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Rainfall parameters for the design of surface water treatment facilities

E D Palagin, A K Strelkov and A A Pavluhin

Samara State Technical University, Architecture and Civil Engineering Academy, 194, Molodogvardeyskaya St., Samara 443001, Russia

E-mail: palagined@mail.ru

Abstract. Summarized data is presented on the maximum rainfall layer, runoff from which should be completely diverted to treatment facilities (runoff from residential areas and industrial enterprises of the first group in the Russian Federation). The calculated values of the precipitation layer are obtained from observations at 238 weather stations located in the Russian Federation, which are necessary for calculating the performance of surface water treatment plants. The results can be used in the design in areas for which these weather stations are representative. The size of the precipitation layer, which ensures the discharge of at least 70% of the annual volume of runoff to sewage treatment plants, for the territory of the Russian Federation is in the range of 2.2–12.8 mm.

1. Introduction

In recent years, the design and construction of wastewater treatment plants for surface runoff treatment, which is one of the most serious sources of pollution of water bodies [1-4], has been actively conducted in the territory of the Russian Federation.

It has an effect on formation of water bodies qualitative composition [1,2], including those water objects which serve as sources of drinking water supply [3]. The qualitative composition of surface run-off is studied sufficiently enough [4-6]. It is characterized by certain seasonal regularities [7-11], typical for a certain region. In quantitative terms, the formation of surface run-off depends on climate conditions [12,13] and on water catchment area characteristics [14,15]. Besides, in modern cities, researchers observe an increase in run-off rate of discharge together with the growth of their urbanization [16-25].

Thus, protecting water bodies from the effects of surface runoff is now very relevant.

2. Problem specification

The volume of rain runoff from the calculated rain W, m3, discharged to treatment plants from residential areas and sites of enterprises, is determined by the formula [14, 15]:

$$W = 10 h_a F \Psi_{mid},$$

where h_a is the maximum rainfall layer, the runoff from which is completely cleaned, mm; Ψmid - average coefficient of runoff for design rain; F - flow area, ha.

The value of the precipitation layer (ha) is determined by the methodology of the Code of Rules 32.13330.2018 Sewerage. External networks and facilities, from the condition of ensuring the discharge of at least 70% of the annual volume of runoff to wastewater treatment plants.

3. Research results

The authors calculated the values (ha) of the maximum daily rainfall layer at 238 weather stations based on the data from the Climate of Russia scientific-applied reference book (prepared in electronic form and posted in the public domain on the VNIIGMI-WDC website). The obtained calculation results are presented in the table 1. An analysis of the data shows that the precipitation layer varies from 2.2 to 12.8 mm and averages 6.4 mm.

