CSO pollution analysis based on conductivity and turbidity measurements and implications for application of RTC

Analyse de la pollution des rejets aux déversoirs d'orage à partir de mesures de conductivité et turbidité, et son implication pour l'application à la GTR

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RÉSUMÉ

Cet article a pour objectif de démontrer l'applicabilité et la nécessité de capteurs de substitution en tant que capteurs robustes pour la GTR basée sur la qualité de l'eau. A cette fin, pendant 1,5 an, des mesures de la conductivité (EC) et la turbidité (TU) à 9 points de mesure de rejet unitaire de temps de pluie (RUTP) ont été effectuées et analysées pour déterminer les points de mesure RUTP les plus pollués. L'analyse est basée sur les concentrations moyennes d'événements de substitution (CMES, définies comme étant EC multiplié par TU) et les charges polluantes de substitution (CPS, définies comme étant les CMES multipliées par le volume de rejet). Il est démontré que les mesures d'EC et de TU peuvent servir de mesures de substitution pour déterminer la pollution relative d'un point de mesure RUTP. L'analyse des valeurs d'EC et de TU portant sur la distance entre le point de mesure RUTP et le MGEP n'a pas permis d'établir que celle-ci a de l'importance. La comparaison des CMES et CPS pour les points de mesure RUTP montre que les mesures de qualité de l'eau auront un grand impact sur l'application de la GTR, conduisant à une GTR basée sur la qualité.

ABSTRACT

The objective of this paper is to demonstrate the applicability of, and need for, surrogate sensors as robust sensors for water quality based RTC. For this purpose 1.5 years of level, conductivity (EC) and turbidity (TU) measurements at 9 combined sewer overflow (CSO) locations have been performed and analysed to determine the most polluted CSO locations. The analysis is based on surrogate event mean concentrations (sEMC, defined as EC multiplied by TU) and surrogate pollution loads (sPL, defined as the sEMC multiplied by the overflow volume). It is shown that EC and TU measurements can serve as surrogate measurements to determine the relative pollution of a CSO location. Analysis of the EC and TU values with respect to the distance between the CSO location and the WWTP gave no indication that this is of importance. Comparison of the sEMC and sPL for the CSO locations, shows that water quality measurements will have a great impact on the application of RTC, leading to quality based RTC.

KEYWORDS

Conductivity, Continuous monitoring, CSO, Quality based real time control, Turbidity

1 INTRODUCTION

Water quality measurements in sewer systems have been a research topic of interest for several years. Recently the need for in-sewer water quality measurements has increased following regulations such as the WFD, focussing on the quality of water bodies. Wastewater management is therefore changing from emission reduction to impact management (Weijers et al. 2012 and Blumensaat et al. 2012).

A similar shift of focus is taking place in the application of real time control (RTC) as one of the means for improving the performance of the available infrastructure and hence the wastewater system. In RTC the focus is shifting from (1) volume based RTC (minimising overflow volumes by maximising the utilisation of the storage capacity), via (2) emission based RTC (minimising emission by redirecting flows to the least polluted outflow), to (3) impact based RTC (minimising impact by redirecting flows to the least sensitive receiving water), see e.g. Erbe et al. (2002), Fuchs and Beeneken (2005), Vanrolleghem et al. (2005) and Lacour and Schütze (2011).

The potential of RTC for adapting the performance of wastewater system infrastructure essentially depends on three factors. For these, respectively: (1) availability of idle system capacity in time and space, and the possibility to activate this unused system capacity. (2) the differences in pollutant levels between discharge locations. And (3) the differences in vulnerability of receiving waters for discharges from wastewater systems.

For emission and impact based RTC pollution estimates have been used, e.g. storm sewer outfall discharges are typically less polluted than wastewater treatment plant (WWTP) effluent, which in turn is less polluted than CSO discharges. No distinction is made in the pollution level of different CSOs. Incorporating this would be a significant step forward in the development of RTC: RTC based on quality measurements. However, this requires more reliable and robust measurements on the quality of combined sewer overflow (CSO) discharges.

Early work on continuous, in-sewer water quality measurements (e.g. Krebs et al. 1999, Veldkamp et al. 2002, Bertrand-Krajewski 2004, Langeveld et al. 2005, Schellart et al. 2007) focussed on turbidity (TU) and conductivity (EC). These parameters are relatively easy to measure, which is an advantage in the hostile environment of a sewer system. Later on, technologic improvements made the application of more complicated sensors such as spectrometers feasible, allowing continuous monitoring of, for example, total suspended solids (TSS) and soluble chemical oxygen demand (CODf) (Langergraber et al. 2003).

