Insights into stormwater drain hydrology and water quality via low-cost sensor monitoring

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Highlights

- Arduino-based low-cost monitoring setup with sensors for water depth, electrical conductivity and water temperature were able to reveal local stormwater drain hydrology and water quality.
- Dry weather events were small in size (10 – 50 mm water depth) but contributed significant amount of water to the receiving water body.

Introduction

Urban stormwater is recognised to carry a number of different water pollutants such as nutrients, heavy metals, hydrocarbons and pathogen faecal microorganisms (Burton and Pitt 2002). These pollutants can be released via stormwater drains with discharges that are not associated with precipitation, i.e. dry weather discharges (Deffontis et al. 2013). These discharges can be associated with groundwater infiltration, cross-connections between wastewater and stormwater drainage networks, or illegal discharges of industrial wastewater (Ellis and Butler 2015). Monitoring of the stormwater drains is required in order to be able to understand the potential impacts these discharges may have on the receiving water environment. Yet, monitoring is often limited by the expenses related to the monitoring equipment, whereby spatial resolution of the monitoring campaign is limited due to limited number of available monitoring sets. Recent developments of low-cost technologies present an opportunity to overcome this constraint. Cost of these monitoring solutions can be tens of times lower than the corresponding commercial version, which in turn can enable increase in number of monitoring locations within the same budget.

In this study, we investigated possibility of developing low-cost solutions for urban stormwater drainage monitoring, tested developed monitoring sets in real conditions at ten locations and analysed collected data for better understanding of local stormwater hydrology and water quality.

Methodology

We monitored water pressure (depth), electric conductivity and temperature in stormwater drains because these parameters provide basic information about stormwater hydrology and water quality. Furthermore, for development of the low-cost monitoring set up we have selected Arduino electronics platform, which is an open-source electronics platform, there are readily available sensors for monitoring of water pressure and temperature and a significant pool of knowledge developed around this platform for environmental monitoring.

Monitoring equipment has been installed in ten stormwater drains discharging directly into the Port Philip Bay. Locations were selected based on the results of regular summer water quality monitoring program conducted by EPA Vicroria which indicated that these locations might be adversely impacted by faecal contamination during dry weather.

Monitoring of the water depth, EC and temperature at each location was conducted every 10 s intervals and averaging measured values every minute. Data was set by the logger via 3G network onto the data server at least every hour if the changes in measured parameter values were below the predefined threshold or as frequently as every minute if the changes were greater than predefined thresholds.

Data analyses included initial data validation (removal of physically impossible values due to sensor malfunctioning), calculation of water depth at each location, checking of measured depths against onsite measurements during maintenance visits and adjusting measured depth for sensor drift. The estimates of stormwater discharge were made based on the measured depth and drain outlet geometry.

The focus of analysis was detecting dry weather discharges that may have contained faecal contamination and consequently represent public health risks. These events were identified by the following criteria: rainfall total for the past 12 h less than 0.5mm, positive depth gradient with more than 5 mm increase in depth, and positive EC gradient. For each of the identified events a number of statistics were calculated to characterise the event.

Results and discussion

Developed monitoring equipment was deployed from start of the summer in December 2019 to mid March 2020 and around 90 days of continuous data collected on average at each site. This clearly demonstrate the promising capacity of these low-cost technologies for urban drainage monitoring. Number of identified dry weather events ranged over the monitoring sites from more than 110 at Beaumaris to no illicit events identified at Blairgowrie.

Event size, i.e. the difference between maximum and minimum depth recorded during an event depends on the size of the drain and the geometry of the system from the sensor pit to the outlet. Nevertheless, at most sites median event size was around 10 mm except at Rye, McCrae and Dromana where median event size was slightly higher, around 50 mm. An increase of 10 – 50 mm over a couple of hours is very hard to identify without monitoring equipment. This illustrates that these events are not ‘obvious’. Yet, significant amount of water can be delivered during these events. McCrae and Mordialloc were the two sites with the highest total event volume, around 10500 m^3 and 3500 m^3, respectively. At other sites there was no significant difference in total event volume, which ranged between 500 – 1000 m^3, with the exception of Dromana which was the site that only had one event that delivered 70 m^3. Interestingly, the sites with the largest number of events might not be the most problematic from the pollution perspective. In fact, Canadian Bay, the site that had the third highest number of events, had also the second lowest total event volume, right after Dromana.

Conclusions and future work

Low-cost stormwater monitoring technologies showed promising results with application in urban drainage. Decreased costs of the monitoring equipment can be used to boost spatio-temporal resolution of the monitoring within the same budgeting constraints. Future work should focus on further testing of the low-cost equipment, data validation and uncertainty analysis.

Data collected during the monitoring campaign enabled better understanding of the local stormwater hydrology and water quality. Number of dry weather events ranged from none to over a hundred at the monitored drains. It was shown that the size of the event expressed as maximum depth of water in the drain is mostly within the range of 10 – 50 mm which may lead to the conclusion that these events may not be significant contributors of the pollutants. However, the quantity of water discharged into the receiving water body was in range 100 – 10000 m^3 over the monitoring period, indicating that these events may be important for the overall water quality.

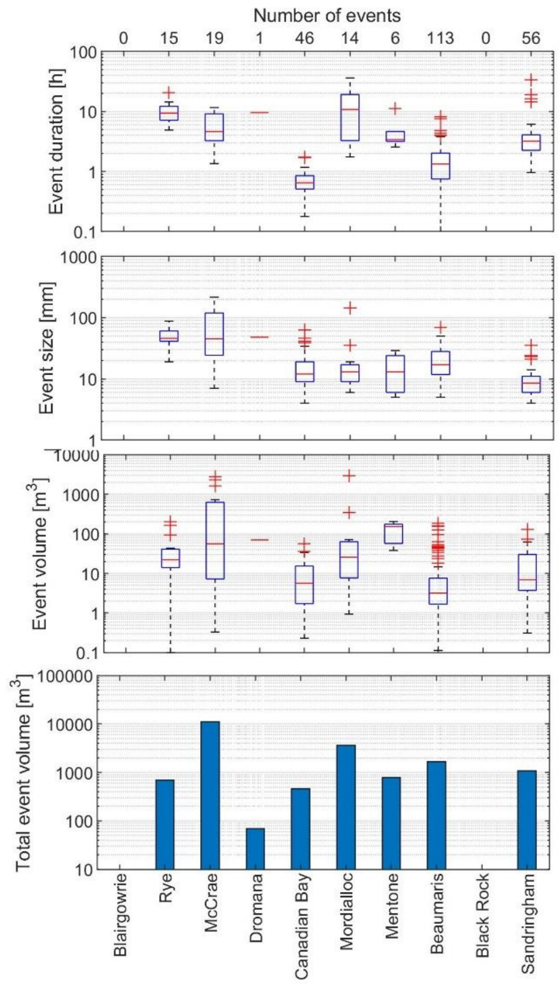

Figure 1 Distributions of event durations, event sizes, event volume and total event volume discharged during the monitoring period for the ten monitoring locations. Number of events identified at each location are shown at the top of the figure.

References

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