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VARIABILITY CHARACTERISTICS OF SEWAGE VOLUME FLOWING INTO THE „SUPERBOS 200" – TYPE TREATMENT PLANT IN SZCZERCÓW TOWN

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Summary. The aim of the study was to characterize, in various aspects, the variation in the amount of sewage discharged to the biological treatment plant in the town Szczerców. The variability of the amount of sewage discharged in each month was examined (overall and per capita) based on the measurement results. Moreover, an analysis of weekly variation in the sewage discharge in a multiyear period of 2000–2010 was conducted and numerical ranges for the obtained results were determined. Basic descriptive statistics for each analysis were presented. The conducted study indicated, among others, a gradual increase in the amount of sewage discharged since 2005, which was related to the connection of a larger number of households to the common sewerage system. An average single inhabitant produced 115.21 $dm^3 \cdot M^{-1} \cdot d^{-1}$, which is an intermediate value as compared with data presented in the literature.

Key words: domestic sewage, sewage discharge, sewage treatment plant

INTRODUCTION

In recent years, a downward trend in water consumption and logically, the amount of discharged sewage has been observed. Equipping almost all households with measuring devices, increasing water and sewage-discharge prices, as well as increased people's awareness on the issue of efficient water consumption – these and other aspects have contributed to this phenomenon. This is also evidenced by the data presented by the Central Statistical Office [CSO 2010]. Yet in 2000, 1 494 000 m^3 sewage was discharged per year. However, in 2009 this amount was only 1 224 700 $m^3 \cdot year^{-1}$. This means that during nine years the annual amount of discharged sewage decreased by 269 300 m^3.

To date, a unit amount of sewage per capita, i.e. 150 $dm^3 \cdot M^{-1} \cdot d^{-1}$ was typically used while designing sewerage systems. It appears that this value can be even twice overstated. According to recent research, a unit amount of consumed

water does not exceed 90 $dm^3 \cdot M^{-1} \cdot d^{-1}$ [Kaczor 2006, Satora and Milianović 2007, Bugajski and Satora 2009, Chmielowski *et al*. 2009].

The aim of this study was to characterize, in different terms, the variability in the amount of sewage influent to the biological treatment plant in the town of Szczerców.

DESCRIPTION OF THE STUDIED FACILITY

The analyzed sewage treatment plant is situated in the western part of the town Szczerców, in the Łódź voivodeship. The facility is a SUPERBOS– type treatment plant, which operates using the activated sludge method. In 2007–2010 the treatment plant was modernized primarily in order to increase its capacity. Currently it serves 3730 people (PE = 3267). The maximum capacity of the treatment plant is 800 $m^3 \cdot d^{-1}$, but due to the fact that only three out of four treatment plant segments are in operation, its capacity is 600 $m^3 \cdot d^{-1}$. The process line of the treatment plant consists of the following objects and devices: cage screen, sewage pumping station, five segments of the SUPERBOS treatment plant (primary settling tank, tri-zone activated sludge chamber, secondary settling tank, oxygenation and disinfection chamber, and sludge stabilization chamber), gravity sludge thickener and a sludge drying bed. The river Widawka is a receiver of treated sewage.

RESEARCH METHODOLOGY

The amount of sewage flowing into the treatment plant has been measured every day, starting from June 1st 2010. The measurement is carried out with a 750 AV flowmeter (Teledyne Isco). Based on the measurement results the variability of the

Table 1. Basic statistics on the amount of sewage flowing into the treatment plant in the town Szczerców from June 2010 to March 2011

Sewage / Descriptive Statistics	Flowing into the treatment plant, $m^3 \cdot d^{-1}$	Unit amounts, $dm^3 \cdot M^{-1} \cdot d^{-1}$
Minimum	399.68	107.15
Maximum	451.14	120.95
Range	51.46	13.80
Mean	429.75	115.21
Median	427.60	114.64
Standard deviation	15.89	4.26
Coefficient of variability	3.70	3.70

sewage amount flowing into the treatment plant is analyzed in each month (in total and per capita). The analysis of variability of a weekly sewage inflow in a multi-year period of 2000–2010 was carried out and the numerical ranges for the obtained results were determined. Basic descriptive statistics for individual analyzes are summarized in Table 1.

