water

Supplementary Material for Manuscript "Dynamization of Urban Runoff Pollution and Quantity"

Description of the methods used to determine the general occurance, timing and strength of the first flush effect

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Figure S4. Correlation pattern for investigated pollutants with parameter b, pollutant EMCs and total pollutant loads with level of significance p = 0.001. Red squares indicating a positive, blue squares a negative correlation coefficient, respectively. P-values are given as numbers.

Description of the methods used to determine the general occurance, timing and strength of the first flush effect

Method 1

Described by Gupta and Saul [11], Method 1 compares the curves of L' and V' plotted versus normalized cumulative time for each rainfall event. In this study, these plots were slightly modified. The L' and V' curves were plotted versus absolute time to derive the absolute time of a potential first flush. This plot allows to determine the maximum difference between L′ and V′. The absolute time at which the maximum difference between L′ and V′ occurs can also be derived and provides information about the time within a rainfall event at which a first flush occurs. For rainfall events where the V′ over the entire rainfall event was greater than L′, the value zero was used for the maximum difference of L'-V'. Absolute time was recorded at each maximum difference for events where at least one positive difference value occurred during the event. Thus, method 1 provides information about the general occurrence as well as the timing of the first flush effect.

Method 2

Method 2, proposed by Geiger [9] compares L' plotted against V' with a 45°-line (bisector) representing a constant pollution concentration over the entire rainfall event. Using method 2, the first flush is considered significant when the difference between the two curves is > 0.2. A difference of 0.2 can theoretically occur over the entire duration of the rainfall event, so the position of the normalized cumulative volume at which a corresponding difference between the two curves occurs was also recorded. This, in relation to the cumulative volume, provides an indication of the first flush occurrence.

Method 3

Presented by Saget et al. [12], method 3 consists of a regression analysis to determine the first flush coefficient, which provides information about the strength of the first flush.

As described in Section 1, for the regression analysis, the data were first log transformed based on Eq. 3 and Eq. 4, where the parameter b represents the slope of the linear regression equation. Consequently, a value of b = 1 corresponds to the 45° bisector line representing a constant pollutant load over the total rainfall event. A further differentiation of the parameter b is made according to Table 1 in the article.

