Une grande rivière urbaine sous pression – Recherches et mesures visant à atténuer les impacts des déversoirs d'orage à Berlin, Allemagne

A large urban river under pressure - Research and actions for the mitigation of impacts from combined sewer overflows in Berlin, Germany

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RÉSUMÉ

La section urbaine de la rivière Spree est une rivière de plaine régulée, affectée par différentes pressions anthropiques et plus particulièrement par les rejets des déversoirs d'orage du réseau d'assainissement berlinois.

L'impact des déversements peut être décelé à travers une combinaison de données mesurées en continue, telles que la conductivité spécifique, le taux d'ammonium (NH_4), la demande chimique en oxygène et l'oxygène dissous (OD). Ces informations, comparées aux consignes de qualité des eaux pluviales, indiquent que les diminutions de l'OD suite aux déversements entraînent régulièrement l'apparition de conditions néfastes pour la faune piscicole. En revanche, les concentrations de NH_4 observés n'atteignent jamais des niveaux de toxicité susceptibles de nuire aux poissons.

Des mesures sont actuellement mises en œuvre par la municipalité afin de limiter les impacts des rejets par temps de pluie. Les effets de futurs scénarios d'aménagements peuvent être évalués par un modèle en cours de calibration.

ABSTRACT

The urban stretch of the River Spree is a regulated lowland-river, which is affected by a number of anthropogenic pressures, most notably impacts from combined sewer overflows (CSO) of the Berlin sewer system.

Collected data show that occurrence of CSO can be detected in the river through a combination of continuous monitoring data, such as specific conductivity, ammonium (NH_4), chemical oxygen demand and dissolved oxygen (DO). Comparison with stormwater guidelines indicates that drops in DO from CSO lead to regular problematic conditions for the fish fauna. In contrast, observed NH_4 peaks never reach fish-toxic levels.

Mitigation measures are currently implemented to reduce these negative impacts during storm events. The effect of past and potential future CSO measures can be studied with a model tool, which has been tested and is currently calibrated based on the above monitoring data.

KEYWORDS

CSO, model tool, oxygen deficit, urban river.

1 INTRODUCTION

The River Spree is a lowland-river type for most of its catchment of ~10,000 km^2 with very low slopes of ~0.009 % in its lower reaches. Before its mouth, it flows through the city of Berlin via several regulated channels with very low flow speeds (Table 1). Nutrient levels allow high, mostly light-limited phytoplankton populations (Table 1). The high trophy (i) reduces visibility (Table 1) and (ii) leads to a low level of dissolved oxygen (DO) with high daily amplitudes. Given the various urban anthropogenic pressures (channelization, ship traffic, effluents from WWTP, stormwater runoff, cooling for power plants) the Berlin section of the River Spree was declared a heavily modified water body in the assessment for the EU Water Framework Directive (WFD). In the assessment, reduced connectivity and acute impacts from stormwater runoff, in particularly from combined sewer overflows (CSO), were of primary concern. Currently a CSO volume of ~7 million m^3/yr (with a sewage to stormwater ratio of ~1:11) flows to the River Spree and its side channels via 179 outlets over a river stretch of ~18 km. The presented work aims at assessing the nature and severity of acute CSO impacts based on continuous water quality monitoring. In a second step the monitoring results are used to establish a coupled model tool to assess the potential effect of past and future mitigation measures.

Table 1: Characteristics of the Berlin River Spree

Parameter	Symbol	Unit	10-year-average	standard deviation
Flow [a]	Q	m^3/s	26.6	18.4
Flow speed [a]	u	m/s	0.15	0.10
Secchi depth [b]	z_{Secchi}	cm	102	46
Total phosphorus [b]	TP	mg/l	0.17	0.07
Orthophosphate [b]	o-PO4	mg-P/l	0.09	0.06
Chlorophyll A [b]	ChlA	µg/l	27.2	21.9
Ammonium [b]	NH_4	mg/l	0.2	0.2
Biological oxygen demand [b]	BOD_5	mg/l	3.3	1.0
Dissolved oxygen [a]	DO	mg/l	9.8	3.0

[a] based on continuous measurements from Oct 2000 to Oct 2010 by the Berlin Senate
[b] based on monthly samples from Oct 2000 to Oct 2010 by the Berlin Senate

2 MATERIALS AND METHODS

Continuous monitoring is performed within the CSO impacted stretch of the Berlin River Spree (i) for standard parameters DO and specific conductivity (κ_{20}) (TechnoLine, company: WTW) at several points by the Berlin Senate and (ii) for chemical oxygen demand (COD) equivalents (UVIS spectrometer, company: s:can) and total NH_4 (ammo::lyser, company: s::can) at one point (Caradot et al. 2011).

A model tool is currently established, which links (i) CSO-simulation of the sewer model Infoworks CS with (ii) the river water quality model Qsim developed by the German Federal Institute for Hydrology and (iii) an impact assessment tool (Matzinger et al. 2011).