Nevertheless, measuring pollution directly through parameters like TSS and CODf is not only more expensive but also requires more expertise and time investment to get reliable results (Schilperoort 2011). Attention is thus turning back to the more easily measurable parameters, which could serve as surrogate measurements for the more complex direct parameters: Lepot et al. (2012) have shown that the uncertainties in TU measurements are smaller than in TSS, and Métadier et al. (2012) have shown that TU measurements can be correlated to the concentration of TSS. Lombard et al. (2010) have shown that combining TU and EC measurements gives a good indication of the constituents of wastewater.

A similar correlation has been found in the influent of the WWTP of Eindhoven, where high frequency measurements of EC and CODf have been performed. EC and CODf show similar behaviour in time, as can be seen in figure 1 (left). In the right side of this figure a near linear correlation between EC and CODf is confirmed.

The objective of this paper is to demonstrate the applicability of and need for surrogate sensors as robust sensors for water quality based RTC. Almost 1.5 years of level, TU and EC measurements at several CSO locations in Eindhoven (The Netherlands) have been analysed to show the suitability of these measurements for determining the most polluted CSO locations. The importance of these results for wastewater system optimisation through quality based RTC is highlighted.

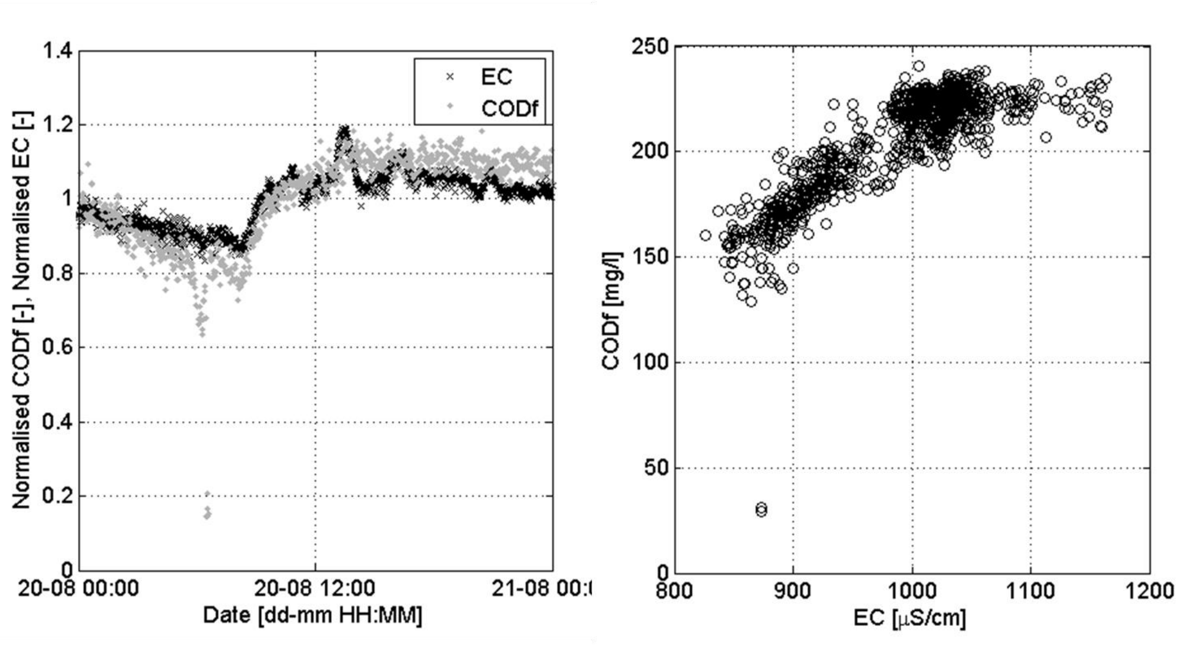

Figure 1. EC and CODf measurements in the WWTP influent of the city Eindhoven show a close correspondence in time (left), resulting in a near linear correlation (right). Dry weather flow, 20 August 2012.

2 MATERIALS AND METHOD

2.1 Area, measurements and sensors

The sewer system under investigation is located in the south of the Netherlands and collects wastewater of the city Eindhoven. It consists of approximately 800 km combined and 350 km separate sewer system, 2000 ha of impermeable area, 280,000 people equivalent and has an average gradient of approximately 1:400. Measurements are performed at 7 CSO locations, the internal and external weir of a stormwater settling tank, and the WWTP influent. A geographical overview of the locations and names can be found in figure 2.

At each location water level, TU and EC measurements are performed. Quality measurements are recorded at a 2 minute interval, water levels are registered every minute. The following sensors are used: SOLITAX t-line sc (Hach Lange) for TU, 3798-S sc (Hach Lange) for EC and VEGABAR 66 (Vega) for the water level. Additional hourly values of the precipitation depth at Eindhoven Airport from the Royal Netherlands Meteorological Institute (station 370, just outside of Eindhoven) are used.

