ANALYSIS OF UNIT POLLUTION LOADS FOR SMALL WASTEWATER TREATMENT PLANTS

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Abstract: Designing and operation of small wastewater treatment plants is specific due to the increased pollutants' concentrations and flow variability. Thus it is very important that in designing such plants accurate values of unit pollution load and flow were used. Still there is very little empirical data regarding these issues. In the paper presented are results of the research performed at 32 small wastewater treatment plants in Poland that became the basis for calculation of unit pollution load and flow values.

Keywords: small wastewater treatment plants, unit pollution loads

INTRODUCTION

The treatment of small volumes of domestic wastewater requires specific approach that is very different form treatment of municipal wastewater at medium and large wastewater treatment plants. Among the most important factors that must be considered is such situation are high concentration of pollutants in influent, and large flow and composition variability. Small wastewater treatment plants usually treat domestic effluents from households, small businesses and local public utility companies that mostly contain easily biodegradable organic pollutants.

Biochemical treatability of wastewater depends much on values of proportions of specific groups of pollutants in influent wastewater and it is widely accepted that these proportions should be as follow:

$$COD : BOD_5 < 2$$
$$BOD_5 : TN > 4$$
$$BOD_5 : TP > 20,$$

and the minimal amount of nutrients in wastewater needed for its biological treatment is described with the following proportion (Municipal investments 1995):

$$TP : TN : BOD_5 = 1 : 4.7 : 150$$

In the past the volume of wastewater discharged by an individual consumer used for design calculations was approx. 200 dm^3/PE*d. The increase in market water price and installation of water meters have caused that water consumption per capita is steadily decreasing in both, municipal and rural areas (Bernacka *et al*. 2001; Pawełek *et al*. 1998; Banaś *et al*. 1998; Kucharski 2000). At present a value of 150 dm^3/d per capita is used for the households with full sanitary services and values 50 to 100 dm^3/d per capita for other households (Pawełek *et al*. 1998; Banaś *et al*. 1998; Kucharski 2000).

Small water consumption per capita and discharge of loads from septic tanks results in increased pollutant concentration inflow of wastewater treatment plants. These numbers may significantly

vary among different sewage systems. Especially destructive could be high ammonia concentrations as ammonia at concentration above 100 g $N\text{-}NH_4/m^3$ may be toxic to activated sludge microorganisms (Kucharski 2000). With high pollution concentrations in influent to a plant keeping up to effluent standards may be difficult to achieve. Thus it is essential to know the actual values of unit flow and pollution loads when designing the wastewater treatment plant for a small community. The article presents the results of such investigations.

METHODOLOGY

The analysis was performed for 32 small wastewater treatment plants of the capacity from 50 to 600 m^3/d, that correspond to PE 400 to 4000. The wastewater flow per capita was calculated on the basis of average daily wastewater inflow to the plant obtained from routine measurements at plants and/or individual measurements performed on selected sewage systems, and considering the number of inhabitants connected to the sewage system. Those numbers included also incidental flows in the sewage systems.

When the average pollution loads in inflow to an individual wastewater treatment plant were divided by the number of inhabitants the unit pollution loads were calculated. Simple statistical analysis of the obtained results became the basis for determination of probabilities and mean values.

RESULTS

The values of wastewater flow per capita and unit pollution loads determined during the performed investigations are presented in Table 1.

Table 1. Unit wastewater flow and unit pollution loads (per capita) in inflow to small WWTP

Unit value for…	Range	Mean and standard deviation
wastewater flow, $dm^3/PE*d$	55 – 185	119 ± 36
BOD_5 load, $gO_2/PE*d$	17 – 76	43.4 ± 16
COD load, $gO_2/PE*d$	36 – 159	85.8 ± 37
TSS load, g/PE*d	14.2 – 87	37.4 ± 19
TN load, gN/PE*d	4.2 – 18	9.3 ± 3.8
TP load, gP/PE*d	0.68 - 2.5	1.3 ± 0.5

Average unit wastewater flow and pollution loads' values (q = 119 $dm^3/PE*d$, BOD_5 = 43.4 $gO_2/PE*d$, COD = 85.8 $gO_2/PE*d$, TSS = 37.4 g/PE*d, TN = 9.3gN/PE*d, TP = 1.3 g P/PE*d) are smaller than typically used for designing in Poland but close to the values used in France, except for the total phosphorus (Pujol *et al.* 1989).

