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ANALYSIS OF MAXIMUM PRECIPITATION IN THE CENTRAL PART OF LATVIA

Abstract

In this regard, in September 2016, we studied and analysed the maximum amount of three-hour precipitation (mm) in the six cities of the central part of Latvia: Riga, Jelgava, Bauska, Dobele, Jurmala and Ogre. The 1996 to 2016 data were considered. Those were the precipitation data (mm) for the warm period of the year (April to October). However, the data for the cold period (November to March) were also considered. The work concerns: rainwater precipitation (mm), precipitation duration (hours, sec.), maximum volume (mm), intensity (l x s^{-1}x ha^{-1}) and flows (m x s^{-1}).

Introduction. In recent years, the water of long intense rains can be often seen on roadways in major cities of the world (in lowlands, in corners and near aqueducts, under bridges and in underground tunnels, and near rivers and canals); this creates some danger for both vehicle traffic and pedestrians. A traffic jam is also possible – for example, when a car jams in a large deep puddle. Thereby, the authors see a need for research on the way to deflect the heaviest rainwater flows. As a result of research, recommendations will be submitted to the relevant institutions, such as city administrations of large cities, urban development departments, Riga City Council Traffic Department, the Latvian State Roads, “Roads administration” and others. The experience of the Netherlands, one of the European countries, has been studied and analyzed as an example. Here, one third of the territory is below sea level, and a large amount of precipitation may create a situation of national disaster! In this regard, great attention is paid to disposal and recycling of rainwater and storm water in the Netherlands. The scientists constantly explore, forecast, study and analyze the conditions and reasons for large amounts of precipitation fallout, the critical volume of which can lead to a long-term "paralysis" in many areas of human activity, such as: traffic infrastructure, public transport, passenger transportation, rural activities, construction (both general and utilities), improvement of urban infrastructure, etc. (Jakovlevs S., Gusta S. & Tilgalis E., 2016), (Ziemelnieks R. & Tilgalis E., 2007, 2008, 2009), (Langeveld, J.G. et al., 2016), (Boogaard F.C., Van de Ven, F.H.M. & Palsma A.J., 2008), (Kluck J. et al., 2010, 2015), (Govert D. Geldof & Floris Boogaard, 2011).

Materials and methods. The 1996 to 2004 data were obtained from the paper files from the archive of the Latvian Environment, Geology and Meteorology Centre, whereas the 2005 to 2016 data were obtained from the electronic database of the Latvian Environment, Geology and Meteorology Centre (LEGMC, 2016).

The data were obtained for the entire period for the city of Riga. The 2005 to 2016 data were obtained from the weather station “Riga-Universitate”. For the city of Jelgava, the data were obtained from the weather station “Kalnciems” as of November 1, 2002. For the city of Bauska, no data were obtained in 2009, 2010 and 2015, since the weather station was out of service from March 9, 2009, to September 30, 2011, as well as from April 2, 2015, to December 31, 2015. For the city of Dobele, the data were obtained for the entire period. For the city of Jurmala, the 2005 to 2016 data are missing, because the weather station stopped its operation in 2005. For the city of Ogre, the amount of rainfall was being registered from 2000 to 2014 by the Lielpechi weather station. In 2014, the station stopped its operation, therefore, there are no data for 2014, 2015 and 2016 (LEGMC, 2016).

Table 1 – Maximum 3h precipitation amount (mm) in cities in the central part of Latvia from 1996 to 2016 (LEGMC, 2016)

No.	Year	City					
		Riga	Jelgava	Bauska	Dobele	Jurmala	Ogre
1	1996	36,7	21,3	20,3	22,7	28,7	35,5
2	1997	16,0	26,7	36,8	18,1	21,2	30,2
3	1998	32,3	43,2	**54,2***	40,8	32,1	46,5
4	1999	25,3	28,5	18,0	19,8	20,9	16,2
5	2000	27,4	19,1	17,6	16,7	**68,7***	18,7
6	2001	31,8	31,8	44,1	34,8	31,5	20,4
7	2002	24,2	23,1	19,1	22,5	22,8	14,5
8	2003	14,5	20,1	25,2	14,3	18,9	31,1
9	2004	17,3	29,7	25,7	31,7	18,3	24,7
10	2005	**47,2***	42,4	26,2	35,8	–	23,9
11	2006	20,0	22,2	14,3	39,6	–	19,3
12	2007	23,5	39,7	31,2	30,7	–	35,6
13	2008	14,4	22,7	16,2	12,5	–	18,6
14	2009	36,1	43,7	–	38,4	–	20,5
15	2010	32,3	50,2	–	**44,2***	–	34,2
16	2011	34,2	**68,7***	12,5	28,2	–	**49,4***
17	2012	28,2	22,4	19,3	28,8	–	34,6
18	2013	29,6	24,2	13,2	21,3	–	29,9
19	2014	41,4	39,2	15,5	32,7	–	–
20	2015	38,2	52,2	–	22,2	–	–
21	2016	39,1	35,7	17,6	30,9	–	–
* – Maximum precipitation, mm x $3h^{-1}$;			– – No data, weather station out of service.				

