The beast from the east: how water quality weathered the storm

Long-term TEAGASC research enabled the gathering of the first temporal resolution record of water quality in Ireland during a snowstorm.

For many in Ireland, severe weather and its effects were the defining features of 2018, including the most significant snowstorm since 2010 (Met Éireann, 2019). Between February 27 and March 5 Tropical Storm Emma, a low-pressure system approaching from the south west, interacted with a severe polar front nicknamed 'The Beast from the East', to produce heavy snowfall focussed on the south east of Ireland. Direct impacts to Irish farms included structural damage, crop loss, livestock fatalities and increased demand on fodder reserves. Long-term monitoring in catchments participating in the Teagasc Agricultural Catchments Programme (ACP) has provided insight into the effects on water quality.

Catchment monitoring

Two catchments located in Co. Wexford, less than 20 km apart and in the region that received the most intense effects of the snowstorm, were monitored as part of the long-term research programme. Castledockrell is a well-drained arable catchment (1,120 ha), with a brown earth soil type. Barley production predominates and the annual average rainfall is 944 mm. Ballycanew is a poorly drained grassland catchment (1,190 ha), consisting of gley soil, with an annual average rainfall of 1,013 mm. Overland flow pathways predominate in this catchment. Each catchment is equipped with a weather station and a bankside analyser at the river outlet. Each analyser monitors total phosphorus (TP), total reactive P (TRP) and total oxygenated nitrogen (TON) at ten-minute intervals, as well as recording stream discharge. Due to impassable road conditions, measurements of snow depth were not possible in either catchment; however, Met Éireann reported maximum depths at four sites in Wexford of 38-42 cm on March 3, with significant drifting widely observed.

Air and water temperature

The event consisted of two phases; a snowfall phase between February 27 and March 1, and a thaw beginning on March 2. In both catchments, air temperature fell below 0°C between February 27 and March 3, and exhibited similar patterns; however, the response in water temperature differed. Stream temperatures never dropped below 0°C in the well-drained arable catchment. Conversely, the poorly drained grassland stream was below 0°C between February 28 and March 4, and warmed more slowly during the subsequent week. This reflects the dominant contribution of groundwater in the well-drained catchment, as opposed to the more overland flow-dominated poorly drained catchment. Groundwater is buffered from sharp changes in air temperature and so maintains a more moderate temperature.

Stream discharge

Stream discharge declined in both catchments during the snowfall period. This is not surprising as the precipitation was effectively immobilised in snow cover. Stream discharge in both catchments began to climb on March 2, corresponding to the beginning of air temperature increases. Increases in discharge were greater and more rapid in the poorly drained catchment due to its limited infiltration capacity and propensity for runoff. Thomas *et al.* (2017) calculated that 79 % of soils in this catchment generate overland flow, compared to 50 % in the well-drained catchment.

Stream nutrients

Both catchments exhibited above average nitrate nitrogen (NO_3-N) concentrations prior to the event as a result of prolonged saturation during spring and groundwater flushing throughout the winter

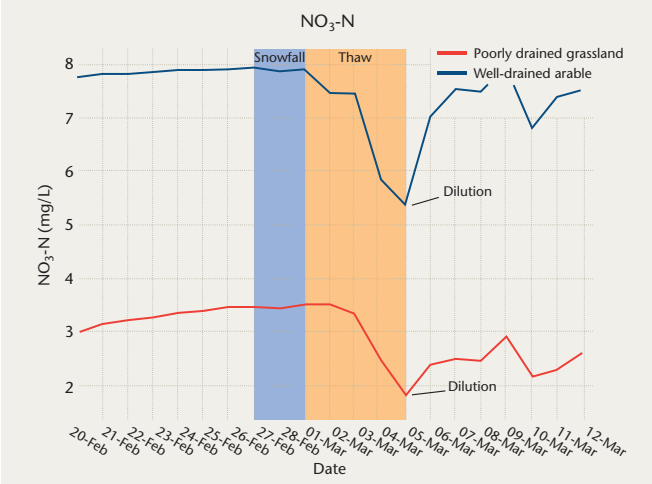

FIGURE 1: Stream NO_3-N concentrations.

