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Combining pressure transducer and tipping bucket rain gauge to measure high variable runoff rate collected from a green roof

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Urban areas are constantly expanding in terms of space and density. It is known that the effect of urbanization is an increase of the area of impermeable surfaces. The infiltration decreases, the surface runoff increases (Baiamonte, Singh, 2017) and the existing stormwater infrastructure may become no more appropriate to face flooding (Berndtsson, 2010). Berndtsson (2010) described the numerous benefits that can be achieved by turning the roofs green through covering them with soil and vegetation. Green roofs i) reduce and attenuate stormwater runoff, which in turn lowers risks of urban floods and improves the urban water balance thus approaching the natural one (Mentens et al., 2006), ii) allow thermal benefits consisting of reductions in cost of heating and air conditioning, iii) reduce urban heat island effect (Fang, 2008), iv) reduce noise and air pollution (Currie and Bass, 2008), and v) provide wildlife habitat and biodiversity enhancement (Dunnett et al., 2008).
A challenging task when approaching full-scale investigation on green roofs is the accurate measurement of water runoff rate, which can be characterized by a wide range of variability as a consequence of many factors (as the precipitation regime, the soil thickness, the soil hydraulic characteristics, the vegetation cover, etc.). In fact, if low fluxes can be easily measured by the classical tipping bucket rain gauge (TBR), high fluxes can overcome the maximum peak flow, Q*, of these gauges, and alternative approaches are needed. This is the case of a small experimental green roof (20 square meters) that was designed and constructed at the Department of Agricultural, Food and Forest Sciences of the University of Palermo, with the aim to investigate some of the features previously mentioned, by also using and testing simplified models of runoff response for high permeable porous media, recently developed (Baiamonte, 2016; Baiamonte and Agnese, 2016).
A tipping bucket rain gauge (TBR) located at the outlet of the green roof was combined with a tank discharge gauge (TDG), consisting of a PVC vertical pipe equipped with a stainless steel pressure transducer (PT), SISGEO P252R, 25 mm filter diameter, 191.5 mm length, with a measurement range of 4 - 20 mA, with an accuracy of 0.01% of the full scale, located at its bottom. A flush/square edged connector, also located at the bottom of the TDG, allows water outlet to flow into the TBR. The outflow from the green roof is measured by a combination of both TBR and TDG techniques, with a time resolution of 1 min starting at the onset of a storm event.
This study present the results of the preliminary calibration of the TDG. First, the head-discharge equation for flush/square edged connector was theoretically derived. Then, the head-discharge equation was tested in the laboratory using a hydrostatic head. In addition, time for emptying of the hydrostatic water column was theoretically derived and experimentally checked. Results showed that the TDG can be used in combination with a classical TBR to accurately measure runoff rate in a wide range of variability.