As seen in Table 1, the maximum amount of three-hour rain precipitation in Riga, 47.2 mm, was registered on July 30, 2005, from 18:00 to 21:00. In Jelgava, the maximum amount of three-hour rain precipitation, 68.7 mm, was registered on August 20, 2011, from 06:00 to 09:00. In Bauska, the 54.2 mm rainfall was registered on July 12,1998, from 00:00 to 03:00. In Dobele, the maximum amount of three-hour rain precipitation, 44.2 mm, was registered on July 18, 2010, from 15:00 to 18:00. In Jurmala, heavy rainfall of 68.7 mm was registered on September 5, 2000, during the night. Ogre saw 49.4 mm of rainfall on July 28, 2011, from 18:00 to 21:00 (LEGMC, 2016). The table also shows a large amount of rainfall (35.0 to 45.0 mm) in cities in the central part of Latvia from 1996 to 2016.

In this work, the following research methods were used: Statistical Procession of Research Data; Data analysis; Statistical analysis; Development of a curve for rainfall rates maximum duration with diverse probabilities.

Once the data on rainfall in the central part of Latvia are studied and analyzed, the authors can conclude that the maximum precipitation here falls, as a rule, from July to August (rarer, from June to September). Very rarely, the maximum amount of rain falls in May. Usually, heavy rains fall in the evening or/and in the night (LEGMC, 2016).

Results and discussion. Based on the above data, we can draw a Figure 1 showing the actual three-hour rainfall and the mathematically calculated repeatability of maximum rainfall (1 to 99%). The calculated repeatability shows how often the maximum amount of precipitation falls (from once a year to once in a hundred years). It is a rather satisfactory result obtained from this work, because the global climate changes are very transient, and there will be certainly more accurate and recent data by other scientists and researchers (Latvian Building Code LBN 223-15, 2015).

Then we also have to consider drawing Figure 2 and a logarithmic scale of the recurrence rate of 0.01 to 100.0.

This logarithmic scale shows theoretically how much precipitation may fall during the three-hour period once a year, once every ten years, once every 100 years, once every 1000 years and once in 10,000 years.

