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PUMPING INSTALLATIONS FOR WASTEWATER SYSTEM REHABILITATION IN BĂBENI TOWN

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Abstract

In this paper, the behaviour of the pumping stations in the town of Băbeni, Vâlcea county, is evaluated in relation to the sewage system and wastewater treatment. They are an important factor that has environmental effect, which needs to be managed carefully, also improving city inhabitant life quality. Their high energy consumption must be reduced, being an element of secondary environmental impact, the networks safety is one of the key efficiency standards, expressed in a quality-like approach, this criterion must be enhanced by quantitative factors. The pumping installation introduction for wastewater system rehabilitation is an extraordinary solution resolving practical issues, even is not a current approach.

Key words*: pumping stations, sewage system rehabilitation, waste water.*

INTRODUCTION

Sewerage systems are, in the modern era, indispensable to a locality, they represent a basic condition for ensuring population life quality and for environmental protection (Ionescu, 2010).

Like any other construction, once built the sewage systems are subject to aging or face under-dimensioning caused by the development of the localities served, so they will undergo rehabilitation, modernization, expansion works during their lifetime (Iancu, 2021).

And this is the situation of the sewage system in the town of Băbeni, a town in Vâlcea County, located approximately 20 km south of the county seat, Râmnicu Vâlcea Municipality, and 30 km north of Drăgășani Municipality, on the right side of the Olt River, approximately 2 km from it.

Vâlcea County is located in southwest Romania (Oltenia), bordering Alba and Sibiu counties to the north, Hunedoara and Gorj to the west, Dolj to the south, Argeș and Olt to the east; includes 2 municipalities, 9 cities and 78 communes, with a total population of 413,570, with an area of 5,765 km2, representing 2.41% of the country's area (INS, 2023).

The summary conditions description of the area shows that the first snowfall generally occurs in the last days of November, the snow phenomenon is recorded around 50 days/year, the prevailing winds are from the north (14.8%), frost is present (110-120) days/year, the frost depth characteristic of the studied area is (0.60-0.70) m (STAS 6054-77, 1977).

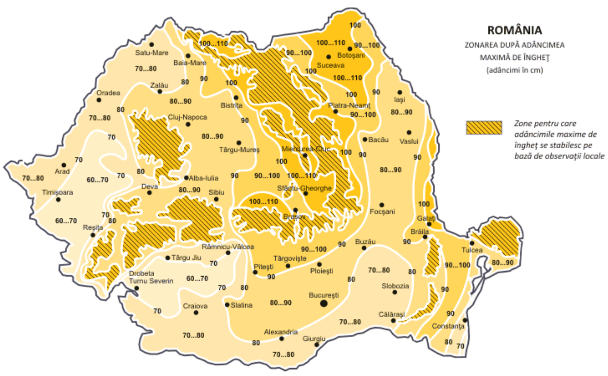

Figure 1. Zoning according to the maximum frost depth of the territory of Romania (STAS 6054-77)

According to NP 100-1/2013 and SR 11100/1-1993, regarding the zoning of the territory of Romania in terms of peak values of ground acceleration for design, for earthquakes with the average recurrence interval (IMR) 100 years, the entire location falls within the area with ag = 0.20g, and the corner period is Tc = 0.70 s.

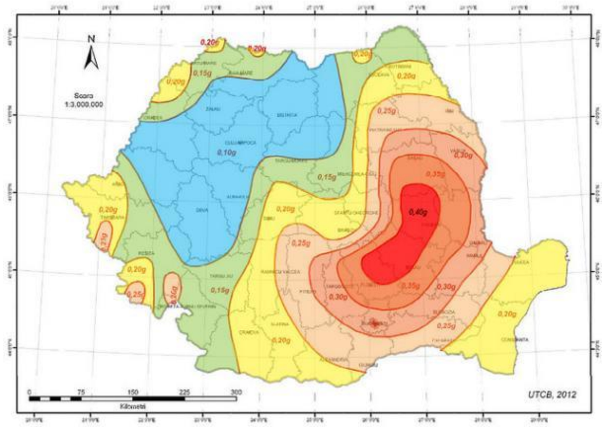

Figure 2. Zoning of the peak values of the ground acceleration for the design of ag on the territory of Romania (SR 11100/1-1993)

In the existing situation in Băbeni, the sewerage works without pumping, the section collecting domestic wastewater and conducting it to the treatment plant passes through several private properties.

