- The sub-catchment of the Headwaters of the Exe (HotE) was used as a case study; monitoring has focused on the outlet of the catchments on the River Barle and the River Exe; results focus on nutrient losses during rainfall events, continuous turbidity and pesticide detections.
- Nutrient levels in the sub catchment tend to be low, although they were significantly higher in the River Exe compared to the River Barle, potentially indicating more extensive diffuse pollution and a greater need for interventions.
- Nutrient losses tend to occur in high flow conditions, i.e. either rainfall events or wetter seasons (for example in the winter)
- Pesticide detections recorded are more prevalent in the River Barle; the number of pesticide detections in spring makes this the more "at-risk" period.
- These results highlight the continued need to implement interventions that can mitigate pesticides loss from land to water.

Context

The Headwaters of the Exe project (HotE) was led by **Exmoor National Park Authority** (ENPA). FWAG-SW was tasked with the delivery of in-catchment interventions, and UoE with the monitoring of water quality. Whilst interventions were examined and modelled at the whole catchment scale (see water modelling section p28), this section details some of the water quality changes that were observed in the sub-catchment over the course of the project, largely focusing on the River Exe (at Pixton gauging station, Figure 1) and the River Barle (at Dulverton; Figure 2).

Figure 1 The River Exe at Pixton gauging station (Brushford); photo by Emilie Grand-Clement.

Figure 2 Continuous sensors on the River Barle at low flow (left) and high flow (right), highlighting different sampling conditions; photos by Paul Henderson.

Water quality change during rainfall events in the River Exe and the River Barle

Contaminant concentrations during rainfall events

In-situ water quality sampling in the River Exe and the River Barle show similar concentrations in DOC and ammonium (NH_4) during rainfall events; however, Total Oxidised Nitrogen (TON) and Soluble Reactive Phosphorus (SRP) were significantly higher in the Exe (Figure 3), potentially indicating more extensive diffuse pollution from agriculture in this sub-catchment. This is, however, concomitant with overall lower flows measured in this river, which tends to coincide with higher TON concentrations.

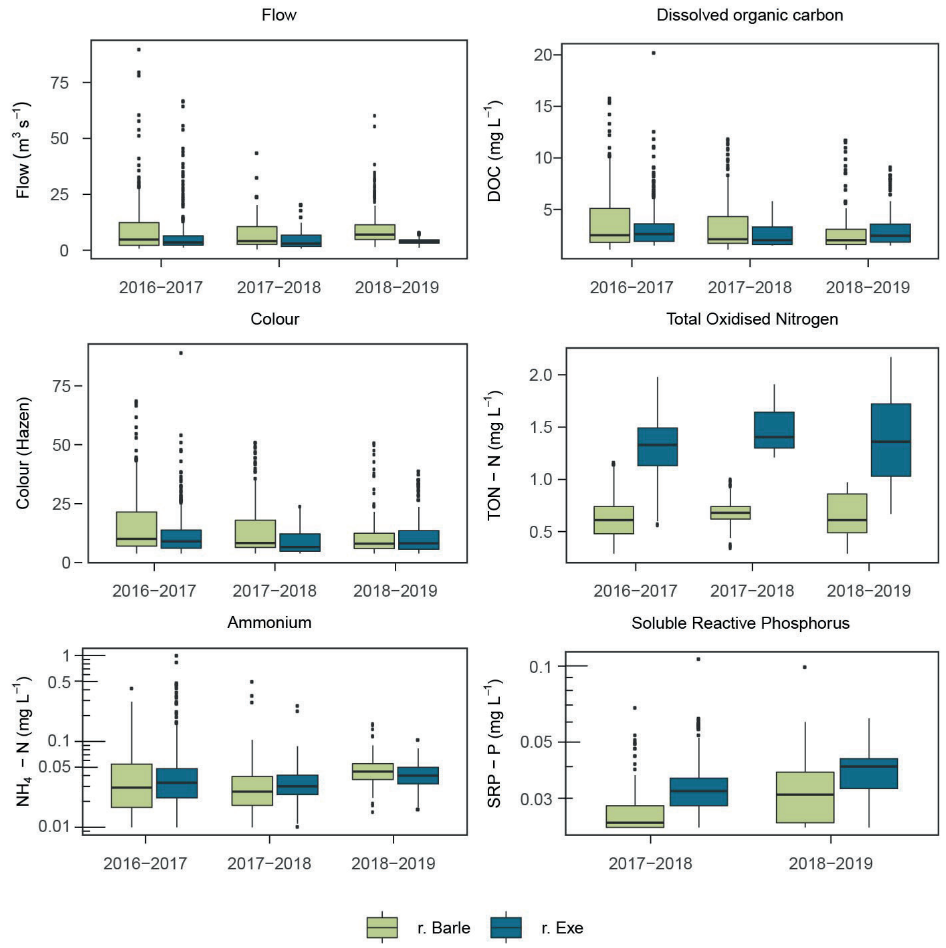
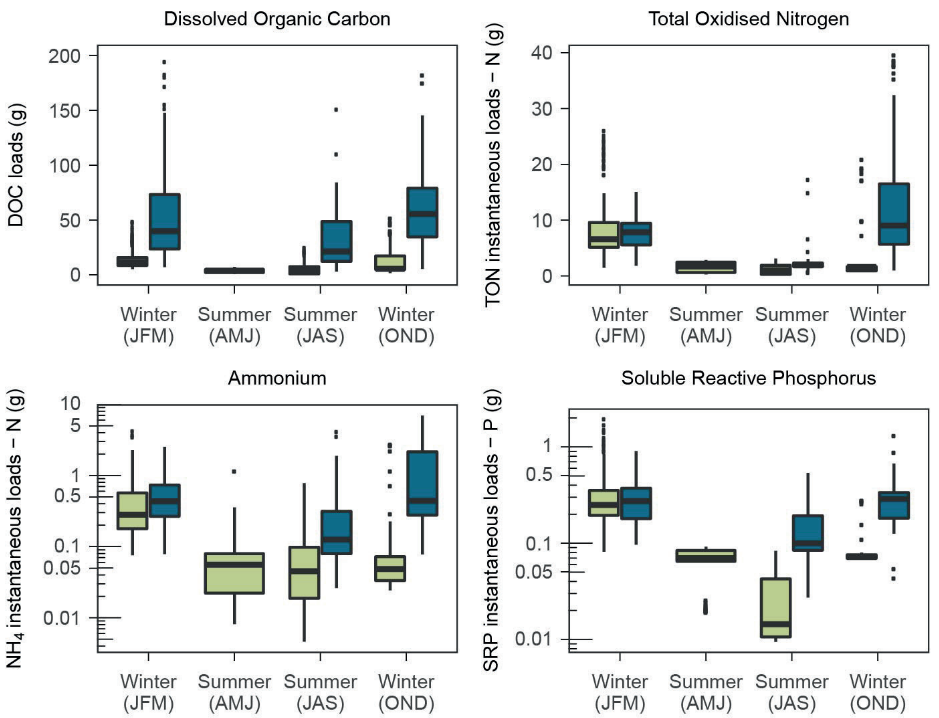