Table 1. (a) Rainfall parameters

№	Synoptic Index (WMO)	The name of the weather station	h_a	№	Synoptic Index (WMO)	The name of the weather station	h_a
1	20069	O. Wiese	2.2	41	23383	Agatha	5.8
2	20087	O. Golomyanny	2.7	42	23405	Ust ' -TSIL'ma	5.3
3	20292	Them.E. K. Fedorova	3.2	43	23445	Nadym	6.1
4	20476	Cape Sterlegova	2.7	44	23463	Janov Stan	5.2
5	20667	Them.Popov	2.8	45	23472	Turukhansk	5.7
6	20674	O. Dixon	3.7	46	23552	Tarco-Sale, OGMS	6.1
7	20744	Malye Karmakuly	3.0	47	23631	Berezovo	6.6
8	20891	Khatanga	4.0	48	23662	Only	6.3
9	20982	Volochanka	4.2	49	23678	Verkhneimbatsk	6.0
10	21432	O. Boiler Room	2.6	50	23711	Trinity-Pechora	6.1
11	21802	Saskylakh	3.0	51	23724	Njaksimvol	6.6
12	21908	Jalinda	4.8	52	23734	Oktyabrskoye	6.8
13	21921	Kyusyur	5.4	53	23867	Lar'yak	5.8
14	21931	Anniversary	3.7	54	23884	Bohr	5.4
15	21946	Chokurdah	3.6	55	23891	Baykit	5.7
16	21982	FR.	2.6	56	23914	Cherdyn	6.5
17	22113	Murmansk	4.8	57	23921	Ivdel	7.0
18	22165	Kanin Nose	3.2	58	23933	Khanty-Mansiysk, CGMS-2	6.7
19	22217	Kandalaksha	5.7	59	23955	Aleksandrovskoe	5.8
20	22235	Krasnoshchelye	5.4	60	23966	Vangeli Kanak	6.1
21	22471	Mezen	5.1	61	23986	Severo-Yeniseyskiy	5.7
22	22520	Kem ' -port	5.4	62	24125	Chevrotain	5.3
23	22550	Arkhangelsk	5.7	63	24136	Suhana	4.5
24	22619	Padans	5.7	64	24143	Gargan	5.8
25	22641	Onega	6.0	65	24266	Verkhoyansk	4.0
26	22676	Sura	5.3	66	24329	Selagoncy	5.9
27	22768	Shenkursk	5.5	67	24343	Zhigansk	5.4
28	22802	Sortavala	6.2	68	24382	Ust-MOMA	5.1
29	22820	Petrozavodsk	6.1	69	24507	Tura	5.4
30	22837	Vytegra	6.3	70	24606	Kislokan	6.1
31	23022	Amderma	4.2	71	24641	Viluysk	5.5
32	23032	Marresale,Cape	3.7	72	24661	Segen-Kyuel	8.0
33	23058	Antipayuta	4.4	73	24671	Tompo	6.2
34	23074	Dudinka	5.1	74	24688	Oimyakon	4.6
35	23205	Naryan-Mar	4.7	75	24713	Nakano	5.4
36	23242	new port	4.2	76	24738	Suntar	5.3
37	23256	Tazovsk	5.3	77	24790	Susuman	5.5
38	23274	Igarka	5.6	78	24817	Rich	5.2
39	23324	Petrun	5.1	79	24908	Vanavara	5.2
40	23330	Salekhard, CGMS-2	6.4	80	24959	Yakutsk	5.5

Table 1. (b)

