THE EFFECT OF RAINFALL ON ACTIVITY OF THE SEWAGE CO-SYSTEM IN RIGA

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Abstract

The human influence on hydrological cycle has created many surface problems in the Riga city. Rainfall amount increases year after year as a result of global warming and bad water exchange. Solid covering of squares and greened areas is one of the most significant results of urban development causing larger rainwater runoff from the territories and calling for the necessity to drain rain water rapidly in a short time. This phenomenon is observed in the last years due to the fast construction development and simultaneous expansion and improvement of streets and court yards. The main problem matter is the still existing old sewage co-system which encounters difficulties to work with full capacity during long term rainfall.

Thus justifiable steps have to be taken in order to discover new engineering solutions to prevent overflow of streets in Riga during rains. To enquire into the matter, rain intensity in Riga, influence of rainwater on streets, overflowing of collectors, and operation of pumping stations are studied in this paper. Rain intensity measurements during 1980-2006 in Riga have been aggregated. As acquired data shows, maximum rain intensity was observed on July 30 of 2005 when the rainfall was 49.4 mm during a 3-hour time, which caused overflowing of some streets, collectors, and pumping stations. Data on local and main pumping stations at the right bank of the river Daugava during various rainfalls suggest that pumping stations start to overflow during enduring rainfalls, 1-3 hours long and with average intensity of 0.1-0.4 mm min⁻¹ (Ziemelnieks, Tilgalis, 2008). Data gathered indicate, that it is necessary to separate sewage systems for everyday necessities from those for rainwater.

Key words: rainfall, precipitation, rain intensity, sewage systems, pumping stations.

Introduction

The routine problem of Riga city in the 21st century is traffic jams that arise from several positive aspects: development of the state economy, welfare, development of technology, and its availability. The fact that precipitation is not duly collected causes additional traffic jams. It is delayed by outdated sewage collection systems, insufficient capacity of pumping stations and sewage purification plants (SPP), and insufficient rainwater management (Tilgalis, Silke, 2003). As a consequence, if pumping stations are not able to process sewage it is necessary to open overflows and unpurified sewage freely flows into the river Daugava. Usually precipitation problems of the sewage arise in summer months, however, recently it has been happening also in winter due to global warming.

It would be useful to reconstruct and separate rainwater sewage from the existing sewage co-system, but it cannot be accomplished rapidly because should be taken into account. Future development concept of the city, changes in the street width, and possibility of an underground construction. It is practically impossible to lay pipes in the largest part of the center of Riga and to accomplish development of the collection reservoir due to the high value of land.

In the accounting program of an automated pumping station of ‘Rīgas Ūdens’ Ltd, nondurable periodic strong rainfalls do not directly influence overflowing of the streets of Riga and do not cause problems with the pumping of sewage in the main pumping stations.

In Latvia, during summer, rainfalls with average intensity do not exceed 2 mm min⁻¹ (Sarma, 1990). The average rainfall intensity in Riga according to calculations is:

0.7 mm min⁻¹ on average in 20 minutes, 1.1 mm min⁻¹ on average in 10 minutes, 3.4 mm min⁻¹ during the first minute (Hydraulic model analysis for sewage network system of Riga, 1999).

Problems are caused by enduring rain that is
from 60 minutes to 2 or 3 hours long with average strong intensity, 0.1-0.4 mm min⁻¹ provided the rain cloud is equally located over the entire city.

Materials and Methods

Publicly available data of the Latvian Environment, Geology, and Meteorology Agency for the period of 1980-2006, i.e., for 27 years, was used to perform the study.

Detailed data was analyzed from May 1 to October 1 when the strongest and largest precipitation take place that are manifested as liquid precipitation, rain, rain storm, and thunderstorm.

Hourly precipitation data was acquired in the center district of Riga by applying measuring method of Tretyakov gauge (Sarma, 1990). Minute data of precipitation was acquired from a pluviograph type P-2 for instruction reports TM-14. Average intensity was determined by analyzing minute, 3-hour, 9-hour, and 24-hour precipitation data in a time period in a set average intensity, which was then compared to the productivity of the main pumping station of Riga during rain.

According to the acquired data and by applying software Excel, data is classified and arranged in tables for calculations precipitation values and to draw diagrams.

Data available in the automated sewage pumping station accounting program was used for the period starting from 2000 on the operation of pumping stations in emergency mode and during drought.