RESULTS AND DISCUSSION

Based on the analysis of the amount of sewage inflowing to the analyzed treatment plant in the period of 2000–2010, it can be stated that the smallest amount, i.e. 94 thousand $m^3 \cdot year^{-1}$ was recorded in 2004 (Fig. 1). In contrast, the greatest inflow, amounting to 156 thousand $m^3 \cdot year^{-1}$ occurred in 2010. Also, nearly twofold increase in the amount of sewage could be observed from 2004 to 2010. Throughout this period (with one exception – 2009, when the amount of sewage slightly decreased), a gradual increase in the amount of sewage could be noticed. This, and the largest amount of sewage recorded in 2010, were primarily related to the modernization of the treatment plant and sewerage network, and in particular to the connection of a large number of new users to the sewer system in this period.

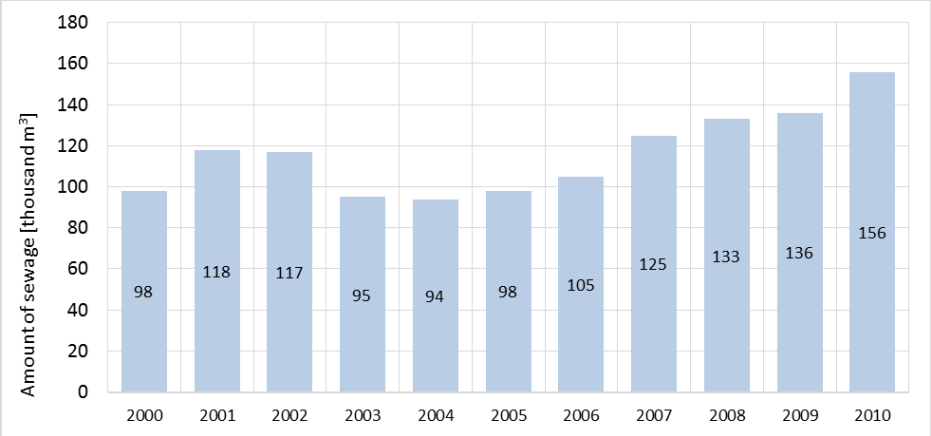

Fig. 1. The annual amount of sewage flowing into the treatment plant in the multi-year period 2000–2010

The analyzed mean monthly amount of sewage in the period from June 2010 to March 2011 (Fig. 2), indicates that the smallest volume (399.68 $m^3 \cdot d^{-1}$) was discharged into the treatment plant in July 2010, while the greatest (451.14 $m^3 \cdot d^{-1}$) – in February 2011. The difference in the amount of sewage reached therefore 51.46 $m^3 \cdot d^{-1}$. On average, 429.75 $m^3 \cdot d^{-1}$ of sewage flowed into the treatment

plant over the analyzed period. Also, a relatively high uniformity in the sewage inflow could be observed, which is evidenced by the size of the coefficient of variation, amounting only to 3.7%.