№	Synoptic Index (WMO)	The name of the weather station	h_a	№	Synoptic Index (WMO)	The name of the weather station	h_a
81	24966	Ust-May	6.0	128	28255	Turinsk	6.3
82	24967	Tegyultya	5.7	129	28275	Tobolsk, OGMS	6.1
83	25062	Billings Point	2.6	130	28418	Sarapul	6.3
84	25138	Insular	3.7	131	28434	Krasnoufimsk	5.8
85	25173	Cape Schmidt	3.7	132	28493	Tara, OGMS	5.7
86	25206	Srednekolymsk	4.8	133	28552	Shadrinsk	6.9
87	25248	Ilirnej	3.3	134	28573	Ishim	5.9
88	25282	Cape Vankarem	2.3	135	28666	Makushino	5.7
89	25325	Ust-Oloj	4.8	136	28698	Omsk, OGMS	5.7
90	25356	Enmuveem	6.7	137	28704	Chulpanovo	6.2
91	25378	Egvekinot	8.3	138	28722	Ufa, Dema	6.1
92	25399	Whelan	3.8	139	28748	Troitsk	6.2
93	25400	Zyryanka	5.5	140	29111	Average Vasyugan	6.0
94	25428	Omolon	4.7	141	29231	Kolpashevo	6.0
95	25503	Korkodon	4.8	142	29263	Yeniseisk	5.0
96	25538	Verkhne-Penzhino	4.8	143	29282	Boguchany	4.5
97	25551	Markovo	5.4	144	29313	Pudina	5.9
98	25563	Anadyr	4.2	145	29328	Bakchar	5.6
99	25594	Providence bay	7.0	146	29379	Taseevo	4.7
100	25677	Bering	5.2	147	29570	Krasnoyarsk, op.p.	5.6
101	25705	Srednekan	7.2	148	29594	Taishet	5.5
102	25927	Brohovo	7.3	149	29612	Barabinsk	5.4
103	25932	Taigonos	6.1	150	29645	Kemerovo, AGRO	5.3
104	25954	Corfe	6.0	151	29752	Inclement	9.4
105	25956	The apuka	6.3	152	29789	Upper Gutara	7.5
106	26063	Saint-Petersburg	6.3	153	29866	Minusinsk	6.0
107	26157	Gdov	6.1	154	29939	Rijsk-Zonalna	6.0
108	26275	Staraya Russa	6.2	155	30054	Vitim	5.4
109	26359	Pushkin Mountains	6.5	156	30089	Dzhikimda	6.9
110	26781	Smolensk	7.1	157	30230	Kirensk	5.5
111	26997	Trubchevsk	6.9	158	30252	Mamakan	6.4
112	27037	Vologda	5.9	159	30309	Bratsk, OBS.	5.2
113	27051	The witch	6.0	160	30372	Chara	8.2
114	27333	Kostroma	6.5	161	30385	Ust-Nyukzha	8.6
115	27459	N. Novgorod, Russia	6.8	162	30393	Chulman	8.4
116	27595	Kazan, CGMS	6.7	163	30433	Nizhneangarsk	6.2
117	27612	Moscow, VDNH	7.4	164	30521	Zhigalovo	6.5
118	27648	Elat'ma	7.1	165	30554	Bagdarin	8.7
119	27675	Poretsky	7.0	166	30612	Balagansk	6.3
120	27707	Sukhinichi	7.1	167	30636	Barguzin	7.0
121	27823	Pavelets	6.8	168	30650	Romanovka, AMSG	8.2
