Storm-water Management in Industrial Areas in Built-Up Area and Non-Built-Up Areas of Localities

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Abstract. The theme of the paper is managing the storm-waters of industrial areas located in built-up and non-built-up areas of localities. In order to better administer the storm-water in localities, it is necessary to have a study on water management of these rainfall waters, in which a plan of implementing it will be included. Until the implementation of these studies, the water management of rainfall waters in the industrial areas will be carried out independently, but which must consider the solutions provided for it, in the study for each locality. The storm-water sewerage system for industrial areas must consider: the location of the objective towards the locality, the nature of the land, the existing sewage system of the locality, the existence of water courses and the drains in the studied area. The most optimal technical solutions for the collection, storage, treatment and disposal/use of meteoric waters from industrial zone premises shall be analyzed.

1. Introduction
Currently, most localities in Romania do not have a centralized rainfall sewerage system. The lack of this centralized system makes the rainfall waters within the localities freely directed through the slope of the land to the lowest located areas.

These areas are frequently prone to floods and there is no control over the management of rainfall waters. With climate change, the phenomenon of flooding for these localities is becoming more and more acute, which is why it is necessary to carry out studies for the management of these waters of each locality. In drawing up these studies, account must be taken of the terrain, the nature of the land, the development of the locality and the watercourses in the area. For the development of industrial areas, it is necessary that the proposed solutions for the management of rainfall waters within the objectives are correlated with the study of a centralized rainfall sewerage system of the locality [1-3].

2. Management of rainfall waters inward city limits
With the management of the rainfall waters on the hearth of the localities, the risk of flooding of areas prone to be flooded is reduced.
The implementation of centralized rainfall sewerage system ensures the protection of groundwater and surface water against pollution. Framework Directive 2000/60/ED requires that the management of rainfall waters be carried out in a separate system [4].

3. Technical solutions for water management of rainfall waters in industrial zones situated inward and outward of city limits

For newly developed industrial areas, the proposed technical solutions for the establishment of a centralized meteoric sewerage system must ensure the collection, transport, treatment and storage or discharge of meteoric waters from the objective premises [1-3].

The size of the centralized meteoric sewerage system shall be based on the nature of the land, the area of the enclosure, the flow coefficient of the surfaces, the calculation flow, the diameter of the channel sections, the hydraulic slope and the calculation speed [5, 6, 7]. For example, an industrial area for storage, clean production and complementary functions located inward of the municipality of Timisoara is considered. The total area of the industrial area is \( S = 248,100 \text{ sqm} = 24.81 \text{ ha} \), being studied in 3 independent lots.

Rainwater, from the streets that will be ceded to the public domain, will be collected through street gutters, passed through hydrocarbon decanters-separators (DSH1, DSH2 and DSH3) and discharged to the proposed retention basins (BR1, BR2 and BR3). The storm shall be carried out independently for each lot, consisting of:
- rainfall sewer system;
- decanter-separator of hydrocarbons;
- retention basin;
- rainfall pumping station;
- discharge pipe;
- river mouth.

3.1. LOT 1

Rainwater on the roadside of LOT 1 shall be collected separately from rainwater from the roof of buildings.

Rainwater on the road side is collected via drains and discharged into the proposed storm sewer network of PVC-KG, SN8, 315 mm, 400 mm and 500 mm tubes, with a total length of 2470 m, 46 manholes and passed through a hydrocarbon separator with a coalescent filter and bypass.

Rainwater from the roof of each building will be collected through a storm sewer network made of PVC-KG, SN8, 315 mm, 400 mm and 500 mm tubes, in a total length of \( L = 2138 \text{ m} \), 45 manholes and discharged into the proposed retention basin. In the retention basin, rainwater from the roadway which is previously passed through a hydrocarbon decanter-separator is also stored.

Conventionally clean waters from the retention basin will be discharged into the HCn 1228/3 drainage channel in the site area by means of a discharge pipe and a spillway.