The quality sensors at the CSO locations and the stormwater settling tank are installed approximately 30 to 50 cm under the weir height, to ensure measuring of CSO discharges rather than inceptor flows. As a result of this setup no measurements are registered during dry weather flow with sensor outputs of approximately -125 µS/cm and 0 FNU. At the WWTP continuous measuring series are available.

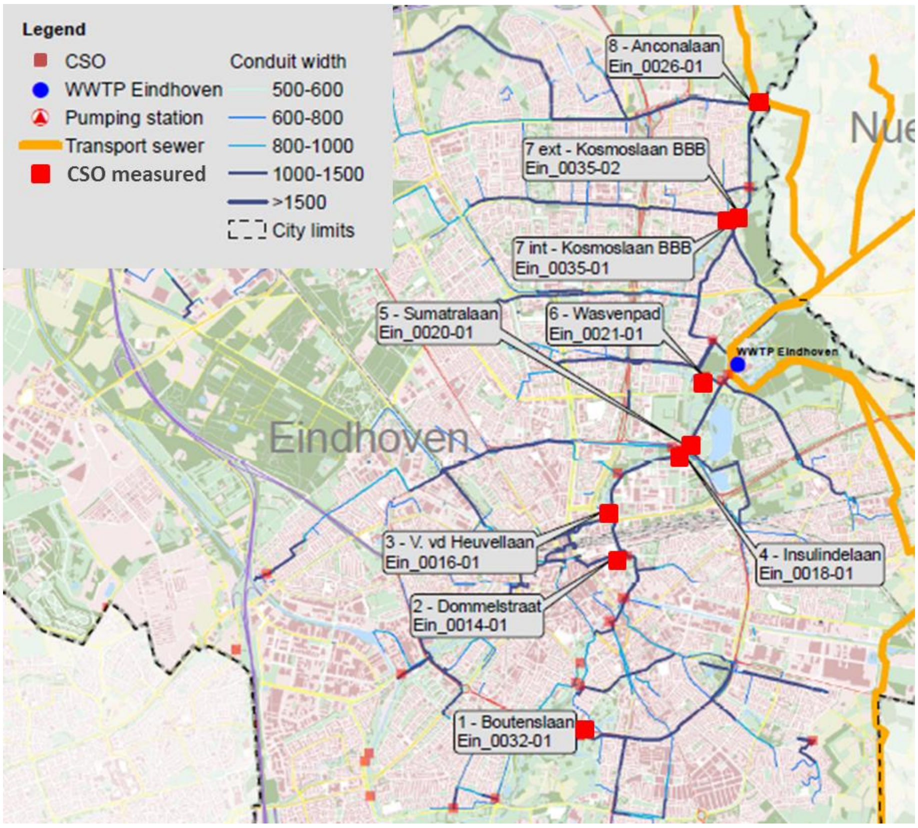

Figure 2. Measurement locations at 7 CSO locations, the internal and external weir of stormwater settling tank and the WWTP influent.

2.2 Data validation and event selection

The measuring period used for this research runs from 1 July 2011 to 15 October 2012. The EC and TU sensors at the CSO locations have been installed during the first month of this period. The EC sensors have only been operational since January 2012. The level sensors have been installed at an earlier date. EC and TU sensors at the WWTP influent have been installed in May 2012.

The quality of all data has been assessed through manual validation and expert judgement. The level measurements show no drift, rise and fall in correspondence to rainfall, and the behaviour during CSO events is as expected. The quality of the EC and TU measurements is assessed for each CSO event individually, since no measurements during dry weather periods are available. The data is evaluated on availability (at least half of the measurements during a CSO event should be available), reasonable values, and the behaviour of the sensor before, during and after the CSO event.

Of in total 118 recorded CSO events, EC measurements have been accepted for 36% of the events, for TU 91% is accepted. If only CSO events from January 2012 onwards are taken into account (total of 61 CSO events) the accepted percentage for EC rises to 59%, which is still much lower than 95% for TU. This is due to more missing values in the EC than in the TU measurements.

To determine the most polluted CSO locations, a limited number of events have been selected for analysis from the validated data set. Only events that have caused spills at a minimum of 4 CSO locations and for which measurements are available for EC and/or TU, have been taken into account. A total of 13 events are selected.

2.3 Surrogate event mean concentration and surrogate pollution load

EC and TU both give an indication of the constituents of wastewater. EC is a measure for the dilution of wastewater, since the conductivity of rainwater is lower than that of raw wastewater (Göbel 2007). TU gives an indication of the amount of suspended sediment in the wastewater. Combining these parameters therefore leads to a parameter that includes both phenomena, and thus characterises how polluted the wastewater is (Lepot et al. 2012, Lombart et al. 2010).

Based on the validated data the surrogate event mean concentration (sEMC) is calculated, following e.g. Mourad et al. (2005). The sEMC is defined as the product of the average values of EC and TU during a CSO event. Please note that the pollution sEMC is a relative measure indicating the quality of the water. The surrogate pollution load (sPL) is calculated through multiplication of the sEMC with the overflow volume.