122	27857	Zemetchino	6.7	169	30673	Mogocha	8.6
123	27995	Bezenchuk	6.6	170	30710	Irkutsk, OBS.	8.3
124	28009	Kirs	5.9	171	30758	Chita	8.3
125	28064	Leushi	6.3	172	30777	Sretensk	8.2
126	28138	Beads	7.1	173	30844	Khilok	7.9
127	28224	Perm	6.4	174	30879	Nerchinsky z-d	9.0

Table 1. (c)

№	Synoptic Index (WMO)	The name of the weather station	h_a	№	Synoptic Index (WMO)	The name of the weather station	h_a
175	30925	Kyakhta	7.9	207	32389	Keys	6.6
176	30935	Red Chikoy	7.5	208	32477	Sobolevo	8.2
177	30949	Kyra	8.9	209	32509	Seed	11.6
178	30965	Greyhound	8.1	210	32562	Bolsheretsk	8.3
179	31004	Aldan	8.5	211	32618	Nikol'skoe(Bering O.)	5.5
180	31088	Okhotsk	9.5	212	34110	Bogoroditskoe-Fenino	7.5
181	31137	Toko	6.9	213	34123	Voronezh	7.3
182	31152	Nelkan	6.8	214	34152	Balashov	6.7
183	31168	Ayan	12.7	215	34163	The October Town	6.0
184	31174	The Large Shantar	9.1	216	34186	Ershov	6.2
185	31253	Bomb	10.1	217	34579	Upper Baskunchak	5.7
186	31329	Ekimchan	9.8	218	34720	Taganrog	7.9
187	31369	Nikolaevsk-on-Amur	8.5	219	34740	Giant	7.4
188	31416	Them.P. Osipenko	9.0	220	34866	Yashkul'	6.2
189	31439	Bogorodskoe	7.9	221	34880	Astrakhan, GMO	5.2
190	31478	The Sophia mine	9.4	222	34927	Krasnodar, Kruglik	8.8
191	31707	Ekaterino-Nikol'skoye	10.9	223	34949	Stavropol, AMSG	8.1
192	31770	Sovetskaya Gavan	10.2	224	35011	Sorochinsk	5.9
193	31829	Golden	11.5	225	36038	Zmeinogorsk	7.8
194	31960	Vladivostok	11.5	226	36064	Yaylu	8.8
195	31961	Timiryazevsky	10.4	227	36096	Kyzyl (TUV. CGMS)	5.3
196	31989	Transfiguration	12.0	228	36229	Ust ' -Koksa	6.6
197	32027	Perish	7.3	229	36259	Kosh-Agach	3.1
198	32061	Aleksandrovsk-Sakhal.	7.9	230	36307	Erzin	3.2
199	32076	Border	9.9	231	37061	Anapa, MG	8.2
200	32098	Poronaisk	10.7	232	37107	Budyonnovsk	7.4
201	32099	The Mys-Terpenija	9.0	233	37126	Krasnaya Polyana	12.8
202	32150	Yuzhno-Sakhalinsk	10.1	234	37228	Shadzhatmaz	7.2
203	32165	Yuzhno-Kurilsk	11.6	235	37358	Makhachkala	6.4
204	32213	Cape Spatula	8.6	236	37472	Vladikavkaz	10.1
205	32252	Ust ' -Voyampolka	6.0	237	37543	Ahty	6.7
206	32287	Ust-Khayryuzovo	6.8	238	37663	Derbent	7.5