Statistical analysis of the obtained results showed that 50% percentile probability values for wastewater flow and pollution loads are respectively q=110 $dm^3/PE*d$, BOD_5 =40.5 $gO_2/PE*d$, COD = 86 $gO_2/PE*d$, TSS = 31 g/PE*d, TN = 8.8 g N/PE*d, TP = 1.4 g P/PE*d, and 80% percentile probability values q = 150 $dm^3/PE*d$, BOD_5 = 58 $gO_2/PE*d$, COD = 132 $gO_2/PE*d$, TSS = 52 g/PE*d, TN = 13.5 g N/PE*d, TP = 1.9 g P/PE*d, as shown in Table 2 and Fig. 1.

Average unit wastewater flow value for the 80% percentile probability of 150 $dm^3/PE*d$ is along with the value typically used for designing in Poland. Similarly are the 80% percentile values for BOD_5, TSS and TP. However, the unit load value of 80% percentile for TN is significantly larger.

Table 2. Probability values for the unit wastewater flow and pollution loads

Unit values for…	Probability of occurrence		
	50%	**80%**	**90%**
wastewater flow, dm^3/PE*d	110	150	160
BOD_5 load, gO_2/PE*d	40,5	58	70
COD load, gO_2/PE*d	86	132	136
TSS load, g/PE*d	31	52	57
TN load, gN/PE*d	8.8	13,5	14
TP load, gP/PE*d	1.4,	1,9	2.4