The class of importance of use according to STAS 4273-83 is class IV:

The flow of meteoric waters falling on road surfaces and green areas is:

\[
Q_p = m \cdot S \cdot \varphi \cdot i
\]
Where:
- $\phi$ – average coefficient = \(\frac{(4.9601 \times 0.8 + 3.1897 \times 0.05)}{8.1498} = 0.51\) – for green zone, road part
- $m = 0.80$ - $t < 40$ minutes.

The total area of objective is:
- $S_{total} = 8.1498$ ha

The rain time will be:
- $t_p = 12 + \frac{L1}{60} \cdot V = 12 + \frac{800}{60} \times 0.7 = 31$ min.

According to STAS 9470-73 zone 13 $f_1/2i = 100$ l/sec.ha
- $Q_{\text{road+gz}} = m \cdot S \cdot \phi \cdot i = 0.8 \cdot 8.1498 \cdot 0.51 \cdot 100 = 332.51$ l/s

The hydrocarbon decanter-separator shall be sized at a flow rate of 350 l/s and shall collect sand and oils accidentally from the vehicles on the roadway of the studied area.

The flow of meteoric waters falling on the surface of the roofs is:

$$Q_p = m \cdot S \cdot \phi \cdot i$$

Where:
- $\phi$ – rainfall coefficient = 0.95 – for roofs
- $m = 0.80$ - $t < 40$ minutes.

The total area of the lens is:
- $S_{total} = 6.1440$ ha

The rain time will be:
- $t_p = 12 + \frac{L1}{60} \cdot V = 12 + \frac{800}{60} \times 0.7 = 31$ min.

According to STAS 9470-73 zone 13 $f_1/2i = 100$ l/sec.ha
- $Q_{\text{proof}} = m \cdot S \cdot \phi \cdot i = 0.8 \cdot 6.1440 \cdot 0.95 \cdot 100 = 466.94$ l/s

The total flow of rainwater from the surface of the roof shall be:
- $Q_p = 466.94 + 332.51 = 799.45$ l/s

The retention basin ensures the storage of water during the rain of a volume of 1,560 m3.
- $V = Q_p \cdot t_p = 799.45 \cdot 10^{-3} \cdot 31 \cdot 60 = 1486.97$ mc

The dimensions of the retention basin are: $H = 1.5$ m, $L = 52.00$ m and $B = 20$ m.

The discharge pipe will discharge a flow of:

$$Q_{\text{evauated}} = m \cdot S_{\text{grass}} \cdot \phi_{\text{grass}} \cdot i = 0.8 \cdot 14,3092 \cdot 0.05 \cdot 100 = 57,23$$ l/s – considering the entire surface of the objective to be grass.

The proposed rainwater discharge pipe is from PE-HD, PE100, PN6, 315x18.7 mm, in a total length of $L = 45$ m.

The flow rate $Q = 799.45$ l/s was determined for a maximum rain of $f_1/2$, for a rain time of 31 min. The flow of meteoric water over one year from the area considered 143, 092 sqm, (total area of the objective), is calculated according to the annual average dropped on the area concerned (592 l/m2 year, conf. data from P.U.G. Timisoara Municipality).

The annual flow rate on the area considered shall be:
- $Q = 592$ l/m2 year x 143. 092 m2 = 592 x 10-3 x 143. 092 = 84.710.46m3/year
3.2. LOT 2
Rainwater on the roadside of LOT 2 shall be collected separately from rainwater from the roof of buildings.

Rainwater on the road side is collected via drains and discharged into the proposed storm sewer network of PVC-KG, SN8, 315 mm, 400 mm and 500 mm tubes, in a total length of \( L = 940 \) m, 19 manholes and passed through a hydrocarbon separator with coal filter and bypass.

Rainwater from the roof of each building will be collected via a storm sewer network made of PVC-KG, SN8, 315 mm, 400 mm and 500 mm tubes, with a total length of 852 m, 17 manholes and discharged into the retention basin Proposed. In the retention basin, rainwater from the roadway which is previously passed through a hydrocarbon decanter-separator is also stored.

Conventionally clean waters from the retention basin will be discharged into the HCn 1207/7 drainage channel in the site area by means of a discharge pipe and a spillway.