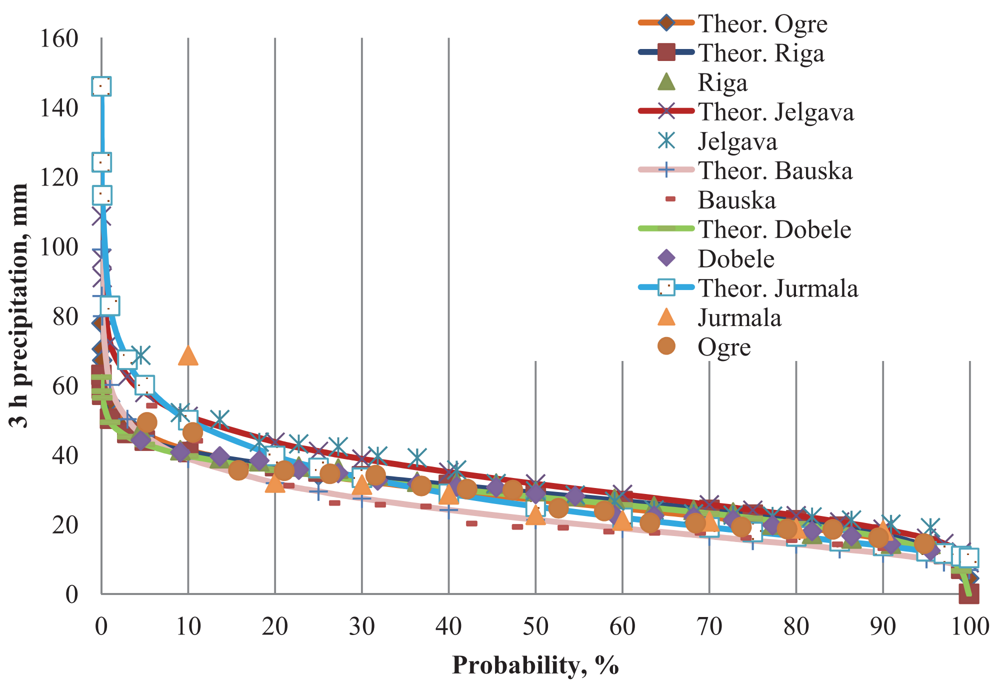


Figure 1 – Maximum 3h precipitation duration curves

For example, according to Figure 2, we can see that 51.15 mm of precipitation may fall potentially in Jelgava once in ten years, the amount of 72.37 mm may fall once in 100 years, 91.02 mm of rain may fall once in 1000 years, and the three-hour rainfall of 108.74 may occur once in 10,000 years.

And for the city of Riga, this probability is: 50.46 mm – once in a hundred years, 57.40 mm – once in a thousand years, and the possibility of 63.03 mm amount of rainfall may occur only once in 10,000 years.

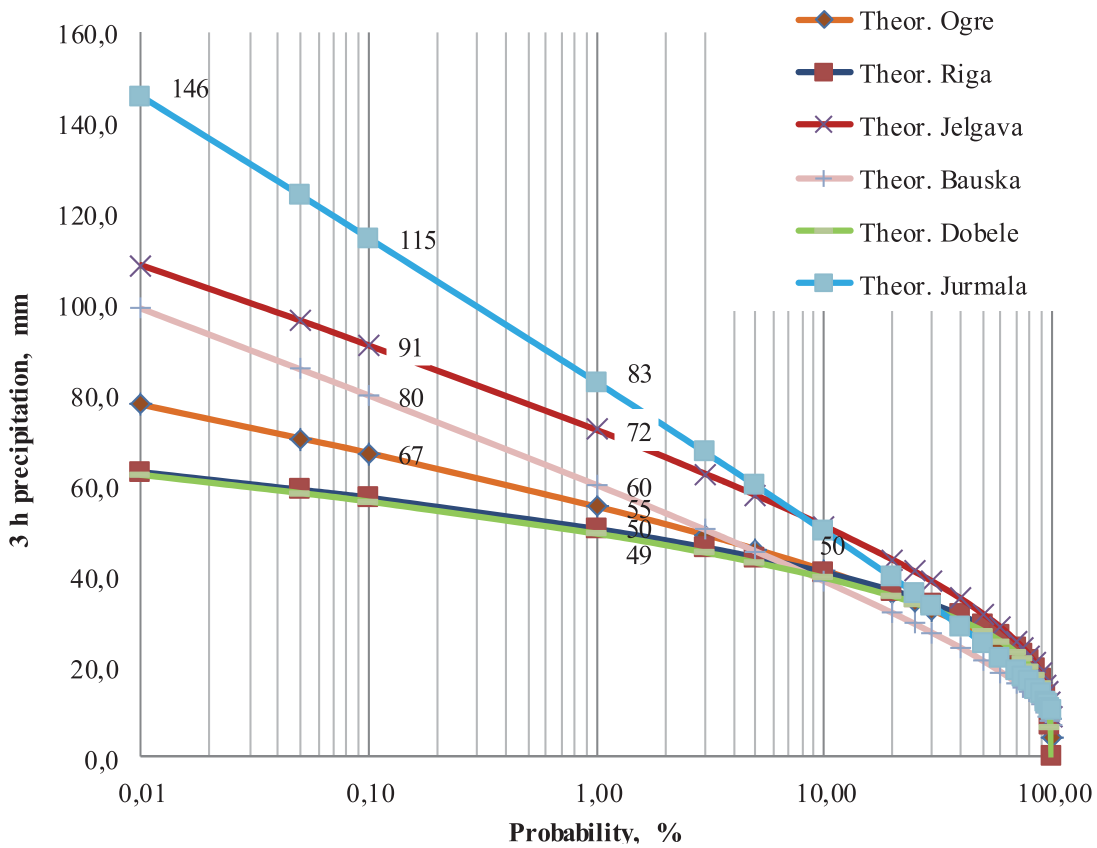


Figure 2 – Maximum precipitation duration curves on a logarithmic scale

But for Jurmala, there is a probability of 146.05 mm – once in 10,000 years, 114.71 mm – once in 1000 years, and 82.91 mm – once in 100 years, etc.

Table 2 shows the detailed data of cities and the % probability of the possible amount of a three-hour rainfall in mm.