Figure 3 River flow, Dissolved Organic Carbon, Total Oxidised Nitrogen, colour, ammonium and Soluble Reactive Phosphorus concentrations measured at Dulverton and Pixton sites; the top box represents the third quartile and the bottom of the box represents the first quartile, separated by the median.

	Poor		Moderate		Good	
	R. Barle	R. Exe	R. Barle	R. Exe	R. Barle	R. Exe
2017-2018	0.0	0.6	8.4	75.4	91.6	24.0
2018-2019	0.7	0.0	36.6	88.9	62.7	11.1

Table 1 Proportion of the number of samples (%) collected falling within each regulatory limits of phosphate concentrations for poor, moderate and good ecological status for each hydrological year monitored on the River Barle (at Dulverton) and the River Exe (at Pixton).

There is a slight increase in SRP between 2017-2018 and 2018-2019, for both sites. Additionally, results show that a higher proportion of water quality samples fall in the 'moderate status' category in the Exe, compared to the Barle where they are mostly within the 'good ecological status' category, as defined for the Water Framework Directive (Table 1). In addition, the proportion of samples falling into the 'good status' category from the 'moderate status' category between 2017-2018 and 2018-2019 has increased, illustrating that there is a slight degradation in both rivers, for the events sampled.



Seasonal change in different pollutant loads

Instantaneous loads at both sites (Figure 4) show that most nutrient losses occur during wetter, winter months, but also at high flow conditions during other times of the year. This highlights that winter, and wetter conditions, are more "at-risk" periods, and should be considered to tackle water quality improvements.

Figure 4 Instantaneous loads for Dissolved Organic Carbon, Total Oxidised Nitrogen, ammonium and Soluble Reactive Phosphorus per season at Dulverton for the events sampled, with green indicating low flow conditions and blue indicating high flow conditions.

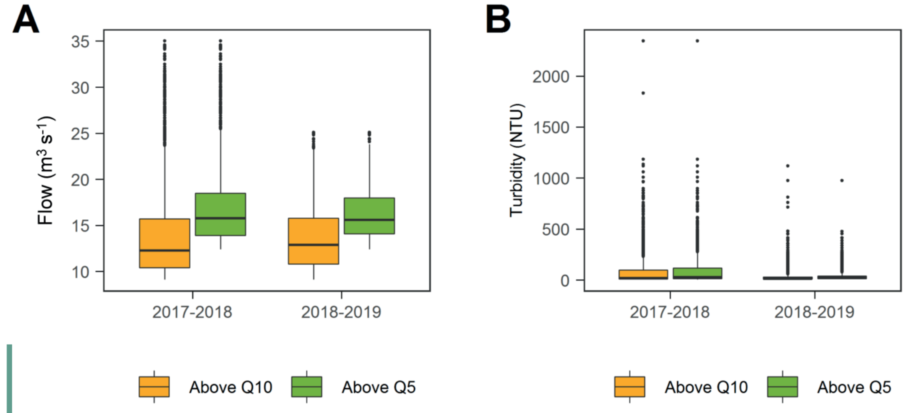


Figure 5 Boxplots representing the variation of flow above Q5 and Q10 (A), and the associated variations in turbidity (B) per Hydrological year in the River Exe.