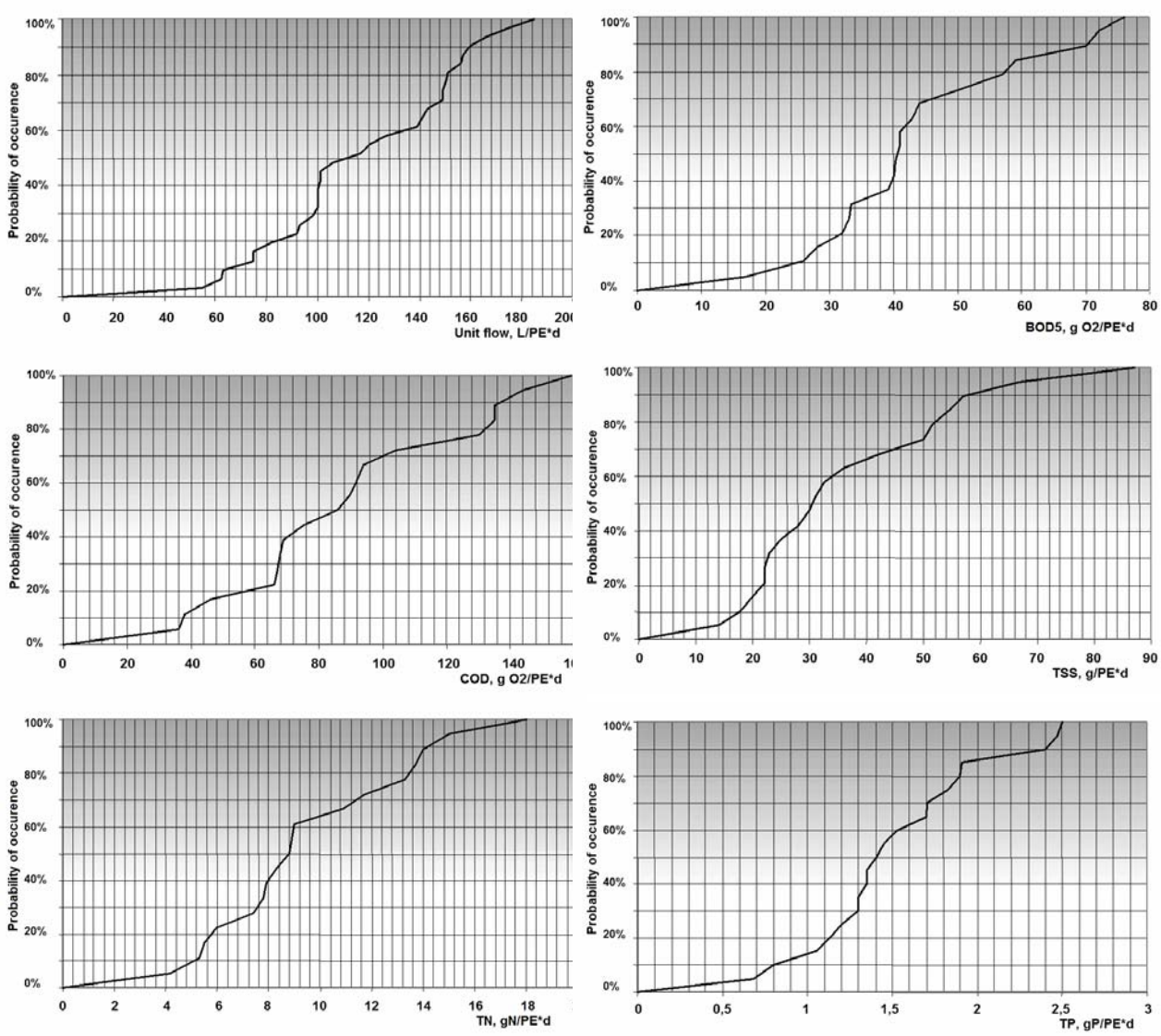

Figure 1. Probability curve for the unit wastewater flow and pollution loads at the investigated plants.

CONCLUSIONS

The data gathered during the research at the investigated small wastewater treatment plants allowed for simple statistical analysis of the unit flow and pollution loads in influent to the plants. The obtained values can be practically used as realistic values for flow and load balance calculations when developing feasibility study or designing small wastewater treatment plants. The 85% percentile unit flow and load values, i.e. q = 156 dm^3/PE*d, BOD_5 = 60 gO_2/PE*d, TSS = 55 g/PE*d, TN = 13.8g N/PE*d, TP = 1.9 g P/PE*d, can be used for reliable designing of the plants with relatively high safety factor.

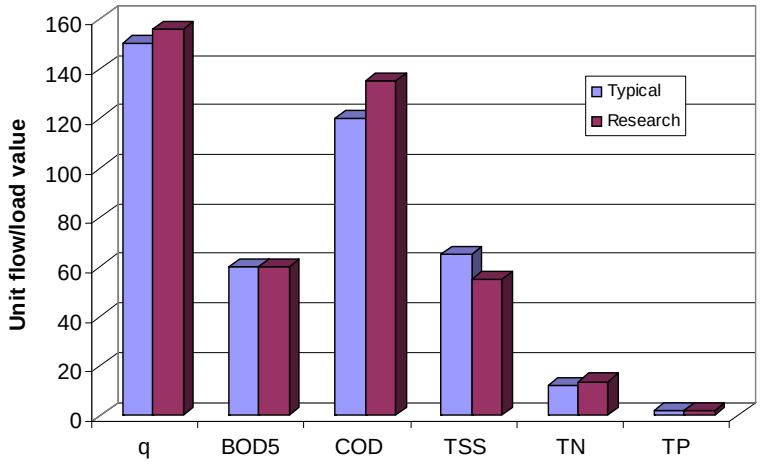

Figure 2. Comparison of the unit flow and load values typically used and those from the research

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