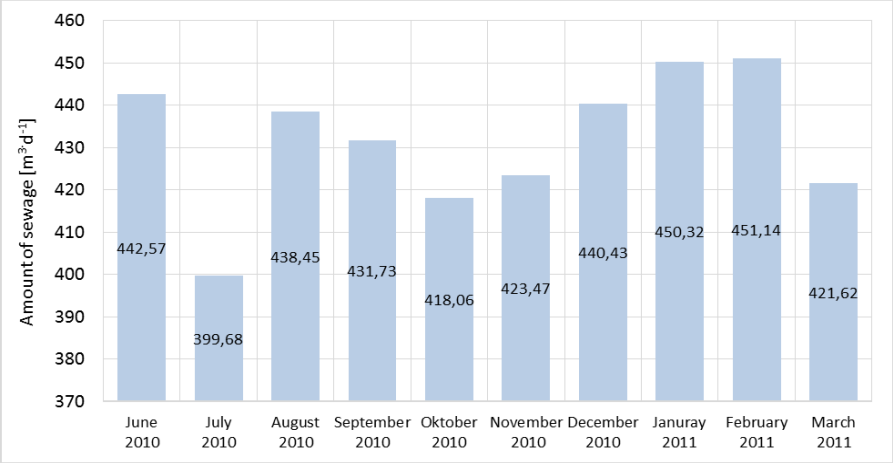

Fig. 2. Mean daily amount of sewage (in each month) flowing into the treatment plant from June 2010 to March 2011

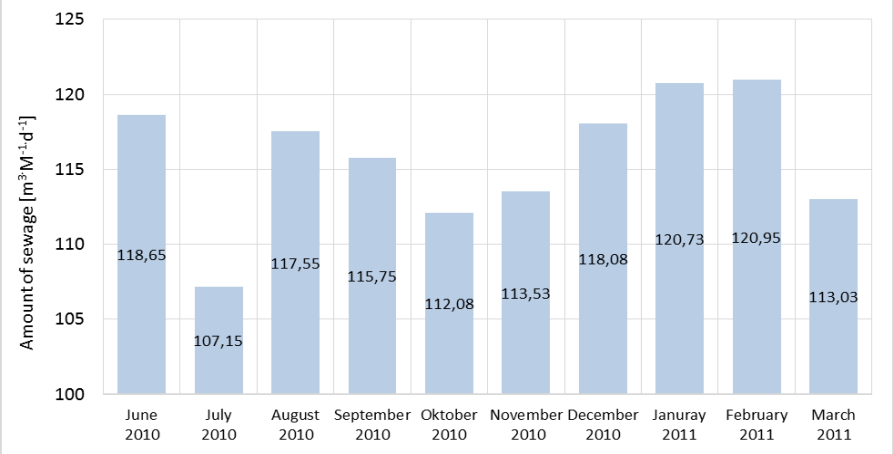

Fig. 3. The amount of sewage flowing into the treatment plant per capita in the period June 2010 – March 2011

The analysis of the amount of sewage per capita in the period from June 2010 to March 2011 (Fig. 3) indicates that the unit amount of sewage averaged 115.21 $dm^3 \cdot M^{-1} \cdot d^{-1}$ and ranged from 107.15 $dm^3 \cdot M^{-1} \cdot d^{-1}$ in July 2010 to 120.95 $dm^3 \cdot M^{-1} \cdot d^{-1}$ in February 2011. Coefficient of variation in this case was also small and amounted to 3.7%. With reference to the literature data [Bergel 2005,

Pawełek and Kaczor 2006, Chmielowski *et al*. 2009], these values are in the middle of the results presented by different authors (they have lower values than those adopted as unit values so far, but they noticeably exceed the results from recent studies).

The analysis of sewage inflow variability depending on the weekday (Fig. 4) shows that the smallest amount of sewage, i.e. 419.15 $m^3 \cdot d^{-1}$ was discharged on Mondays and the highest, i.e. 447.46 $m^3 \cdot d^{-1}$ on Saturdays. The increase in sewage inflow in the last three days of the week (Friday, Saturday, Sunday) is clearly visible, as the values significantly exceed the mean of 432.12 $m^3 \cdot d^{-1}$.