According to Figure 3, duration of rain within the considered three-hour period was 180 minutes (from 2:40 to 5:40), and the second period of greatest intensity lasted 115 minutes (3:05 to 05:00). The maximum intensity "flash" was 2.6 mm x min^{-1} at 03:10 (LEGMC, 2016).

By mathematically calculating the average intensity of precipitation, one gets I = 14.2 mm x 180 min^{-1} (3 h) = 0,079 mm x min^{-1} that significantly differs from the observed maximum intensity 2.6 mm x min^{-1} (Figure 3). After analysing hydrographs of rainfall intensity in other cities, we obtained similar results and concluded that we must use in calculations the rainfall amount in mm during a 3-hour period and that the use of these calculations to determine maximum amounts for a 20-minute period requires further careful studies. Currently, weather stations measure the maximum rainfall intensity only every 3 hours. Our future task is to develop a new method for calculation of maximum rainwater by using the available observations made by weather stations every 3 hours.

Table 2 – The % probability of the possible amount of a three-hour rainfall in mm for cities in the central part of Latvia.

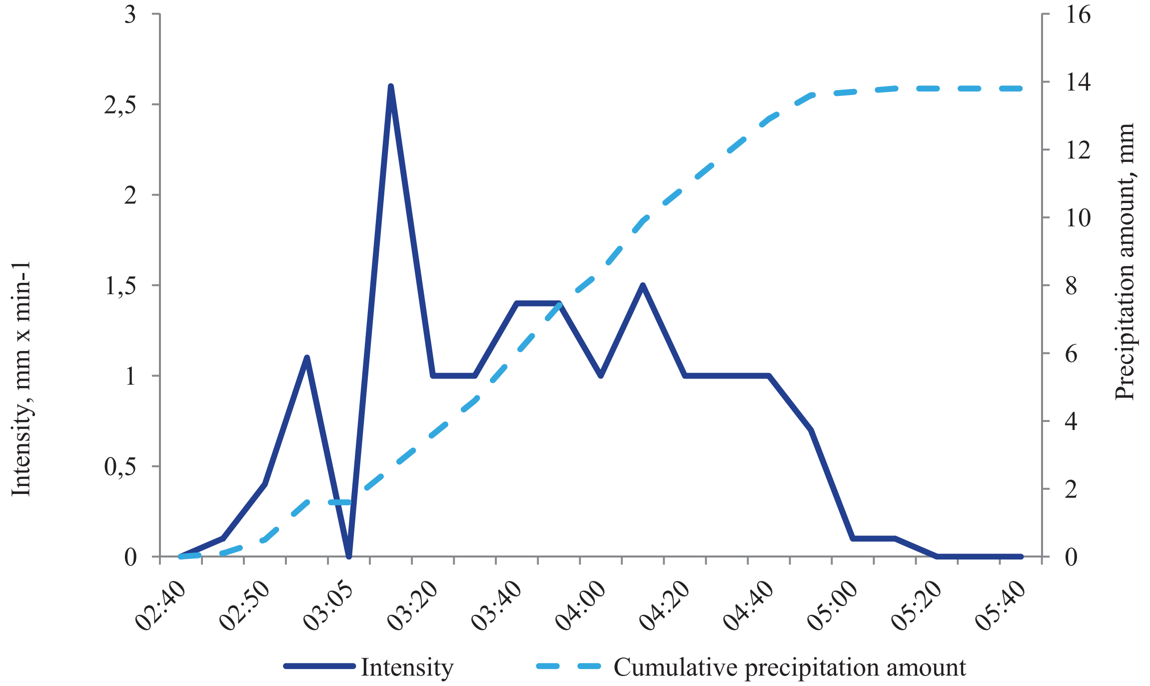
No.	Probability,	City					
	%	Riga	Jelgava	Bauska	Dobele	Jurmala	Ogre
1	0,01	63,0	108,7	99,1	62,4	146,1	77,9
2	0,05	59,1	96,5	85,7	58,4	124,2	70,5
3	0,1	57,4	91,0	79,9	56,5	114,7	67,2
4	1	50,5	72,4	60,2	49,4	82,9	55,4
5	3	46,4	62,7	50,3	45,3	67,4	49,2
6	5	44,2	58,0	45,5	43,0	60,1	46,0
7	10	40,9	51,1	38,9	39,7	50,0	41,4
8	20	36,8	43,7	31,9	35,7	39,7	36,1
9	25	35,3	41,1	29,5	34,1	36,3	34,2
10	30	33,9	38,9	27,5	32,7	33,5	32,5
11	40	31,4	35,1	24,2	30,2	28,8	29,6
12	50	29,1	31,7	21,3	27,9	25,1	27,1
13	60	26,7	28,7	18,8	25,6	21,9	24,6
No.	**Probability,**	**City**					
	%	**Riga**	**Jelgava**	**Bauska**	**Dobele**	**Jurmala**	**Ogre**
14	70	24,2	25,7	16,6	23,1	19,2	22,1
15	75	22,8	24,1	15,3	21,8	17,9	20,8
16	80	21,2	22,6	14,3	20,2	16,6	19,4
17	85	19,4	20,7	12,9	18,4	15,2	17,7
18	90	17,1	18,7	11,7	16,2	13,9	15,8
19	95	13,8	16,1	10,1	12,9	12,3	13,2
20	97	11,5	14,5	9,2	10,7	11,7	11,5
21	99	7,3	12,1	8,0	6,7	10,9	8,7
22	99,9	0,1	9,0	6,9	-0,2	10,4	4,5