It is proposed to place a sewage pumping station, in the lowest part of the neighborhood, for the correct functioning of the area of blocks in the city of Băbeni.

MATERIALS AND METHODS

The water requirement is determined according to specification of STAS 1343-1/2006, as in Table 1.

Table 1. Specific water flow values for household needs (qg) and coefficient of daily non-uniformity values (STAS 1343-1/2006)

Areas or localities differentiated according to the degree of equipment with cold, hot water and sewage installations	qg(i)	Kzi(i)
Areas with households having internal installations of cold water, hot water and sewage, with individual preparation of hot water	100-120	1,20

For the main parameters for sizing water requirements, the following aspects were taken into account:

- Population evolution in the next 20 years;
- Specific residential and non-residential water flows;
- Hourly and daily coefficients of variation;
- Coefficients for covering water losses;
- Water for fire extinguish;
- flow rates for the dimensioning and control of the elements in the water supply system (sources, treatment station, intake pipe and distribution network).

For the sizing of sewerage systems, the maximum hourly used flow from the use of water by type of consumption (household, public, economic agents, etc.) is considered (NP 133/2-2013).

The relationships used to determine the water requirement are:

$$Qzi,med = \frac{1}{1000} \cdot \sum_{k=1}^{n} \left[\sum_{i=1}^{m} N(i).q_s(i) \right] (1) \qquad [m3/zi]$$

$$Qzi,\max = \frac{1}{1000} \cdot \sum_{k=1}^{n} \left[\sum_{i=1}^{m} N(i).q_s(i).K_{zi}(i) \right] (2)$$

$$Qor,\max = \frac{1}{1000} \cdot \frac{1}{24} \cdot \sum_{k=1}^{n} \left[\sum_{i=1}^{m} N(i).q_s(i).K_{zi}(i).K_{or}(i) \right] (3)$$

where:

N(i) - number of users;

qs(i) - specific flow (average daily amount of water needed by a consumer);

Kzi(i) - coefficient of daily variation;

Kor(i) - coefficient of hourly variation.

To calculate the water requirement (STAS 1343-1/2006) the relationship used is:

$$Q_s = K_s.K_p.Q (4)$$

where:

Kp - coefficient representing the addition of water quantities to cover water losses in the water supply system up to the users' connections; for rehabilitated distribution networks Kp = 1.35;

Ks - servitude coefficient for covering the own needs of the water supply system (for washing tanks, washing the distribution network, etc); Ks = 1.05.

All the elements of the water supply scheme, from the intake to the treatment station, will be dimensioned at the QIC flow rate (STAS 1343-1/2006):

$$Q_{IC} = K_p.K_s.Q_{zi,\max} + K_p.K_s.Q_{Ri} (5)$$

where:

Kp - coefficient of increase in water demand

Ks - servitude coefficient

QRi - the recovery rate of the intangible fire reserve

The water treatment plant components are dimensioned to the same QIC.

Between the treatment station and the storage tank, all components (intake, pumping stations) are dimensioned to:

$$Q'_{IC} = \frac{Q_{IC}}{K_s} (6)$$

where:
QIC - dimensioned with equation (5)
Ks - servitude coefficient
For the dimensioning of the intake pipes, the specific flow rate for household needs was chosen considering the degree of equipment with cold water, hot water and sewage installations the values are: qs = 120 l/person, day, when Kzi = 1.30.