The overflow volume of a CSO event is estimated from the level measurements. The volume Q is calculated through $Q = 1.7\ m\ b\ h^{3/2}$, with m an empirical constant taken to be 0.8 for all locations, b the width of the weir and h the difference of the water level and the weir height. This equation is only valid under free outflow conditions. In determining the overflow volume this is assumed for all events and locations. The uncertainty in the overflow volume and its consequences for the results are discussed in section 3.5.

3 RESULTS AND DISCUSSION

3.1 Description of EC and TU behaviour

Figure 3 shows typical EC and TU measurements for WWTP influent. The EC measurements clearly respond to rainfall on May 5th, 15th and 20th: the values show a sharp decrease caused by the dilution of the wastewater transported to the WWTP, followed by a gradual return to average dry weather flow values of approximately 800-1100 µS/cm. The EC values do not respond to the rainfall on May 9th. This may be due to the local character of rainfall combined with the low spatial density of the rainfall measurements (one location just outside of Eindhoven).

The TU measurements show a less evident response to rainfall than the EC measurements. Only after rainfall on May 15th a clear increase in TU is recorded. Rainfall on May 5th and 20th, in both cases leading to a strong decrease of EC, leads only to a small increase in TU. Average TU dry weather flow values range between approximately 50-200 FNU.

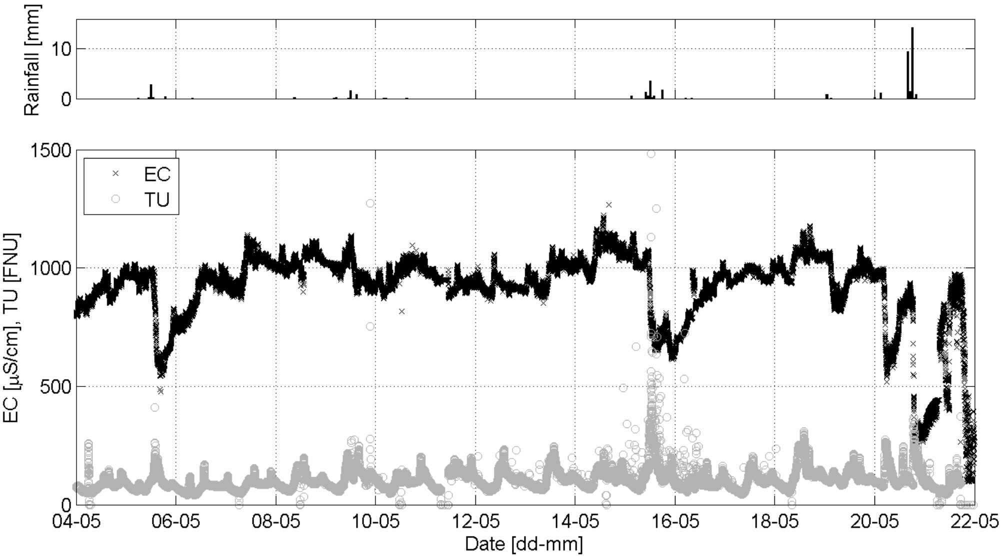

Figure 3. Example of typical EC and TU measurements. Please note that the sensors are malfunctioning from the rainfall at the 20th of May onwards. WWTP influent, May 2012.

In figure 4 EC and TU measurements during a CSO event are depicted. Please note that that the EC and TU sensors are only operational when the level surpasses the installation level of the sensor. As for the measurements at the WWTP influent, see figure 3, the EC values decrease due to the dilution of the wastewater followed by gradual return to dry weather flow values. At the CSO locations, however, only a certain time window is captured (where the dilution of the wastewater is just at its end) resulting in a smaller changes in EC.

The TU measurements show a general decline during the CSO event. When the water level is close to the CSO level, increases in TU are registered. This is most likely due to changes in the hydraulic conditions, leading to an increase in sheer stress and thus an increase in re-suspension of sediment. When the water level is close to the installation height of the sensor, at the start and end of the measurements, a few outliers are recorded.