Results and Discussion

It was observed that in the territory of Riga during strong rain it was raining with various intensities but the rain cloud had not affected the entire city. In these occasions only some local pumping stations were endangered as well as collectors and streets aligning to these stations. But it did not cause inability to pump the sewage in the main pumping stations. Temporary rainfalls with average strong intensity are accepted well by the co-system sewage system by gradually filling in the collector with no overload that operates as a collection reservoir.

From the data of 1980 - 2006 it was observed that precipitation had reached the maximum on June 1 of 1985 when during rainstorm in a 3-hour period rainfall was 47.9 mm and on July 30 of 2005 in a 3-hour period rainfall was 49.6 mm and in a 9-hour period 47.2 mm. The average intensity at 49.4 mm per 3h was 0.3 mm min⁻¹. By observing average intensity in a 3-hour period within 27 year period during moderate rain intensity, it was observed 0.07 mm min⁻¹, but on average during 9-hour period 0.02 mm min⁻¹.

Figure 1 shows average rainfall in Riga in the month of July during the period of 1980 to 2006.
Strong and enduring precipitation reflects on the operation of sewage pumping stations and may cause floods on the driving section of the streets. Floods caused in the center streets of Riga signify that the sewage system is too full and pumps are not able to process sudden rainwater runoff and sewage. Almost every time, when rainwater had overflooded sewage collectors, an emergency release of the main over-pumping station located on the right side of the river Daugava was used (Tilgals, Juhna, Ziemelnieks, 2006). Sewage of the central district is collected in the pumping stations located in 7 Hanzas Street, 16a Eksporta Street, 28 Eksporta Street, 3 Grostonas Street, and 16 Elizabetes Street where they come together in the main pumping station of the right side of the river Daugava in 2 Ilzenes Street (Tilgals, Sīļke, 2000). Some data is inaccurate, especially during strong rain storms when waving of water is observed in the collector of network pumping stations. This is regularly taking place in the pumping station in 7a Hanzas Street therefore measuring units there show inaccurate data. Exception is the pumping station in 16 Eksporta Street which even during the smallest rain storms (approximately 0.4 mm min\(^{-1}\)) is overflowed constantly because unfortunately the calculated pump of 120 l s\(^{-1}\) has been selected with too low productivity.

Rain intensity during an hour can change considerably as can be seen from the example of rainfall data measurements on 13 August 2001 (see Fig. 2).

\[\text{Time T, min}\]
\[\text{Rainfall intensity I, mm min}\(^{-1}\)\]

Figure 2.
Precipitation on 13 August 2001 (from 4:05 p.m.- to 5:05 p.m.).

Up to now it has not been precisely calculated how much time is necessary for rainwater to reach a pumping station and it depends on a flow amount, speed, pipeline decline and level of silting and it will be researched.

Problems for pumping stations arise if rain pours in the entire territory of Riga evenly for at least 1-3 hours (Ziemelnieks, Tilgals 2007). As can be seen from the Figure 2 above, after short, sudden rain storms with average intensity during the time observed (0.3 mm min\(^{-1}\) and maximum intensity 1.13 mm min\(^{-1}\) ) do not cause problems in pumping stations but cause them locally on streets because water is unable to flow away rapidly from the driving section to gullies or to be absorbed by any surface that is permeable to water.

Table 1 shows data on the operation of these pumping stations during rainstorm in comparison to dry period showing over-pumped amount of sewage that was observed on June 28 of 2007 in Riga during the time period from 3:00 p.m. to 6:00 p.m. and rainfall was 17.2 mm (average strong rain storm).
## Working regime of pumping stations

<table>
<thead>
<tr>
<th>Pumping station</th>
<th>Productivity drought period, m³ dnn⁻¹</th>
<th>During rain, m³ dnn⁻¹</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Ilzenes Street (the main pumping station on the right side of the river Daugava)</td>
<td>40 000-50 000</td>
<td>117 020</td>
<td>Pumping station operated with maximum productivity of ~14 800 m³ h⁻¹</td>
</tr>
<tr>
<td>2b Eksporta Street</td>
<td>1870</td>
<td>9520</td>
<td>Pumping station operated with max productivity of ~1480 m³ h⁻¹</td>
</tr>
<tr>
<td>7 Hanzas Street</td>
<td>8920</td>
<td>20 880</td>
<td>Pumping station operated with max productivity of ~2800 m³ h⁻¹</td>
</tr>
</tbody>
</table>

Figure 3 shows operation of the main pumping station in 2 Ilzenes Street during and after the rain. The rain was recorded on June 11 of 2005 in 9-hour measurement interval: from 3:00 p.m. to 6:00 p.m. the rainwater was in total 22.4 mm, and from 6:00 p.m. to 03:00 a.m. 27 mm. Rain intensity decreased to 1.8 mm within the interval from 03:00 a.m. to 06:00 a.m. Emergency release of the pumping station opened at 6:00 p.m. and closed at 04:00 a.m.

