Stormwater runoff leads to pollution peaks in small urban stream

Les pics de pollution dans les rivières urbaines lors d'évènements pluvieux

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RÉSUMÉ

Cet article présente une analyse de la qualité de l'eau d'une petite rivière urbaine à Berlin en Allemagne. Les mesures concernent les paramètres classiques ainsi qu'une liste de micropolluants et ont été effectuées aussi bien par temps sec que par temps de pluie. Le tronçon étudié reçoit les effluents d'une station d'épuration (STEP) et les eaux de ruissellement d'un bassin versant imperméable de 11 km². Les résultats montrent une nette augmentation des concentrations par temps de pluie d'un facteur >20 pour le Zinc, les HAP (Hydrocarbure aromatique polycyclique), deux herbicides et un retardateur de flamme. De plus, des polluants typiques des effluents de STEP et des eaux de ruissellement ont été mesurés en concentrations majeures, comme par exemple l'inhibiteur de corrosion Benzotriazole (0.8 µg/L en moyenne) et le Diisodecyl phthalate (4.0 µg/L en moyenne). Ces premiers résultats seront complétés par les résultats de la campagne de mesure en cours.

ABSTRACT

We investigate water quality of a small urban river during dry and wet weather conditions, including both standard parameters and trace organics. The monitored river stretch receives both effluents from WWTP as well as (separate) stormwater runoff of an impervious area of 11 km^2. Results show increases in concentrations in the river during rain events with a factor > 20 for zinc, polycyclic aromatic hydrocarbons, two herbicides and one flame retardant. Also, substances which are expected both in WWTP effluent and in stormwater effluents were detected at important concentrations in the river during wet weather, such as the corrosion inhibitor Benzotriazole (0.8 µg/L on average) and the plasticizer Diisodecyl phthalate (4.0 µg/L on average). The presented results are preliminary and will be complemented by more results and substances as well as an assessment of the relevance of the findings.

KEYWORDS

Micropollutants, stormwater, urban stream

1 INTRODUCTION

Stormwater runoff from impervious surfaces (roads, roofs, courtyards, etc.) can contain (trace) substances from various sources (e.g., Zgheib et al. 2012). On the one hand the number of substances and substance groups is expanding with every new study. On the other hand the impact of these substances on rivers and lakes remains to be shown. The presented paper aims at starting a discussion on the latter aspect, by giving a first glimpse on substance patterns in an urban river during storm events.

2 STUDY SITE

The small lowland Panke River flows from an upstream rural catchment through the city of Berlin (Table 1). The flow regime in the upstream section (~75 % of the catchment) is close to its natural state, while the downstream part is characterized by strong stormwater inputs from impervious surfaces mostly connected via a separate sewer system to the river (SenStadtUm 2009).

Table 1: Characteristics of the Panke River

Parameter	Symbol	Unit	Value
Catchment area [a]	A	km^2	200
Impervious area [a]	A_{imp}	km^2	11
Length	l	km	29
Flow [b]	Q	m^3/s	0.4 ± 0.2
Flow speed [b]	u	m/s	0.19 ± 0.15
Total phosphorus [c]	TP	mg/l	0.25 ± 0.08
Ammonium [c]	NH_4	mg/l	0.2 ± 0.2
Biological oxygen demand [c]	BOD_5	mg/l	3.0 ± 0.9
Electrical conductivity [c]	κ	µS/cm	961 ± 198
Total Zinc [c]	Zn	mg/l	118 ± 734

[a] SenStadtUm 2009
[b] 2013/01/01 to 2013/12/31, 5-min flow, station Bürgerpark, Berlin Senate
[c] 2006/01 to 2013/12, monthly grab samples, station Bürgerpark, Berlin Senate

Figure 1 exemplifies the impact of storm events on the flow within the urban river section. During dry weather the water quality of the Panke River is characterized by natural base flow and varying inflow of treated effluent from an upstream waste water treatment plant (WWTP) with high levels in nutrients and electrical conductivity (Table 1). During storm events strong impact of pollutants from impervious surfaces is expected.

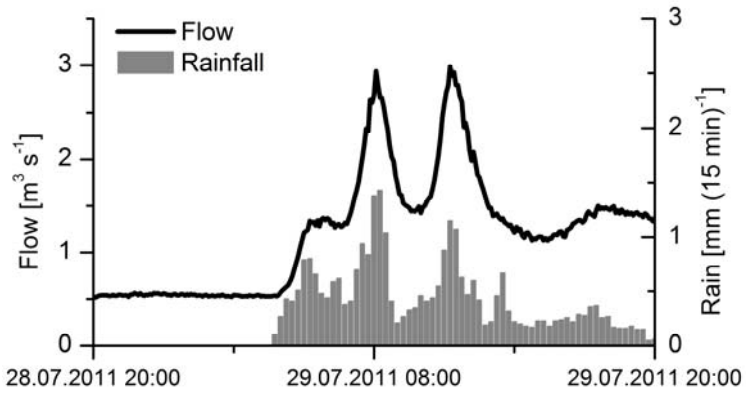

Figure 1: Flow at the station “Bürgerpark” and rainfall at a nearby rain gauge (data by Berlin Senate and Berliner Wasserbetriebe)

3 MATERIALS AND METHODS

Samples are taken at the station “Bürgerpark”, directly downstream of the separate sewer section with numerous inlets of stormwater runoff (see also Fig. 1). Up to date, one sample was taken during dry weather and 8 samples during wet weather. Wet weather samples are taken automatically, triggered by electrical conductivity κ. If κ drops below 550 µS/cm a first sampling interval is started, filling 12 glass bottles of 350 ml using a 1 minute interval. 30 minutes later a second interval is started filling another 12 glass bottles. The bottles taken in the interval with lower κ are mixed into a composite sample of ~4.2 L, which is analyzed.