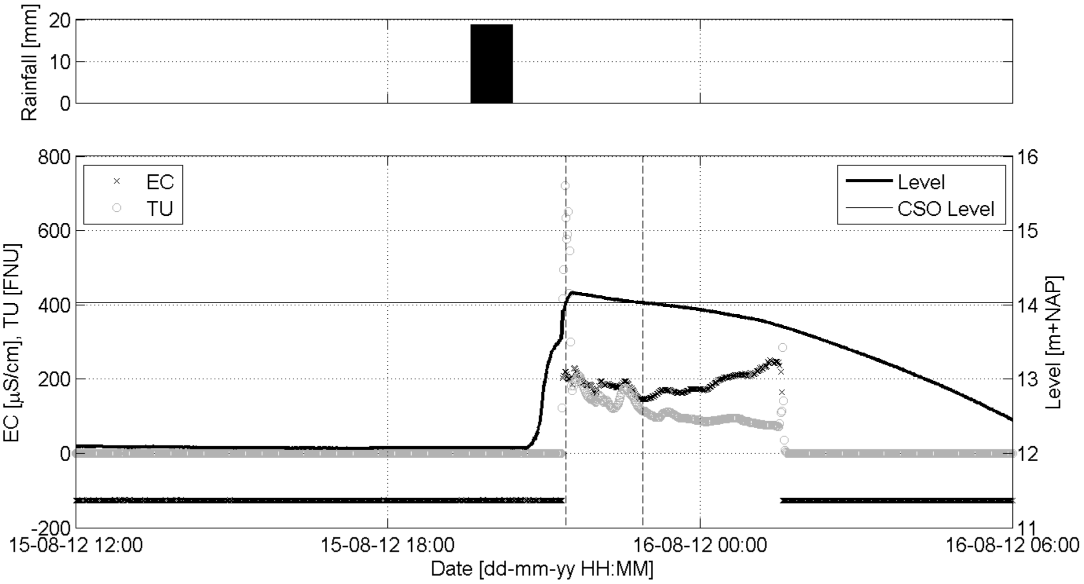

Figure 4. Example of typical EC and TU measurements during a CSO. Location 4 - Insulindelaan, 15-16 August 2012

3.2 sEMC and sPL

Average EC and TU values, overflow volumes, the sEMC and sPL have been calculated for 13 events as described in the previous chapter. The results are presented in table 1.

In the results a strong variability for the average EC and TU values between locations and CSO events can be found. However, looking at the highest/lowest average values for EC and TU a pattern emerges. The highest values for EC are consistently measured at location 1 - Boutenslaan. There is no location that consistently has the lowest EC values. For TU locations 1 - Boutenslaan and 3 - V. vd Heuvellaan have the highest values. Lowest values for TU are measured at location 7 ext - Kosmoslaan BBB.

Consistent with the results for EC and TU, location 1 - Boutenslaan has the highest sEMC and location 7 ext - Kosmoslaan BBB the lowest. More specifically, both locations have the highest/lowest sEMC for all measured events. Still it should be noted that only one event has sEMC values for both locations 1 - Boutenslaan and 3 - V. vd Heuvellaan, that has the second highest pollution level values.

From maintenance it is known that the sewer system near location 1 - Boutenslaan is relatively heavily polluted. This CSO is located in a catchment that is connected to the main sewer system via an internal weir and vortex flow regulator before which sedimentation takes place. The high sEMC found, indicate that this sediment could re-suspended during heavy rainfall and is emitted in case of a CSO event.

That location 7 ext - Kosmoslaan BBB has a lower sEMC than location 7 int - Kosmoslaan BBB as well as the overall lowest sEMC, which confirms the supposed functioning of the stormwater settling tank. This is further supported by the results for TU and EC: it has the lowest values for TU (sediments settle in the tank and are not emitted to the receiving water), but not for EC (for which settling has no effect).

Looking at the sPL discharged from a CSO instead of the sEMC of the overflow water, a more diffuse picture arises. This is caused by the large differences in overflow volumes between locations and events. No location is consistently discharging the lowest sPL. Location 7 ext - Kosmoslaan BBB is discharging the highest sPL for most events, but also the lowest in one occasion. That location 7 ext - Kosmoslaan BBB discharges the highest sPL despite having the lowest sEMC, indicates that the stormwater settling tank is positioned at the CSO where it is most effective.

Table 1. Average EC and average TU values, CSO volume, sEMC and sPL for each event and CSO location.

		14 August 2011					23 August 2011					14 December 2011					16 December 2011					3 January 2012				
location	distance to WWTP	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL
1 - Boutenslaan	6.0	-	235	1,1E+4	-	-	-	253	1,7E+4	-	-	-	190	1,8E+3	-	-	-	114	4,1E+3	-	-	183	87	5,0E+2	1,6E+4	7,9E+6
2 - Dommelstraat	2.7	-	34	5,0E+3	-	-	-	65	1,3E+4	-	-	-	54	6,5E+2	-	-	-	41	2,9E+3	-	-	-	93	1,7E+1	-	-
3 - V. vd Heuvellaan	2.1	-	71	3,4E+4	-	-	-	131	5,8E+4	-	-	-	125	3,6E+3	-	-	-	74	1,0E+4	-	-	-	153	1,3E+3	-	-
4 - Insulindelaan	1.0	-	41	2,1E+4	-	-	197	73	6,3E+4	1,4E+4	9,0E+8	-	79	2,3E+3	-	-	-	50	8,8E+3	-	-	-	106	3,7E+2	-	-
5 - Sumatralaan	0.9	-	38	1,4E+4	-	-	-	75	2,7E+4	-	-	-	62	6,7E+1	-	-	-	34	2,0E+3	-	-	X	X	X	X	X
6 - Wasvenpad	0.1	X	X	X	X	X	326	53	2,2E+4	1,7E+4	3,8E+8	-	43	1,8E+3	-	-	-	35	8,5E+3	-	-	-	85	2,1E+1	-	-
7 int - Kosmoslaan BBB	2.4	-	73	7,2E+4	-	-	-	77	9,2E+4	-	-	-	-	2,8E+4	-	-	-	-	6,0E+4	-	-	-	50	1,2E+4	-	-
7 ext - Kosmoslaan BBB	2.5	-	24	4,7E+4	-	-	102	50	7,1E+4	5,1E+3	3,6E+8	-	34	3,2E+4	-	-	-	28	8,4E+4	-	-	X	X	X	X	X
8 - Anconalaan	3.4	-	80	0,0E+0	-	-	-	63	0,0E+0	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