Strong rainstorm with hail (size of grains 5-8 mm in diameter) was observed in the center and some parts of Riga on May 25 of 2007 from 14:25 to 14:35. Active rain intensity was 3-5 minutes long. The rain cloud moved from Bauska Street district to the center of the city and soon reached Sarkandaugava, and later decreased in the area of Teika and Jugla. On that day in Pārdaugava area there was almost no rain and there was not a significant amount of sewage in the pumping stations. According to observations of the Latvian Environment, Geology, and Meteorology Agency, rain intensity reached maximum in the center of Riga at 14:20 to 14:21 with rainfall of 0.8 mm min⁻¹. According to the measure method by Tretyakov gauge rainfall was 7.7 mm in the center of Riga during the period of 06:00-15:00 I assume that at other time there was no precipitation because automatic rain intensity measuring unit showed no results. The recorded amount of 7.7 mm is not large. As observed on May 25 of 2007 in the center part of Riga after rain 2b Eksporta Street pumping station worked with all 3 pumps full capacity 450-500 l s⁻¹. At 14:36 and 14:42 pumping station suddenly worked with full capacity and it has to be concluded that water of rain precipitation reached the pumping station in approximately 15 minutes from the beginning of rain (see Fig. 4).
On May 27 of 2007 the main pumping station of the right side of the river Daugava in 2 Ilzenes Street at the rain with started to work with additional capacity at 14:44, i.e., approximately 17-20 minutes after it rained. Maximum amount of the sewage pumping (12000 m³h⁻¹) was reached at around 15:00 p.m. and continued till around 18:30. In this case approximately 20 minutes long strong rain with maximum intensity in one minute of 6.7 mm min⁻¹ also affects operation of the main pumping station. Significantly, at this time streets were not overfl owed because rain water was received by the collector at sufficient speed. According to analysis of the pumping station, the rain cloud moved towards Jugla, therefore the sewage was evenly pumped from collected center collectors and later they flowed from direction of Jugla direction and thereby letting the pumping station to work stably with almost full capacity of 12 000 m³ h⁻¹. Also in this case it was necessary to open the emergency release. The pumped amount of sewage on May 29 of 2007 in the pumping station of Ilzenes Street was 110 889.7 m³ dnn⁻¹.

Conclusions

1) Maximum rain intensity in Riga in the time period from 1980 to 2006 was observed on June 29 of 1999 and was 4.87 mm min⁻¹. Rainstorm in 3 hours reached 47.9 mm on June 1 of 1985, and 49.4 mm on July 30 of 2005, but 47.2 mm in a 9-hour period. Maximum rainfall was observed in 2000 when it was 837 mm year⁻¹.
2) Nondurable rainstorm with an average intensity of 1-2(3) mm min⁻¹ does not significantly affect the operation of the main pumping station.
3) Streets are overfl owed less often because during this period sewage collectors do not get full. Usually nondurable precipitation (approximately 5-20 minutes) that occur in summer at rapid vaporization can be easily envisaged and dark skies are also easy to notice by a pumping station dispatcher and he/she duly gets ready and pumps out reservoirs of the main pumping station Ilzenes street 2.
4) Overfl owing of streets and pumping stations occurs if rain is pouring in the entire territory of Riga, at least for 1-3 hours, periodically becoming stronger with impulsive strength maintaining for several minutes at 1-2 mm min⁻¹, which is more characteristic of Latvia's summer months June, July and August. By reviewing data of a 27-year period, the average
intensity in 3 hours at moderate rain intensity was observed to be 0.07 mm min\(^{-1}\), but in 9 hours on average 0.02 mm min\(^{-1}\).

5) In the future when electricity will become more expensive it would be useful to invest assets for a construction of a separation system for the sewage system to avoid necessity for several pumping stations to overpump inflowing water when, as the result, part of it gets in the river Daugava without being purified.

References