4. Conclusion

The calculated values of the precipitation layer according to observations at 238 weather stations located on the territory of the Russian Federation are necessary for calculating the performance of surface water treatment plants, which can be used in designing in settlements for which these weather stations are representative. The size of the sediment layer, which ensures the discharge of at least 70% of the annual volume of runoff to treatment facilities in the Russian Federation, is in the range of 2.2-12.8 mm.

References

[1] Kichigin V I and Bykova P G 2002 Study of Physical and Chemical Characteristics of Surface Run-off of Settlements *Water Del. & Sanit. Eng.* **11** 28–32
[2] Kichigin V I and Palagin E D 2005 *Modelling of Water Currents Pollution by Surface Run-off* (Samara: SGASU)
[3] Strelkov A K, Shuvalov M V and Gridneva M A 2015 Samara Surface Wastewater and its Impact on Water Sources such as Water Supply *Scien. Survey* **7** 139–43

[4] Bykova P G, Strelkov A K, Palagin E D and Kondrina E E 2010 Quality of Surface Waters Coming from the Territory of the City of Samara to the Saratov Reservoir and the River Samara *Traditions and innovations in architecture and civil engineering: 67th All-Russia Scientific Practical Technical Conf Proc (Samara)* pp 567–9
[5] Palagin E D, Gridneva M A, Bykova P G and Nabok T Yu 2018 Study of Dynamics of the Surface Run-off Composition of Urban Areas *Water Del. & Sanit. Eng.* **1** 51–6
[6] Palagin E D, Gridneva M A, Bykova P G and Nabok T Yu 2013 Patterns of Changes in the Composition of Surface Wastewater *Water Del. & Sanit. Eng.* **12** 56–60
[7] Palagin E D, Bykova P G and Pakhomova U M 2011 Analysing Regularities of Variation in the Quality of Surface Wastewater in Samara *Architecture and Building Engineering* **2** 80–2
[8] Palagin E D, Bykova P G and Pakhomova U M 2011 Analysing Seasonal Variability of the Contents of BOD, Suspended Substances and Petroleum Products in Surface Run-off *Architecture and Building Engineering* **4** 57–9
[9] Palagin E D et al 2017 Urban Land: Study of Surface Run-off Composition and Its Dynamics *IOP Conf Ser: Mater Sci Eng.* **262** 012181
[10] Palagin D E et al 2018 Urban land surface wastewater: dependence of formation and changes in its composition *IOP Conf. Ser.: Mater. Sci. Eng.* **451** 012093
[11] D E Palagin et al 2018 Surface run-off as a factor of water quality in water-supply sources formation *IOP Conf. Ser.: Mater. Sci. Eng.* **451** 012094
[12] Palagin E D, Bykova P G and Pakhomova U M 2011 Study of Basic Patterns in the Formation of Qualitative Composition of Surface Wastewater *Traditions and innovations in architecture and civil engineering: 68th All-Russia Scientific Practical Technical Conf Proc (Samara)* pp 771–4
[13] Palagin E D, Bykova P G and Pakhomova U M 2011 The Influence of Seasonality on the Content of Suspended Substances, BOD and Oil Products in the Surface Run-off *Traditions and innovations in architecture and civil engineering: 68th All-Russia Scientific Practical Technical Conf Proc (Samara)* pp 774–7
[14] Palagin E D, Strelkov A K, Bykova P G, Tsypin A V and Vdovin D V 2016 Parameters of Rainfall for the Determination of the Productivity of Sewage Treatment Plants *Water Del. & Sanit. Eng.* **12** 41–6
[15] Palagin E D, Tsypin A V, Bykova P G and Vdovin D V 2015 Determining the Productivity of Sewage Treatment Plants in the Volga Federal District *Water Del. & Sanit. Eng.* **12** 56–62
[16] Palagin E D, Bukhman N S and Tsypin A V 2014 Determining Estimated Costs and Volumes of Structures in the Regulation of Surface Run-off *Scien. Survey* **9(3)** 823–6
[17] Palagin E D and Tsypin A V 2014 Peculiarities of Calculation of Different Schemes of Surface Run-off Regulation *Traditions and innovations in architecture and civil engineering 71th All-Russia Scientific Practical Technical Conf Proc. (Samara)* pp 763–5
[18] Strelkov A K, Gridneva M A, Nabok M Yu et al 2014 Urbanization Impact on Wastewater and Surface Water Treatment Systems (with Samara as an Example) *Town Planning and Architecture* **4 (17)** 55–62
[19] Strelkov A K, Gridneva M M and Kondrina E E 2012 Monitoring of Changes in Surface Wastewater Discharge in Conditions of Samara City Development *Traditions and innovations in architecture and civil engineering: 69th All-Russia Scientific Practical Technical Conf Proc (Samara)* pp 213–4
[20] Bykova P G and Palagin E D 2012 Factors in water supply sources quality reduction *Traditions and innovations in architecture and civil engineering 69th All-Russia Scientific Practical Technical Conf Proc (Samara)* pp 204–6
[21] Palagin E D, Bykova P G and Gridneva M A 2018 Calculation of the dilution rate in regulating effluent discharge to water bodies *Water Del. & Sanit. Eng.* **1** 24-31
[22] Palagin E D, Gridneva M A, Bykova P G and Nabok T Iu. 2018 Study of the dynamics of surface runoff composition of the urban lands *Water Del. & Sanit. Eng.* **1** 51-6

[23] Strelkov A K, Shuvalov M V and Gridneva M A 2005 Substantiation of Choice and Calculation Method of the Main Ingredients while Selecting a Technological Scheme of Surface Run-off *Purification Improvement of water supply and wastewater systems for natural and wastewater purification (SGASU)* pp 300–10

[24] Bykova P G, Strelkov A K and Anpilogova S Yu 2010 Increasing the Barrier Role of Water Treatment Facilities in the City of Samara *Traditions and innovations in architecture and civil engineering: 67th All-Russia Scientific Practical Technical Conf Proc (Samara)* pp 569–70

[25] Bykova P G and Palagin E D 2012 The Concept of the Target Program "Development of Rainwater Drainage System in Samara" *Traditions and innovations in architecture and civil engineering 69th All-Russia Scientific Practical Technical Conf Proc. (Samara)* pp 246–7