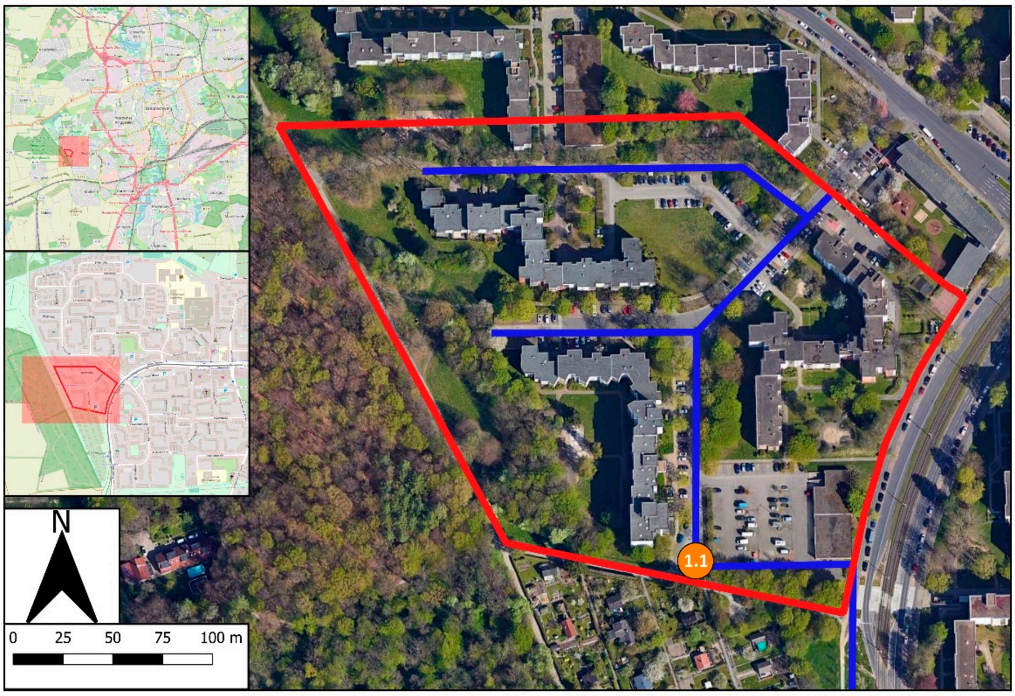

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Table S1. Sampling Program

Date	Sampling Programme	Samples taken
11.10.2020	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-7
18.10.2020	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-7
20.10.2020	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-12
23.10.2020	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-12
30.10.2020	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-9
12.01.2021	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-12

13.01.2021	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-10
18.01.2021	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-3, 5-12
06.05.2021	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-11
11.05.2021	4x 0.5 L every 5 minutes, 4x 0.5 L every 10 minutes, 4x 0.5 L every 18 minutes	1-8

Table S2. List of monitored substances, analytical methods, and limits of quantification (LOQ).

Substance	Device	Method	Unit	LOQ
COD	Cuvette test (LCK Series, Hach Lange GmbH, Germany), spectral photometer (DR 2800, Hach Lange GmbH, Germany)	ISO 6060-1989, DIN 38409-H41-H44	mg L^{-1}	5
TSS	0.45 µm filters (nitrocellulose membrane, GVS Filter Technology, USA)	DIN EN 872	mg L^{-1}	
Total P (as o-PO_4-P)	Cuvette test (LCK Series, Hach Lange GmbH, Germany), spectral photometer (DR 2800, Hach Lange GmbH, Germany)	ISO 6878_2004, DIN EN 6878/D11	mg L^{-1}	0.05
Dissovled P (as o-PO_4)	930 Compact IC Flex (Deutsche Metrohm GmbH & Co. KG, Germany) Metrosep A Supp 7 250/4.0 column (Deutsche Metrohm GmbH & Co. KG, Germany), 850 Professional IC Detector (Deutsche Metrohm GmbH & Co. KG, Germany) and 3.6 mmoL/L Na_2CO_3 eluent ($Na_2CO_3 \cdot H_2O \geq 99.5$ %, p.a., ACS, Carl Roth, Germany)	DIN EN ISO 10304-1	mg L^{-1}	
Nitrate (as NO3)	930 Compact IC Flex (Deutsche Metrohm GmbH & Co. KG, Germany) Metrosep A Supp 7 250/4.0 column (Deutsche Metrohm GmbH & Co. KG, Germany), 850 Professional IC Detector (Deutsche Metrohm GmbH & Co. KG, Germany) and 3.6 mmoL/L Na_2CO_3 eluent	DIN EN ISO 10304-1	mg L^{-1}	

	($Na_2CO_3 \cdot H_2O \geq 99.5$ %, p.a., ACS, Carl Roth, Germany)			
Ammonia (as NH4-N)	ammonia gas-sensitive electrode (NH 500/2, Xylem Analytics Germany Sales GmbH & Co. KG, Germany) and pH/ISE laboratory meter (inoLab® pH/ION 7320, Xylem Analytics Germany Sales GmbH & Co. KG, Germany)	DIN EN ISO 6778:1984	mg L^{-1}	0.02
pH	IDS pH-electrode SenTix® 940 (Xylem Analytics Germany Sales GmbH & Co. KG, Germany) and multi-parameter portable meter MultiLine® Multi 3620 IDS (Xylem Analytics Germany Sales GmbH & Co. KG, Germany)	DIN EN ISO 10523:2008		
Conductivity	universal conductivity measuring cells TetraCon® 325 (Xylem Analytics Germany Sales GmbH & Co. KG, Germany) and multi-parameter portable meter Multi 340i (Xylem Analytics Germany Sales GmbH & Co. KG, Germany)	DIN EN ISO 27888:1993		