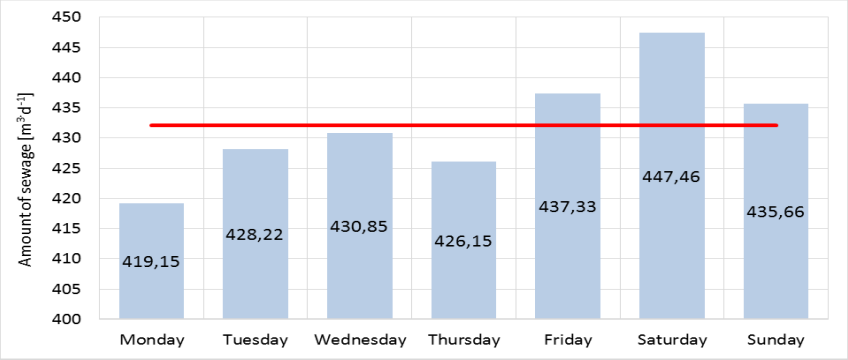

Fig. 4. The amount of sewage flowing into the treatment plant on each day of the week, in the period from June 2010 to March 2011

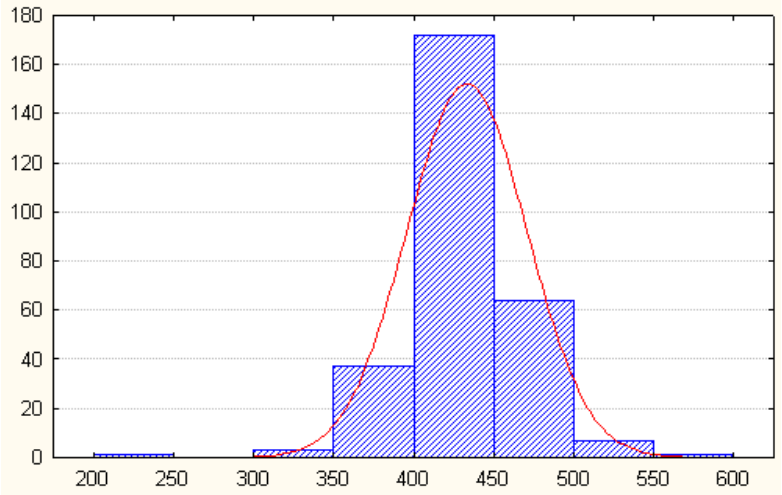

Fig. 5. Numerical ranges for all measurements of the amount of sewage in the period June 1st 2010 – March 13th 2011

The analysis of the sewage influent to the treatment plant in the study period (Fig. 5) indicates that most frequently its amount fell within the range of 400–450 $m^3 \cdot d^{-1}$. This was observed in 172 cases per 285 results, which constituted 60% of all readouts. The amounts within the range of 450-500 $m^3 \cdot d^{-1}$ were also frequent (64 cases), as well as those within the range of 350–400 $m^3 \cdot d^{-1}$ (37 cases). The least frequent values, i.e. single cases, were within the ranges of 200–250 $m^3 \cdot d^{-1}$ and 550–600 $m^3 \cdot d^{-1}$. These results, similarly to the previously mentioned low value of the coefficient of variation, evidence small variability in the amount of sewage inflowing in the analyzed period. The lack of highly over- or undervalued results allows to conclude that there were no extreme events in the study period, that could threaten the proper operation of the sewage treatment plant.

The analyzed unit sewage inflow to the studied treatment plant needs to be considered as similar to the ones reported by other authors [Bergel 2005, Pawełek and Kaczor 2006]. For instance, Henze *et al*. [1995], based on research conducted in 24 countries, reports that the mean annual volume of sewage discharged from households is at the level of 165 $dm^3 \cdot d^{-1}$.

SUMMARY AND CONCLUSIONS

The aim of this study was to characterize the variability of the amount of sewage flowing into the biological treatment plant in the town Szczerców. Primarily, the amount of sewage inflowing to the treatment plant in the period 2000–2010 was determined. Subsequently, the variability of the sewage volume in different months, unit amounts of sewage, as well as the changes in the amounts of sewage inflow depending on the day of the week were presented with respect to the period from June 2010 to March 2011. The performed detailed analysis allows to draw the following conclusions:

– A gradual increase in the amount of discharged sewage has been observed since 2005, which was associated with the connection of a larger number of households to the collective sewerage system.