3 RESULTS AND DISCUSSION

3.1 Impacts of CSO on the River Spree

Fig. 1 shows clear signals in the river following CSO events in 2011. Typically κ_{20} shows a decrease during CSO influence as a result of dilution by rain water. Concurrently, NH_4 and COD increase as a result of the sewage content and rain wash-off in CSO. Finally, DO decreases as a result of degradation of organic matter in CSO, reaching its minimum level with a delay compared to COD. Both DO decrease and NH_4 increase can lead to critical conditions for the aquatic fauna, as indicated in Fig.1 by thresholds for 24h- and 10min-exposure by Lammersen (1997). Whereas NH_4 never reaches critical level, DO drops below 24h-threshold for almost 2 months in 2011 and below 10min-threshold during the three CSO events 2, 3 and 5 (Fig. 1). The findings are confirmed by up to 12 years of DO measurements at different stations with CSO-impact, which indicate violation of DO-criteria by Lammersen (1997) during 10 to 90 calendar days per year and very low DO-concentrations < 2 mg/l during 1 to 60 calendar days per year. While some of these low DO situations are also caused by the background situation, CSO are responsible for the majority of the occasions with < 2 mg/l, which can lead to acute fish kills, according to local fish experts.

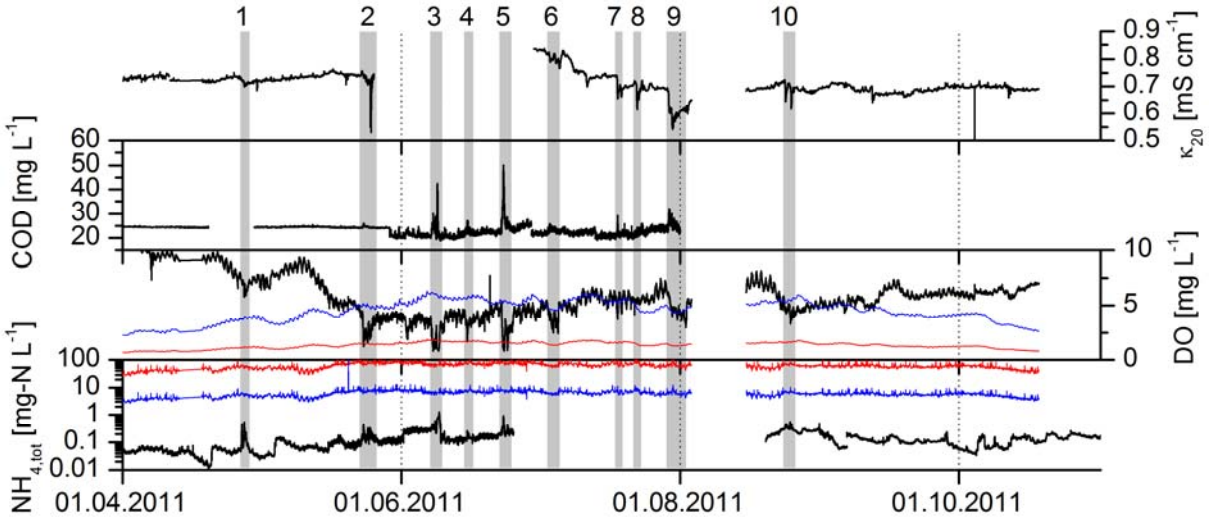

Figure 1: Continuous measurements in the Berlin River Spree within the section affected by CSO. Black lines are measured values, grey numbered areas mark CSO impacts, blue and red lines are 24h and 10min thresholds by Lammersen (1997), respectively.

3.2 Mitigation efforts

To mitigate acute CSO impacts in the River Spree and its side channels, a program was started to increase the specific storage capacity of the sewer network from 21 to 43 m^3/ha of impervious area until the year 2020. Currently ~70 % of the planned storage has already been realized. The effect of this clear improvement on the River Spree is difficult to assess with monitoring data, given the large inter-annual climatic variability, in particular regarding the occurrence of storm events. As a result, a model tool is currently calibrated (i) to show the effect of realized mitigation measures and (ii) to test measures that go beyond the realized storage (if necessary). Simulations for the year 2010 show good functionality for prediction of suboptimal conditions by Lammersen (1997). However calibration of both the sewer and the river water quality model is necessary to improve simulation of the very low DO-concentrations < 2 mg/l.

4 CONCLUSION

- CSO impacts in the Berlin River Spree can be detected by combining continuous monitoring data of κ_{20}, NH_4, COD and DO.
- Drops in DO lead to regular problematic conditions for fish fauna in the Berlin River Spree; in turn, NH_4 never reaches critical levels.
- The effect of past and future CSO measures in the combined sewer area of Berlin can be studied with a model tool, which is currently calibrated.

5 ACKNOWLEDGEMENTS

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