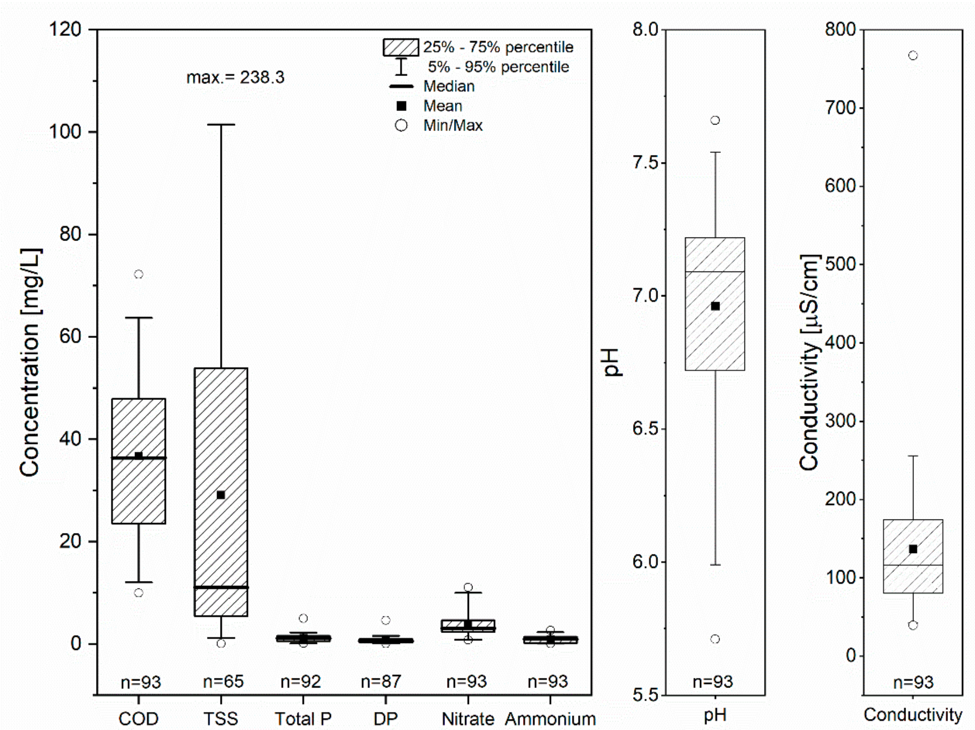


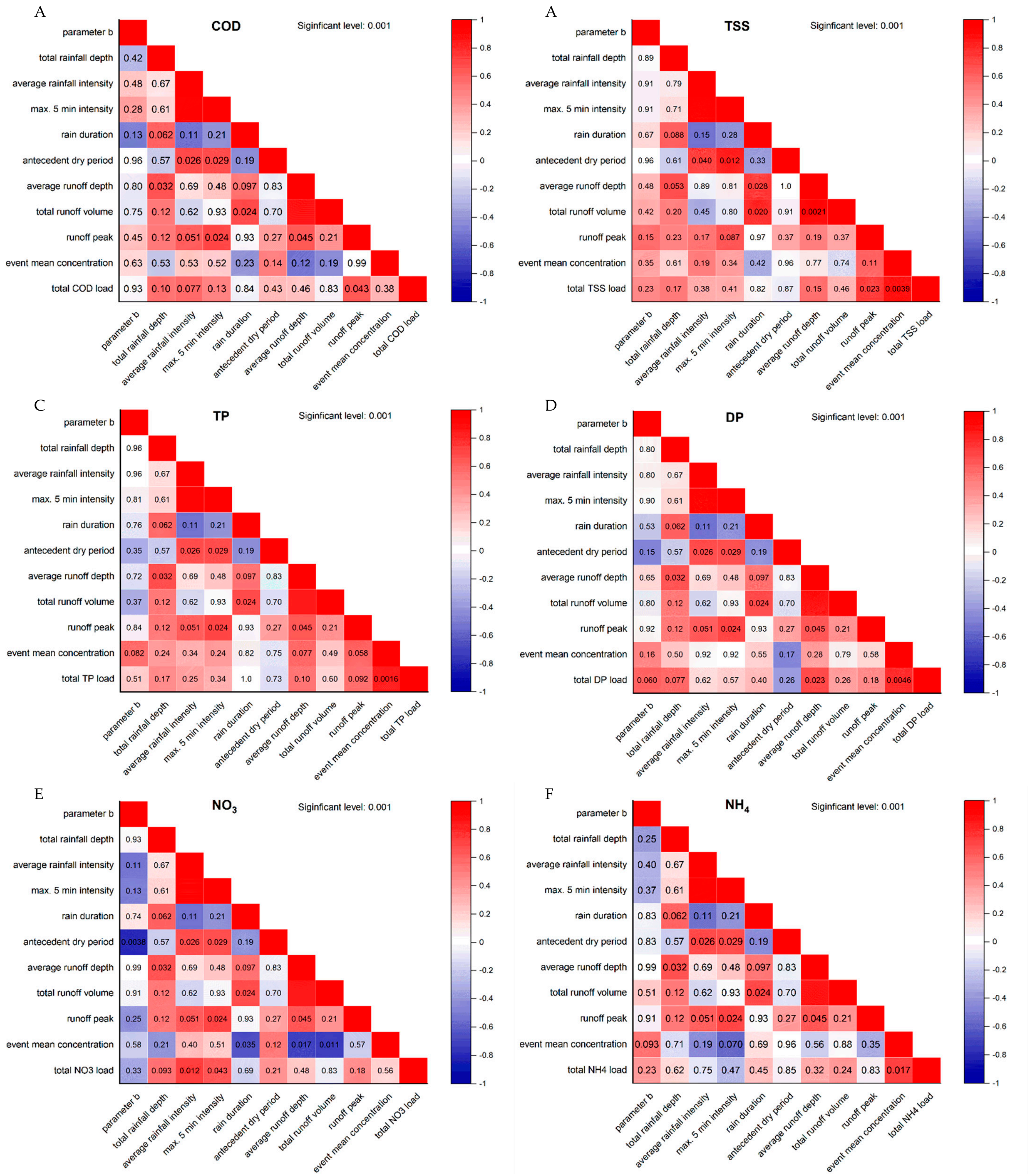
Figure S2. Concentration boxplots of analyzed pollutants in stormwater. Boxes show 25% and 75% percentiles with median as thick line, whiskers show 5%/95% percentiles, n is number of samples.

Table S3. Event mean concentrations of the investigated rainfall events

Date	COD	TSS	TP	DP	NO3	NH4
11.10.2020	33.35	7.16	0.22	0.15	0.87	1.02
18.10.2020	50.49	5.47	0.43	0.19	2.14	0.05
20.10.2020	45.65	10.79	0.45	0.36	0.87	0.15
23.10.2020	28.05	61.07	0.62	0.36	0.43	0.12
30.10.2020	45.89	6.95	0.47	0.36	0.70	0.12
12.01.2021	14.79	2.61	0.13	0.11	0.55	1.25
13.01.2021	35.99	92.78	0.35	0.09	0.71	0.74

18.01.2021	15.44	17.76	0.50	0.48	0.21	0.93
06.05.2021	51.84	N/A	0.23	0.05	1.50	1.41
11.05.2021	49.95	N/A	0.07	0.07	0.74	1.07
Mean	37.14	25.57	0.35	0.22	0.87	0.69
Stand. Dev.	13.33	30.97	0.17	0.15	0.53	0.50