		5 January 2012					19 January 2012					4 June 2012					11 July 2012					15 August 2012				
location	distance to WWTP	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL
1 - Boutenslaan	6.0	X	X	X	X	X	321	48	4,8E+2	1,5E+4	7,4E+6	270	89	9,2E+2	2,4E+4	2,2E+7	-	230	6,4E+3	-	-	X	X	X	X	X
2 - Dommelstraat	2.7	X	X	X	X	X	124	-	5,2E+2	-	-	X	X	X	X	X	212	30	6,1E+3	6,3E+3	3,9E+7	198	145	4,7E+2	2,9E+4	1,3E+7
3 - V. vd Heuvellaan	2.1	-	77	3,6E+2	-	-	131	111	5,8E+3	1,4E+4	8,4E+7	X	X	X	X	X	153	100	1,5E+4	1,5E+4	2,2E+8	X	X	X	X	X
4 - Insulindelaan	1.0	116	55	3,2E+2	6,3E+3	2,0E+6	118	68	5,9E+3	8,0E+3	4,7E+7	148	58	2,8E+3	8,6E+3	2,4E+7	123	84	1,1E+4	1,0E+4	1,1E+8	184	182	5,7E+2	3,4E+4	1,9E+7
5 - Sumatralaan	0.9	X	X	-	X	-	-	52	9,4E+2	-	-	164	39	3,1E+1	6,4E+3	2,0E+5	134	59	1,9E+3	8,0E+3	1,5E+7	X	X	X	X	X
6 - Wasvenpad	0.1	-	41	4,0E+2	-	-	115	60	5,1E+3	6,9E+3	3,5E+7	222	39	2,0E+3	8,6E+3	1,7E+7	137	41	9,2E+3	5,6E+3	5,1E+7	273	106	9,9E+2	2,9E+4	2,8E+7
7 int - Kosmoslaan BBB	2.4	-	73	2,2E+4	-	-	-	55	5,3E+4	-	-	158	70	5,5E+4	1,1E+4	6,1E+8	-	93	7,7E+4	-	-	-	-	3,5E+4	-	-
7 ext - Kosmoslaan BBB	2.5	-	34	2,0E+4	-	-	-	34	5,1E+4	-	-	163	40	3,5E+4	6,6E+3	2,3E+8	109	30	6,8E+4	3,3E+3	2,3E+8	181	72	2,4E+4	1,3E+4	3,1E+8
8 - Anconalaan	3.4	X	X	X	X	X	X	X	X	X	X	-	24	2,2E+3	-	-	-	51	9,8E+3	-	-	X	X	X	X	X

		26 August 2012					24 September 2012					3 October 2012				
location	distance to WWTP	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL	EC	TU	volume	sEMC	sPL
1 - Boutenslaan	6.0	274	57	3,9E+2	1,6E+4	6,1E+6	-	245	5,6E+3	-	-	374	93	7,0E+2	3,5E+4	2,4E+7
2 - Dommelstraat	2.7	-	-	9,0E+2	-	-	-	60	4,3E+2	-	-	-	73	3,5E+2	-	-
3 - V. vd Heuvellaan	2.1	-	68	3,7E+3	-	-	-	72	3,8E+3	-	-	-	123	2,6E+3	-	-
4 - Insulindelaan	1.0	131	52	3,6E+3	6,8E+3	2,5E+7	161	64	3,7E+3	1,0E+4	3,7E+7	131	73	9,7E+2	9,5E+3	9,2E+6
5 - Sumatralaan	0.9	145	39	4,9E+2	5,7E+3	2,8E+6	-	68	2,4E+2	-	-	X	X	X	X	X
6 - Wasvenpad	0.1	163	45	5,6E+3	7,2E+3	4,1E+7	155	69	1,8E+3	1,1E+4	1,9E+7	158	56	4,0E+2	8,8E+3	3,5E+6
7 int - Kosmoslaan BBB	2.4	-	-	7,4E+4	-	-	-	218	4,1E+4	-	-	-	114	5,5E+4	-	-
7 ext - Kosmoslaan BBB	2.5	129	27	5,2E+4	3,5E+3	1,8E+8	163	39	2,5E+4	6,4E+3	1,6E+8	156	41	2,9E+4	6,3E+3	1,8E+8
8 - Anconalaan	3.4	-	51	7,7E+3	-	-	X	X	X	X	X	X	X	X	X	X