The class of importance of use according to STAS 4273-83 is class IV: **The flow of meteoric waters falling on road surfaces and green areas is:**

\[
Q_p = m \cdot S \cdot \phi \cdot i
\]

Where:
- \( \phi \) – average coefficient = \((1.9290 \times 0.8 + 1.2265 \times 0.05)/3.1555 = 0.51\) – for green zone, roadside
- \( m = 0.80 \) - \( t < 40 \) minutes.

The total area of the objective is:
- Total \( S = 3.1555 \) ha

The rain time will be:
- \( t_p = 12 + \frac{L}{60} \cdot V = 12 + \frac{500}{60} \cdot 0.7 = 23.90 \) min

According to STAS 9470-73 zone 13 \( f \) \( 1/2 \) \( i = 115 \) l/sec ha

\[
Q_{p\text{roadside+gz}} = m \cdot S \cdot \phi \cdot i = 0.8 \cdot 3.1555 \cdot 0.51 \cdot 115 = 148.05 \text{ l/s}
\]

The hydrocarbon decanter-separator shall be sized at a rate of 150 l/s and shall collect sand and oils accidentally from the vehicles on the roadway of the studied area.

**The flow of rainfall waters falling on the surface of the roofs is:**

\[
Q_p = m \cdot S \cdot \phi \cdot i
\]

Where:
- \( \phi \) – coefficient of drain = 0.95 – for roof
- \( m = 0.80 \) - \( t < 40 \) minutes.

The total area of the lens is:
- Total \( S = 2.346 \) ha

The rain time will be:
- \( t_p = 12 + \frac{L}{60} \cdot V = 12 + \frac{500}{60} \cdot 0.7 = 23.90 \) min

According to STAS 9470-73 zone 13 \( f \) \( 1/2 \) \( i = 115 \) l/sec ha

\[
Q_{p\text{roof}} = m \times S \times i = 0.8 \times 2.346 \times 0.95 \times 115 = 205.04 \text{ l/s}
\]

The total flow of rainwater from the surface of lot 2 shall be:
- \( Q_p = 148.05 + 205.04 = 353.09 \text{ l/s} \)

The retention basin ensures the storage of water during the rain of a volume of 522 m³.
The dimensions of the retention basin are: H = 1.5 m, L = 29.00 m and B = 12 m.

The discharge pipe will discharge a flow of:
\[ Q_{\text{evaluated}} = m \cdot S_{\text{grass}} \cdot \varphi_{\text{grass}} \cdot i = 0.8 \cdot 5.5169 \cdot 0.05 \cdot 115 = 25.37 \text{ l/s} \]

- considering the entire surface of the objective to be grass.

The proposed rainwater discharge pipe is from PE-HD, PE100, PN6, 200x11.9 mm, in a total length of L = 21 m.

The flow rate Q= 353.09 l/s was determined for a maximum rain of f 1/2, for a rain time of 23.90 min.

The flow of meteoric water over one year from the area considered 55169 sqm, (total area of the objective), is calculated according to the annual average dropped on that area (592 l/m² year, conf. data from P.U.G. Timisoara Municipality).

The annual flow rate on the area considered shall be:

- \[ Q = 592 \text{ l/m² year} \times 55169 \text{ m²} = 592 \times 10^{-3} \times 55169 = 32.660.05 \text{ m³/year} \]

3.3. LOT 3
Rainwater on the roadside of LOT 3 shall be collected separately from rainwater from the roof of buildings.

Rainwater on the road side is collected via drains and discharged into the proposed storm sewer network of PVC-KG, SN8, 315 mm, 400 mm and 500 mm tubes, with a total length of 600 m, 13 manholes and past through a hydrocarbon separator with a coalescent filter and bypass.

Rainwater from the roof of each building will be collected via a storm sewer network made of PVC-KG, SN8, 315 mm, 400 mm and 500 mm tubes, with a total length of 571m, 12 manholes and discharged into the retention basin Proposed. In the retention basin, rainwater from the roadway which is previously passed through a hydrocarbon decanter-separator is also stored.

Conventionally clean waters from the retention basin will be discharged into the HCn 1228/3 drainage channel in the site area by means of a discharge pipe and a spillway.

