Decline in chalk stream water quality immediately downstream of freshwater fish farms and the potential impact on macroinvertebrate communities

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Introduction

85% of the world's chalk streams are located in England, these are unique ecosystems with a high standard of water quality. They support a diverse community of macrophytes, invertebrates and salmonids, including the blunt-fruited water-starwort (*Callitriche obtusangula*), wild brown trout (*Salmo trutta*) and the blue-winged olive (*Serratella ignita*). However, chalk streams and the wildlife they support are highly sensitive to pollution from various sources, including:

- Effluent from sewage treatment works
- Fertiliser run-off from agriculture
- Effluent, food waste and faeces from freshwater fish farms

Freshwater fish farms: a neglected pollution source

Pollution sources can introduce a range of organic chemicals to chalk streams, including nutrients, personal care products, pharmaceutical residues, plant protection products and industrial chemicals. These chemicals can significantly affect invertebrate species, with a loss of 4 mayfly species observed from 2016-2018 due to a diverse range of pollutants in the River Test according to the WildFish RiverFly Census.

Research into the water quality of chalk streams has primarily focused on pollutants from sewage treatment works and agriculture, neglecting the influence of numerous fish farms across southern England.

Pollutants released by fish farms include:

- Veterinary drugs and antibiotics to control disease outbreaks
- Metal salts and phosphate within fish feed to maximise growth rates

The impact of phosphate pollution

Phosphate (PO_4^{3-}) is considered a particularly influential pollutant in chalk streams. This nutrient can stimulate excessive algal growth and eutrophication, reducing oxygen levels, acidifying waters and warming temperatures to stress invertebrates and salmonids.

Each year, the EU Water Framework Directive classifies water bodies as 'high', 'good', 'poor' or 'bad' quality based on different ecological and chemical parameters. Although chalk streams have naturally low PO_4^{3-} concentrations, 77% achieved 'poor' or 'bad' water quality status in 2022 largely due to PO_4^{3-} pollution. With 85% of global chalk streams located in England, sources of PO_4^{3-} and other pollutants must be holistically monitored to protect the water quality and ecology of these unique ecosystems.

Monitoring nutrient pollution from Itchen Abbas Trout Farm

The River Itchen, Hampshire is one of 224 UK chalk streams in England. Our research project based at the University of Portsmouth aimed to assess the influence of a trout farm located

within the Itchen Abbas catchment. The main objective was to elucidate the impact this nutrient source has on the water quality of the surrounding catchment.

Over 24 days (September-October 2022), PO_4^{3-} concentrations were sampled approximately 50m upstream (Fig.1a) and downstream (Fig 1b.) of the trout farm using an ISCO automated bottle sampler (Fig 1c). This method minimises financial costs and sampling time relative to manual spot-sampling techniques used by the Environment Agency. Temperature, conductivity and dissolved oxygen levels were also measured using a CTD probe.

Fig 1: Site locations and monitoring equipment for the study (a) Upstream location (b) downstream location (c) ISCO automated sampler

To understand long-term changes in water quality approximately 1500m downstream, concentrations of PO_4^{3-}, ammoniacal nitrogen and dissolved oxygen were also obtained from the 2000-2022 EA Water Quality Archive at 3 sites – 1 upstream and 2 downstream of the trout farm. Overall, PO_4^{3-} concentrations increased 50m downstream over the 24-day field trial and 22-year archive, by an average of 0.38 mgL^{-1} and 0.014 mgL^{-1}, respectively (Fig. 2).

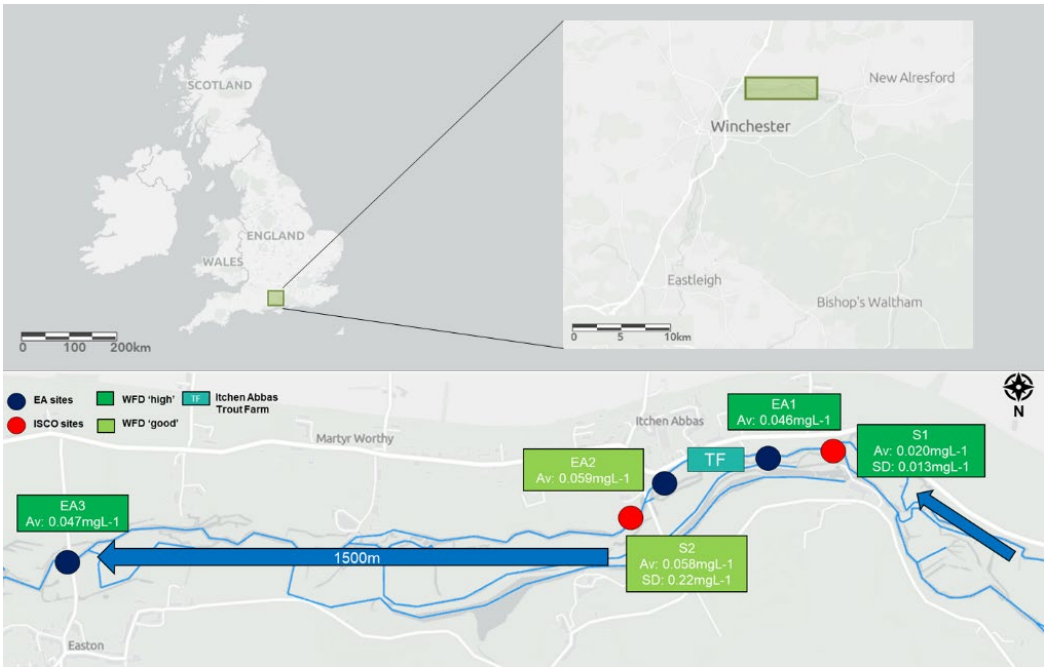

Fig. 2: Graphic of sampling sites and concentrations from ISCO samplers (S1 and S2) and EA monitoring stations (EA1-EA3)

Consequently, water quality degraded from ‘high’ to ‘good’ WFD status. This change coincided with an increase in ammoniacal nitrogen, temperature and conductivity, and a 25-30% decline in dissolved oxygen. However, all parameters recovered 1500m downstream to ‘high’ WFD status, suggesting nutrient pollution was only of concern over short distances.

Whilst ‘good’ is considered to be an acceptable standard for most freshwater bodies, any classification below ‘high’ in chalk streams could be ecologically significant. For example, recent research suggests small water quality declines can significantly hinder the reproduction of invertebrates, reducing the number of individuals available to consumers including trout, birds and otters. Consequently, nutrient loading from Itchen Abbas Trout Farm could still be of high ecological concern over short distances.

Preventing chalk stream pollution

To minimise the ecological impacts of chalk stream pollution, trout farms should consider reducing their nutrient outputs over short distances by:

- Reviewing and updating current effluent treatment processes
- Introducing a low phosphate, high protein diet to improve the retention of nutrients in cultivated fish
- Monitoring food waste using underwater cameras, electric pellet counters or sonar systems

All potential pollutant sources should be monitored more consistently to understand their impact on chalk stream water quality and inform future management strategies.

Recently, the Environment Act 2021 proposed ambitions to monitor water quality upstream and downstream of every pollution source in the UK. It is hoped this will provide further insight into the extent of nutrient loading from trout farms and encourage more action to improve the water quality and biodiversity of UK chalk streams.