Conclusions.

1 As a result, according to the analysis of the methods of calculating the maximum flow of rainwater and meltwater, the authors can state that the methods require constitutional changes, since the same formulas have been used for 42 years already. But today, we use materials with different properties and structure; we also use new technologies in manufacturing of products and installation of equipment. Moreover, now the technical capabilities of the equipment used at construction sites are really impressive.

2 The methods of calculating the maximum flow of rainwater require changes, since a 20-minute period used nowadays cannot reflect the whole picture of the precipitation intensity; however, the three-hour period reveals more details on the duration of rain intensity and "flashes" of its maximum values. These data can be used to improve sewerage of the rain water collected from the surface of roads, roadways, bridges and aqueducts.

3 Moreover, the study analysis shows another trend: in the last decade, the maximum rainfall (mm) was often registered in September and October. Then, a few decades back, the maximum rainfall was usually observed only in July and August. Could it be caused by global climate changes or by large man-induced cataclysms? We need more research, analyses and calculations to answer this question.



igure 3 – A hydrograph of precipitation amount and intensity in Bauska during a 3-hour period from 02:40 AM to 05:40 AM, 16.08.2008 (LEGMC, 2016).

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РАЗРАБОТКА ИНФОРМАЦИОННО-ДИАГНОСТИЧЕСКОЙ СИСТЕМЫ ОЖИВЛЕНИЯ ВОДНЫХ ОБЪЕКТОВ В ГОРОДЕ

С древних времен человек селился у воды. При этом он решал многие проблемы, в первую очередь, водоснабжения и обороны. Со временем стали возникать проблемы загрязнения и истощения рек. Реки стали превращаться в сточные канавы. Решения этих проблем в конце XX века осуществлялось путем разработки и реализации Программ по восстановлению и сохранению рек и водоемов [1]. Для создания благоприятной среды обитания человека в городах и восстановления рек в начале XXI века понадобились значительные финансовые ресурсы, которые зачастую отсутствуют. Такими примерами могут служить разработанные и но к сожалению не утвержденные «Целевая долгосрочная программа по восстановлению малых рек и водоемов города Москвы на период до 2010 года» и региональная целевая программа «Развитие водохозяйственного комплекса Санкт-Петербурга в 2013–2020 годах» [2].

Существующая в городах гидросеть обычно функционально используется в системе отвода и очистки поверхностного стока. Водные объекты, частично деформированные техническими средствами, совместно с городской водосточной сетью образуют единую коллекторно-речную сеть. Современное состояние большинства водных объектов и прибрежных территорий не соответствует действующим экологическим и градостроительным требованиям. В наиболее неблагополучном экологическом состоянии находятся реки, полностью заключенные в коллекторы и утратившие природную самоочищающую способность. Основные загрязнения поступают в реки города через городскую водосточную сеть и непосредственно по рельефу местности с городских территорий. Существующая система пойменных и прибрежных территорий представляет собой фрагментированную цепочку незастроенных площадей с частично сохранившимся озеленением и природными сообществами в различной стадии антропогенной дегрессии. Долины рек трансформированы, подвержены оползневым и эрозионным проявлениям, отдельные участки водоохранных зон захламлены, имеют место несанкционированные свалки, незаконно размещенные постройки, некоторые участки русел рек завалены деревьями и мусором. В результате этого в настоящее время многие экологические функции водной системы и прилегающих территорий, такие как водоохранная, экологическая, частично утрачены, а ландшафтно-рекреационные функции прибрежных территорий недостаточно задействованы в градостроительной практике.

Для решения проблемы, предлагается разработка «Информационно-диагностической системы оживления водных объектов в городе». ИДС «Жемчужное ожерелье города».