Turbidity change at high flow

Contamination of freshwaters by sediment, as shown with turbidity data, occurs during high flows. Comparison between the hydrological years measured show no statistically significant change in the flow at both Q5 and Q10 levels (Figure 5). In similar hydrological conditions during subsequent years, there is no statistically significant change in turbidity at high flow, indicating that water quality has not degraded.

Exmoor Ponies at Landacre; photo by Nigel Stone (ENPA).

Pesticide detection in the Headwaters of the Exe sub-catchment

Neither the total number of detections nor the maximum concentrations measured show a clear change between monitoring years at Pixton or Dulverton. Over the six monitoring seasons, the total number of detections per season ranges between 6 and 15 (Table 2). The River Barle tends to experience both higher numbers of detections and higher maximum concentrations per pesticide than the River Exe.

Table 2 Total number of detections, exceedances above 100 ng L^{-1}, maximum concentrations detected and total number of compounds detected in the River Exe (at Pixton Gauging station) and River Barle (at Dulverton) between spring 2016 and autumn 2018. The blue shading indicates a severity scale separately applied to each parameter, from light blue (low) to dark blue (high).

		Spring 16	Autumn 16	Spring 17	Autumn 17	Spring 18	Autumn 18
Total number of detections	R. Barle	15	7	13	6	12	9
	R. Exe	14	9	8	9	13	9
Nb single exceedances >100 ng L^{-1}	R. Barle	0	0	0	0	0	0
	R. Exe	0	0	0	0	0	0
Max value (ng L^{-1})	R. Barle	47	6.9	1.9	31.4	11	6.7
	R. Exe	27.3	3.8	2.2	5	2.3	1.9
Total number of compounds	R. Barle	5	4	5	3	5	5
	R. Exe	6	4	4	4	5	4

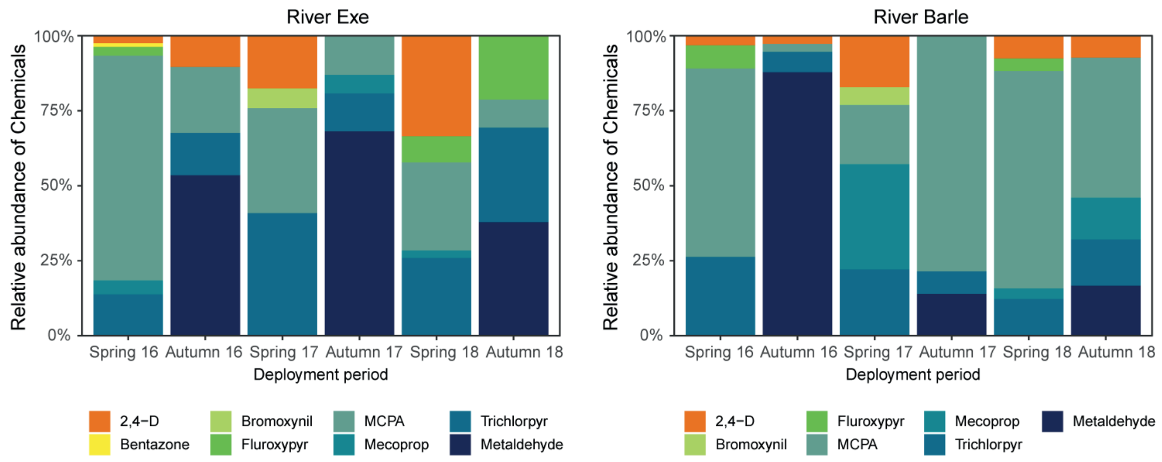


Figure 6 Relative abundance of chemicals found during each deployment period in the River Exe at Pixton gauging station (left) and the River Barle at Dulverton (right).

Spring periods appear to be more "at-risk" than autumn for the number of detections, suggesting that pesticides are more likely to leave the agricultural land and enter the water at this time of year.

All compounds found in both catchments are widely used as broadleaf weed pesticides. MCPA and Trichlopyr are consistently present (Table 2 and Figure 4) during all monitoring periods; 2,4-D and Mecoprop, are also regularly found, but to a lesser extent. Finally, metaldehyde, commonly used in slug pellets, is found during each autumn, corresponding with the prime application time of the chemical on re-seeding grassland.

Sampling on the River Quarme; photo Paul Henderson.