dobowe zmiany ilości i składu ścieków dopływających do oczyszczalni w Zielonej Górze. Metodą bezpośrednich pomiarów wyznaczono natężenia przepływu i stężenia zanieczyszczeń w ściekach. Na podstawie wyników badań opracowano krzywe częstości skumulowanych do natężeń przepływów i ładunków zanieczyszczeń oraz linie dobowych zmian ładunków zanieczyszczeń w ściekach surowych.