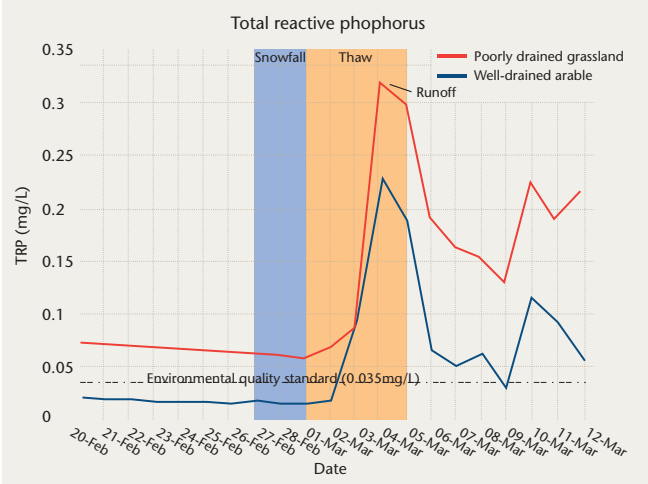

FIGURE 2: Stream TRP concentrations.

(**Figure 1**). These concentrations arise via the groundwater pathway, and were diluted by the addition of meltwater from March 3 and 4. TRP was marginally below average concentrations in both catchments prior to the snowfall (**Figure 2**). In the well-drained catchment, TRP spiked to 0.12 mg/L on March 3, and rapidly declined over the subsequent 48 hours. Particulate P was slower to arrive at the stream, peaking on March 4. This suggests physical immobilisation of particles beneath the snow cover. Analysis of high-frequency hydrochemistry data indicated rapid thaw and exhaustion of P sources near to the stream, followed by longer flow pathways from more distant sources. As these well-drained soils were not saturated throughout the spring, nutrients would have been applied once the closed period ended and a limited amount of bare soil was awaiting tillage.

Higher and more prolonged elevations in TRP were observed in the poorly drained grassland, occurring from March 4 onwards. These concentrations exceeded the environmental quality standard of 0.035 mg/L, and remained elevated throughout the thaw period. The slower mobilisation of P in this catchment suggests that sources were more distant from the receptor. This may reflect low soil moisture deficits in the near-stream areas prior to the event, with limited opportunity for fertiliser application after the closed period ended. However, once thaw began there was greater mobilisation of P from the soil surface throughout the catchment. Thereafter, high levels of P loss were observed, as is typical of soils within this drainage class, which generates high levels of overland flow and has short pathways to the stream.

Recommendations

Compared to severe rainfall, snow accumulation exceeding 10 cm is relatively infrequent, occurring roughly every five to 18 years in inland areas and more rarely along the coast. Nevertheless, it influences stream nutrient concentrations and has implications for land and nutrient management. Heavy snowfall should be treated similarly to rainfall forecasts as regards nutrient loss; however, effects are likely to be delayed due to immobilisation of water as snow. Antecedent soil moisture conditions influence both the propensity for runoff and land management. Decisions regarding fertiliser application should take snowfall forecasts into account and should avoid application near watercourses and on saturated or highly sloping ground. Breaking the pathway is crucial, as this prevents transport of nutrients in more distant areas of the catchment. This research presents the first high temporal resolution record of water quality in Ireland during a snowstorm and was made possible due to the long-term monitoring in operation in these study catchments.

References

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Authors

Sara Vero
Research Officer, Teagasc Agricultural Catchments Programme, Environment Research Centre, Johnstown Castle, Co. Wexford
Correspondence: sara.vero@afbini.gov.uk

Per-Erik Mellander
Senior Research Officer, Teagasc, Agricultural Catchments Programme, Environment and Land Use Programme, Johnstown Castle, Co. Wexford