RESULTS AND DISCUSSIONS

For the sewage system pumping station the calculation flow is:

$$Q_{or,\max} = 6\frac{l}{s} = 21{,}6\frac{m^3}{h}$$

The caisson, in which the wastewater pumping station is located, is sized considering a storage time of approx. 5 minutes (12 starts/stops/hour):

$$V_{inmag,nec} = Q_{or,\max}\cdot\frac{5}{60} = 21{,}6\frac{m^3}{h}\cdot\frac{5}{60} = 1{,}8m^3$$

If the caisson diameter is chosen D = 2.00 m, the useful storage height will be:

$$H_u = \frac{V_{inmag,nec}}{\pi.R^2} = \frac{1{,}8m^3}{\pi.2^2m^2} = 0{,}57m \approx 0{,}6m$$

The caisson depth results:

$$H_{caisson} = H_{geod} + H_u + 0{,}4m$$

where:
Hgeod - geodetic height of the caisson;
Hu - useful storage height (previously determined);
0,40 m - consists of: 0.20 m (guard height for the required volume) + 0.20 m (measured from the caisson scraper to the pump suction point).
Thus,

$$H_{geod} = CT - CR = 205{,}38mdMN - 202{,}82mdMN = 2{,}56m \approx 2{,}6m$$

where:
CT - land geodetic elevation
CR - surveyor's geodetic elevation
Deci,

$$H_{caisson} = 2{,}56 + 0{,}6 + 0{,}4 = 3{,}56m$$

The resulting pumping head (STAS 12594-1987) is:

$$H_{pump} = H_{geod} + H_u + 0{,}4 + H_r,$$

knowing:

$$H_{geod} = CR_{exit} - CR_{entry} = 208{,}83mdMN - 202{,}82mdMN = 6{,}01m$$

where:
CRexit - exit point radier elevation
CRentry - entry point radier elevation
Hr - pressure loss on the discharge pipe knowing for a discharge pipe of De = 110 mm, having L = 307 m and Q = 6 l/s, v = 0,74 m/s, hr=5,4m/km, local head loss - 15% (Kiselev, 1988), results:

$$H_r = 0{,}307km.5{,}4\frac{m}{km}.15\% = 1{,}9m$$

In this manner:

$$H_{pump} = H_{geod} + H_u + 0{,}4 + H_r = 6{,}01 + 0{,}6 + 0{,}4 + 1{,}9 = 8{,}91m \approx 9m$$

Summing up, choose (1+1) pumps with the characteristics:

$$Q_p = 6\frac{l}{s} = 21{,}6\frac{m^3}{h},$$

$$H_p = 9m,$$

$$P = 4kW,$$

and the dimensioned caisson will have the dimensions D = 2 m, H=3,6 m
The materials used for the sewer pipes in the rehabilitated portion will be PVC-KG SN 8, with diameters of Dn 250, Dn 400, respectively PAFSIN in the case of Dn 500, distributed as follows:

Table 2. Sewer system rehabilitation pipelines

Street	L (m)	Material	D mm
Calea lui Traian	2.015	PAFSIN	600
Dragoș Vrânceanu	548	PVC	250
Blocks area	509	PVC	250
Total			

The values obtained following the appropriate methodology, indicated by design standards and norms, are the basis for the sizing of the works required for the rehabilitation of the sewerage system.

CONCLUSIONS

The locality existing sewage system worked without pumping, by gravity. The section that led the waste water to the treatment plant was found to be in a bad condition that requires several interventions, and the fact that it is not located in the public domain creates difficulties. Therefore, in order to fix these problems and and overcome the repair restrictions, it is proposed to place a sewage pumping station that will discharge into the extensive sewerage network.
In the waste water sewage system, the highest energy consumption is caused by pumping activity; the present paper aims, through the technical solutions presented, to lead to a

minimal environmental impact generated by energy consumption. The calculation methods used and the pumping installations choice rise to maximum energy performances, therefore complying with the condition of low impact.

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