distance	[km]
EC	[µS/cm]
TU	[FNU]
volume	[m³]
X	no CSO event
-	no data available or data rejected

3.3 Influence of location

Figure 5 displays boxplots for EC (left) and TU (right) for all available events as a function of the distance of the CSO with respect to the WWTP. This distance is measured, following the dominant water flow through the sewer system. No indication is found that the location of the CSO is dominant in either parameter. For EC the dilution in the sewer system seems rather uniform with the exception of location 1 - Boutenslaan, TU shows larger differences over the locations and is therefore likely to be determined by local conditions.

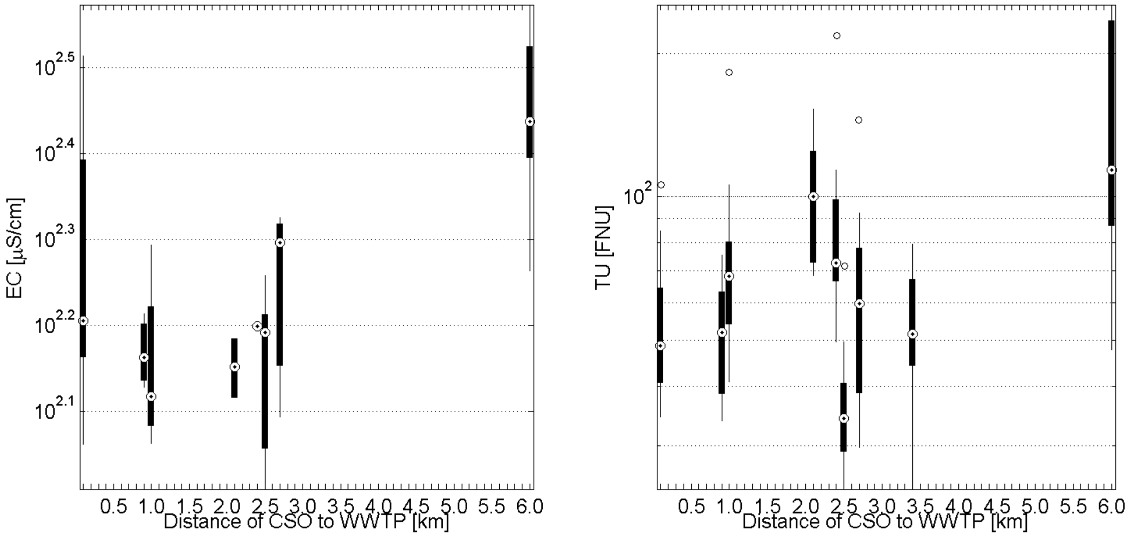

Figure 5. Boxplots for the EC (left) and TU (right) as a function of distance between the CSO and WWTP. Locations are indicated by their number (grey) close to the mean value.

3.4 RTC potential and water quality measurements

Applying (knowledge based on) quality measurements at CSO locations can have a large impact on the optimal control of wastewater systems. This is found from figure 6, displaying boxplots of sEMC and sPL for all locations.