Analysis includes a large number of substances. Here we show TP, Zn, the pharmaceutical Carbamazepine (CBZ, CAS-number 298-46-4), the plasticizer Diisodecyl phthalate (DIDP, 26761-40-0), the flame retardant Tris(2-butoxyethyl) phosphate (TBEP, 78-51-3), the herbicides glyphosate (GLY, 1071-83-6) and mecoprop (MCPP, 93-65-2), the corrosion inhibitor Benzotriazole (BTA, 95-14-7) and the combustion byproduct polycyclic aromatic hydrocarbons (PAH16, sum of 16 EPA PAHs). Analysis is done following appropriate ISO or DIN procedures.

4 RESULTS AND DISCUSSION

Figure 2 shows preliminary results after 3 to 9 analysed samples and compares dry and wet weather concentrations for each of the selected substances. As expected, the sewage based pharmaceutical CBZ shows a 10 to 100 fold dilution during stormwater influence. BTA, TP and DIDP are expected in high concentrations both in WWTP effluent and in stormwater runoff. The relative importance of stormwater for those substances is underlined by moderate changes during wet weather (from ~0.3 µg/L to ~0.9 µg/L TP, from ~3.4 µg/L to ~0.8 µg/L BTA and from ~1.6 µg/L to ~4.0 µg/L DIDP). In turn, the classical stormwater tracer Zn shows the expected strong increase by an average factor of 31. Similarly, strong increases during stormwater influence are shown for herbicides (GLY: 63-fold increase, MCPP: from below detection limit to 0.4 µg/L), flame retardants (TBEP: from below detection limit to 3.2 µg/L) and PAHs (PAH16: 22-fold increase).

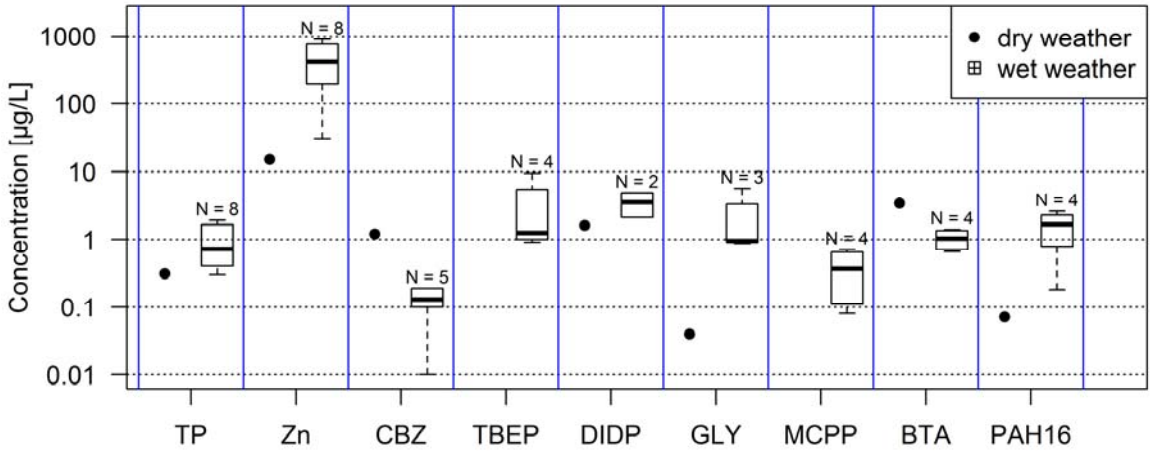

Figure 2: Preliminary results. For each substance (separated by blue lines, for abbreviations see text) the point shows concentration during dry weather on 2014-07-23 (no point if not detected) and the boxplot shows concentration during wet weather. N indicates the number of analysed samples. Boxes show 25 and 75 % quantiles, whiskers are maxima/minima.

5 CONCLUSIONS

The results indicate that (i) stormwater runoff from impervious surfaces can have a strong impact on chemical properties of urban rivers and (ii) substances involved comprise many substance groups apart from the well documented heavy metals and PAHs, such as herbicides, flame retardants, corrosion inhibitors and plasticisers.

It is important to note that the results are preliminary (in some cases only few samples are analysed) and will be completed after conclusion of the monitoring program in 2015. The relevance in terms of relative annual loads and (acute) toxicity remains to be investigated.

6 ACKNOWLEDGEMENTS

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