– On average 429.75 $m^3 \cdot d^{-1}$ of sewage reached the treatment plant during the study period.

– The coefficient of variation, which was 3.7%, both in the case of the amount of sewage per capita and in the total amount of sewage over the study period, indicates low variability of the sewage volume inflowing to the studied treatment plant.

– On average, a single resident discharged 115.21 $dm^3 \cdot M^{-1} \cdot d^{-1}$ of sewage, which is an intermediate value between data provided in the literature.

– Weekly variability in the amount of sewage indicates that the smallest volume is discharged on Mondays (419.15 $m^3 \cdot d^{-1}$), and the greatest on Saturdays (447.46 $m^3 \cdot d^{-1}$). The increase in sewage inflow at the end of the week is apparent.

– The most frequent amount of sewage discharged to the analyzed treatment plant fell within the range of 400-500 $m^3 \cdot d^{-1}$, which constituted 60% of all analyzed measurements.

REFERENCES

Bergel T., 2005. Optimizing the selection of unit sewage discharge as a condition for proper functioning of rural sewer systems. Gaz Woda Tech. Sanit. 11, 23–26.

Bugajski P., Satora S., 2009. Variability of the unitary average daily water consumption by Olkusznian man. Infrastr. Ecol. Ter. Wiej. 5, 51–60.

Chmielowski K., Satora S., Wałęga A., 2009. Variability of the unitary average daily water consumption by Mszanian man. Infrastr. Ecol. Ter. Wiej. 5, 61–71.

CSO, 2010. Environmental protection. Information and statistical study. Warsaw.

Henze M., Harremoes P., Jansen J., Arvin F., 1995. Wastewater treatment. Biological and chemical processes. Springer Verlag.

Kaczor G., 2006. Unit sewage outflows from rural sewer system in Koszyce municipality. Infrastr. Ecol. Ter. Wiej. 2 (1), 171–182.

Pawełek J., Kaczor G., 2006. Unit water consumption per household during 8-year period of observations. Infrastr. Ecol. Ter. Wiej. 2 (1), 159–170.

Satora S., Milianović E., 2007. Amount of water consumption by waterworks users in Jordanów. Infrastr. Ecol. Ter. Wiej. 1, 205–214.

CHARAKTERYSTYKA ZMIENNOŚCI ILOŚCI ŚCIEKÓW DOPŁYWAJĄCYCH DO OCZYSZCZALNI TYPU „SUPERBOS 200” W MIEJSCOWOŚCI SZCZERCÓW

Streszczenie. Celem artykułu było scharakteryzowanie, pod różnym kątem, zmienności ilości ścieków dopływających do biologicznej oczyszczalni ścieków w miejscowości Szczerców. Na podstawie uzyskanych wyników pomiarów przeprowadzono analizę zmienności ilości ścieków dopływających w poszczególnych miesiącach (ogólnie oraz w przeliczeniu na jednego mieszkańca). Wykonano analizy tygodniowej zmienności dopływu ścieków w wieloleciu 2000–2010 oraz określono liczbowe przedziały wartości dla uzyskanych wyników badań. Przedstawiono podstawowe statystyki opisowe dla poszczególnych analiz. Na podstawie przeprowadzonych badań stwierdzono między innymi sukcesywny wzrost ilości odprowadzanych ścieków od 2005 roku, co związane było z przyłączeniem większej liczby gospodarstw do zbiorczej kanalizacji. Średnio od pojedynczego mieszkańca odpływało 115,21 $dm^3 \cdot M^{-1} \cdot d^{-1}$, co jest wartością pośrednią pomiędzy różnymi danymi przedstawionymi w literaturze.

Słowa kluczowe: ścieki bytowe, dopływ ścieków, oczyszczalnia ścieków