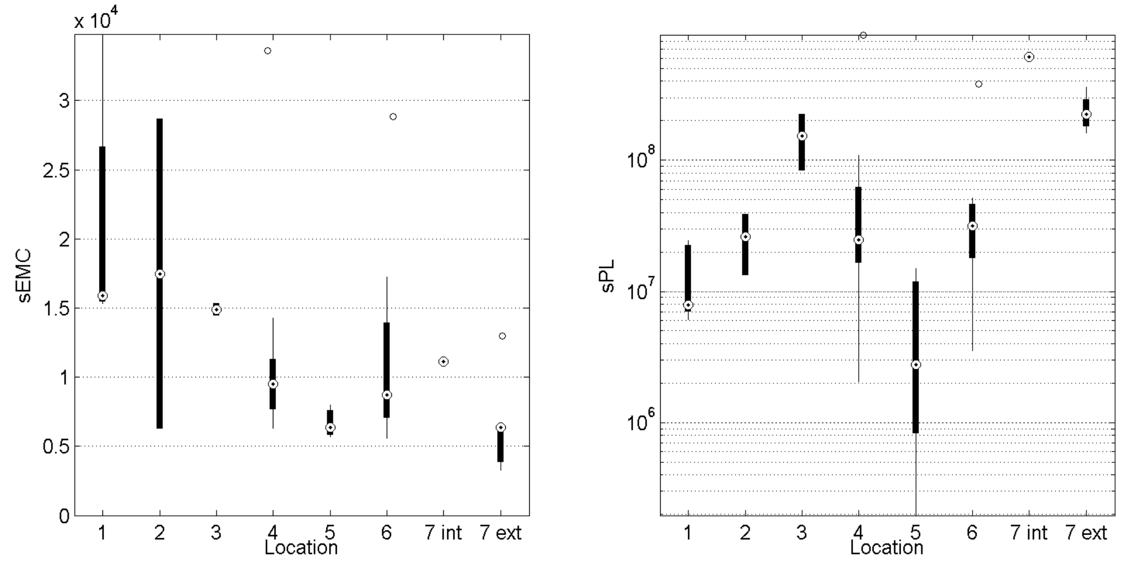

Figure 6. Boxplots for the sEMC (left) and sPL (right) for each location. No values are available for location 8 - Anconalaan.

Based on the sEMC (left), locations 1 - Boutenslaan and 2 - Dommelstraat would be the first to turn attention to when minimising the impact of the sewer system on the receiving water. Locations 5 - Sumatralaan and 7 - Kosmoslaan would be last. Based on the sPL (right, please note the logarithmic scale on the y-axis), locations 3 - V. vd Heuvellaan and 7 - Kosmoslaan would by far be the first places to reduce the impact, while locations 1 - Boutenslaan and 5 - Sumatralaan would be last. The difference between both parameters is the incorporation of the overflow volume in the sPL, while this is irrelevant for the sEMC.

With RTC it is possible to divert flows and therefore change to some extend the overflow location. If the minimisation of the impact on the receiving water based on the sPL were to be considered, the optimisation would to a large extend dominated be by the overflow volume. The clear difference in sEMC between the locations would have only a minor influence. If only the sEMC was to be considered very different choices would be made.

3.5 Discussion

The measuring period available for the analysis contains a limited number of events only. Not all selected events lead to CSO evens at all locations, and not all CSO events have been registered properly. The analysis is thus based on an incomplete dataset. However the results for the sEMC are consistent between events and locations, and are in line with theoretical expectations and practical evidence. This suggests that the method and outcome are valid. A longer and more complete dataset is necessary to perform a more statistically solid analysis.

For determining the sPL, the overflow volumes have been calculated from level measurements. These calculations are based on an empirical formula, which should be calibrated for local conditions. It is known from Bos and Kruger (2007) that errors in the order of 30% are not uncommon. The CSO locations described in this paper have not been calibrated and the associated errors have not explicitly been taken into account. This will be looked into in further research. It has been checked, however, that the presented conclusions still hold when incorporating a 50% error in the calculated volumes.

Another point of interest for a more thorough investigation is the quality assessment of the data. Ideally the data is validated automatically with standard routines, leading to reproducible results. In the case of measurements at the CSO locations it is difficult to implement such routines, since no continuous time series are available. More attention is needed for this. The quality assessment in this study is based on manual validation and expert judgement. The reproducibility has been tested by having two people perform the assessment independently. They agreed in 92% of measurements, the remaining measurements have been discussed and decided upon.

For this study only EC, TU and level measurements have been available at the CSO locations. The results for the sEMC and sPL based on these measurements are promising. However, additional measurements (from short campaigns), are needed to quantify how polluted a CSO location actually is. These additional measurements could be grab samples to calibrate the EC and TU sensors, or direct high frequency measurements (e.g. TSS) to derive relations between the direct parameter and EC and/or TU. Ideally these measurements should be performed at every location.

4 CONCLUSION

In this study it is shown that EC and TU measurements can serve as surrogate measurements in determining the (relative) pollution of a CSO location. The sEMC, defined as the product of EC and TU, has been determined for different locations and events. The results are consistent between locations and events, and locations with the highest/lowest sEMC are in line with theoretical expectations and practical evidence. The sPL, defined as the sEMC multiplied by the overflow volume, is a less strong indicator for the measure of pollution of a CSO location.

EC and TU values have been analysed with respect to the distance between the CSO location to the WWTP. No indication is found that the location of the CSO with respect to the WWTP is of importance for the EC or TU values of a CSO.

Comparison of the sEMC and sPL at the CSO locations, shows that water quality measurements can have a significant impact on the optimal control of a wastewater system. Clear differences in the sEMC and sPL between CSO locations have been established. This provides evidence for the RTC potential in the Eindhoven area (differences in pollutant levels between discharge locations; the second factor for RTC potential as indicated in the introduction), enabling RTC based on quality measurement.

sEMC and sPL are relative measures. Additional measurements are needed to quantify the amount of pollution.

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