N/A Data not available



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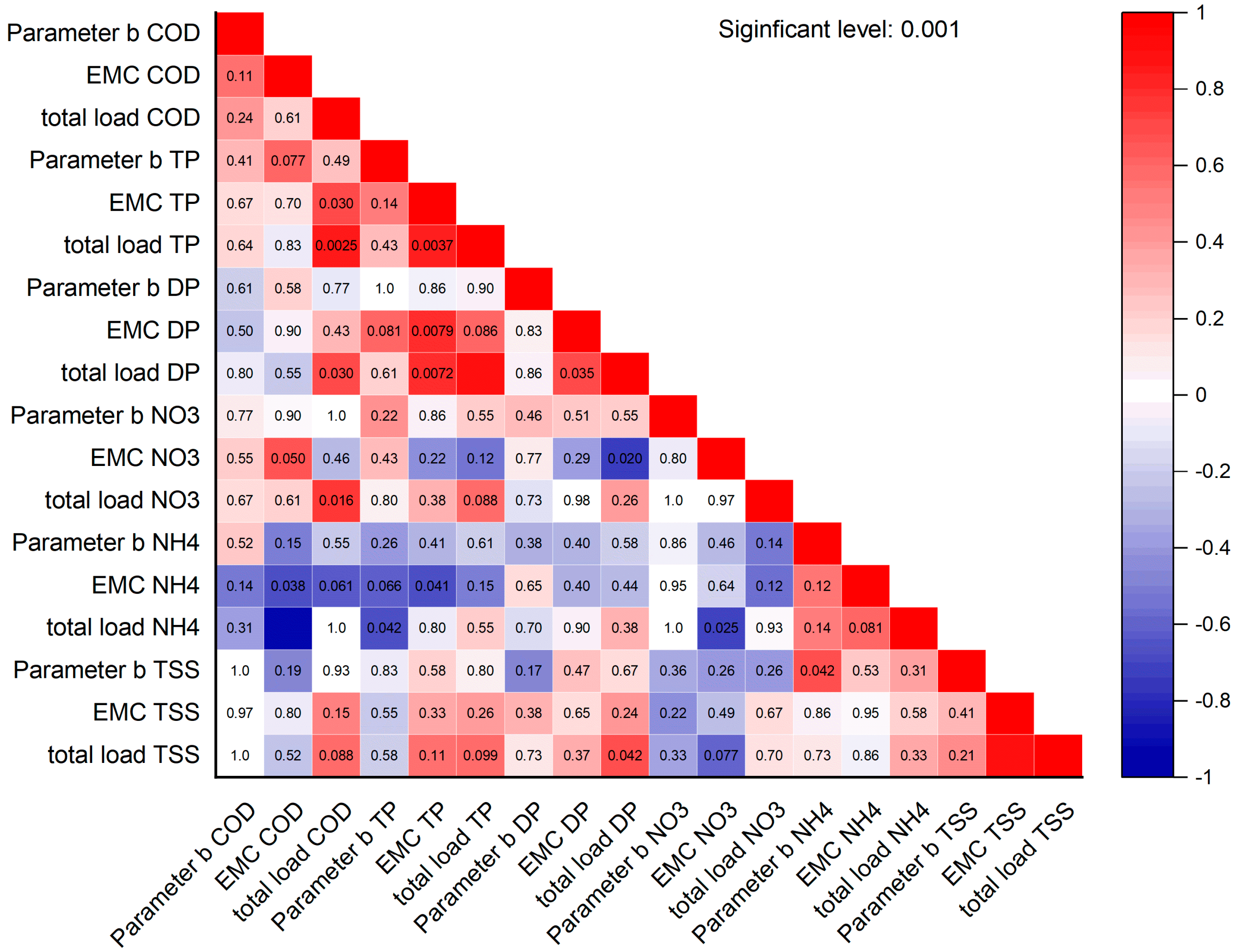

Figure S4. Correlation pattern for investigated pollutants with parameter b, pollutant EMCs and total pollutant loads with level of significance p = 0.001. Red squares indicating a positive, blue squares a negative correlation coefficient, respectively. P-values are given as numbers.