The class of importance of use according to STAS 4273-83 is class IV:

The flow of meteoric waters falling on road surfaces and green areas is:
\[ Q_p = m \cdot S \cdot x \cdot i \]

where:
- \( \rho \) – average coefficient \( = (1.0698 \times 0.8 + 0.7180 \times 0.05) / 1.7878 = 0.49 \) – for green zone, part Carriageway
- \( m = 0.80 \) - t <40 minutes.

The total area of the lens is:
\( S_{\text{total}} = 0.7776 \text{ ha} \)

The rain time will be:
\[ t_p = 12 + \frac{L1}{60} \times V = 12 + \frac{310}{60} \times 0.7 = 19.38 \text{ min.} \]

According to STAS 9470-73 zone 13 f 1/2 i = 138 l/sec.ha

\[ Q_{\text{roof}} = m \times S \times i = 0.8 \times 1.7878 \times 0.49 \times 138 = 96.71 \text{ l/s} \]

The hydrocarbon decanter-separator shall be sized at a rate of 100 l/s and shall collect sand and oils accidentally from the vehicles on the roadway of the studied area.

The flow of meteoric waters falling on the surface of the roofs is:

\[ Q_p = m \cdot S \cdot x \cdot i \]

Where:

- \( \rho \) – drain coefficient = 0.95 – for the roof
- \( m = 0.80 - t < 40 \text{ minutes.} \)

The total area of the lens is:

\[ S_{\text{total}} = 0.7776 \text{ ha} \]

The rain time will be:

\[ t_p = 12 + \frac{L1}{60} \times V = 12 + \frac{310}{60} \times 0.7 = 19.38 \text{ min.} \]

According to STAS 9470-73 zone 13 f 1/2 i = 138 l/sec.ha

\[ Q_{\text{roof}} = m \times S \times i = 0.8 \times 0.7776 \times 0.95 \times 138 = 81.55 \text{ l/s} \]

The total flow of rainwater from the surface of lot 3 shall be:

\[ Q_3 = 96.71 + 81.55 = 178.26 \text{ l/s} \]

The retention basin ensures the storage of water during the rain of a volume of 210 m³.

\[ V = Q_p \cdot t_p = 178.26 \times 10^{-3} \times 19.38 \times 60 = 207.28 \text{ mc} \]

The dimensions of the retention basin are: \( H = 1.5 \text{ m}, L = 20.00 \text{ m}, B = 7 \text{ m}. \)

\[ Q_{\text{evapot}} = m \times S_{\text{grass}} \times \varphi_{\text{grass}} \cdot i = 0.8 \times 2.5808 \times 0.05 \times 138 = 14.24 \text{ l/s} – \text{considering the entire surface of the objective to be grass.} \]

The proposed rainwater discharge pipe is from PE-HD, PE100, PN6, 160x9.5 mm, in a total length of \( L = 19 \text{ m}. \)

The flow rate \( Q = 178.26 \text{ l/s} \) was determined for a maximum rain of f 1/2, for a rain time of 19.38 min.

The flow of meteoric water over one year from the area considered 55169 sqm, (total area of the objective), is calculated according to the annual average dropped on that area (592 l/m² year, conf. data from P.U.G. Timisoara Municipality).

The annual flow rate on the area considered shall be:

\[ Q = 592 \text{ l/m² year} \times 25808 \text{ m²} = 592 \times 10-3 \times 25808 = 15.278.33 \text{ m³/year} \]

Figure 1 shows the industrial zone consisting of the 3 independent lots.
4. Conclusions
The technical solution adopted for the industrial area studied contributes to reducing the risk of flooding of the 3 proposed lots and to the protection of groundwater and surface water in the objective area.

Conventionally clean waters stored in the 3 retention basins can be discharged into the existing drainage channel in the area or used for the maintenance of greenspaces, for washing the roadways, for washing the sewer sections or for fire as an additional source of water. Depending on the nature of the land, the retention basins can be opened with a drain base to infiltrate the water into the groundwater thus ensuring the water circuit in nature.

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