Results and discussion of fish and invertebrate monitoring on the River Nent and South Tyne

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Background to metal mines in the Nent valley

There have been lead mines in the Nent valley since Roman times and over 90 mine entries have been recorded throughout the area. As technology advanced in the 1700s and 1800s and longer access tunnels and drainage levels (adits) could be constructed, the centres of activity became concentrated around Nenthead and Nentsberry. By the 1920s mining had ceased, but mining has left large areas of contaminated spoil which has little vegetation cover and is being eroded by high rainfall and washed into the River Nent. The network of mines beneath the valley also act as drainage channels that carry groundwater to the River Nent.

As water passes through this spoil and along drainage channels a series of chemical reactions take place which allow metals such as zinc, cadmium and lead to dissolve into the water so that the river concentrations become detrimental to aquatic organisms. All dissolved metals, whether essential or non-essential, are toxic to life above a threshold bioavailability[1].

Fish introduction

Most fish species occupy a position high up the food chain in river ecosystems. Consequently, the status of fish populations can be affected by a wide range of direct and indirect impacts. For example, fish typically respond to reduced oxygen levels, acidification, physical modifications to spawning and nursery habitat and pollution by contaminants, such as metals.

Fisheries surveys in the River South Tyne generally find healthy and diverse populations of fish, including migratory salmon, but not in all areas. The picture is different however in the River Nent where migratory fish are not expected because of the Nent Force waterfall. Here fisheries surveys show that the densities of non-migratory brown trout, the primary fish species in the watercourse are found at very low levels compared with the expected population.

The high metal concentrations not only affect the number and variety of the river flies (invertebrates) available for fish to eat but can also directly affect fish reproduction and survival. Improving the water quality through treatment schemes such as Nent Haggs will lead to a healthier river ecosystem for these and other species, as well as the general water quality for all water users.

Our results

In 2017 the Environment Agency surveyed fish numbers at 5 locations on the River Nent. The estimated density of Brown Trout was between 5.6 and 15.7 fish per 100m2. The average Density was about half that of a control site of Deepdale beck in the Tees catchment 8.7 vs 16.28 /100m2. No other species were found.

In 2018 the same 5 locations were surveyed again. The estimated density of Brown Trout was between 3.9 and 12.4 fish per 100m2. 3 of the 5 locations were lower than in 2017. The average density was lower (7.5 fish per 100m2) and it was less than half of the average estimated density of the control site at Deepdale beck, 7.5 vs 17.72 fish per 100m2.

Fish surveys are carried out in a wide range of rivers across the North East, 10 of these sites are comparable to the River Nent because they are also upstream of natural barriers e.g. waterfalls. The results of the latest surveys show that the River Nent is the lowest scoring of these sites.

Impacts on fish

The Environment Agency uses the Metals Bioavailability Assessment Tool (MBAT) to understand the impacts of metals in rivers. MBAT allows us to calculate the metal concentrations that should have no impact on aquatic organisms (including fish and invertebrates (river flies)); this calculated concentration is the Environmental Quality Standard (EQS). The MBAT takes account of the water

[1] Luoma, SN & Rainbow, PS. 2008. *Metal Contamination in Aquatic Environments: Science and Lateral Management.* Cambridge University Press, Cambridge, 573 pp.

chemistry, particularly the pH, dissolved calcium and dissolved organic carbon, to calculate the EQS since these factors influence the toxicity of metals to aquatic organisms. Because the water chemistry varies with rainfall and river flows, the EQS also varies so we have to report a range rather than a single number.

We compare the measured dissolved metal concentrations to the EQS to assess whether the river is polluted. When cleaning up rivers, the normal target is for measured concentrations to be less than or equal to the EQS. Table 2 shows the calculated EQS and the measured concentration for each metal in the River Nent at Alston. The final column shows by how much the measured concentrations exceed the standard (note that high measured concentrations do not correlate directly with high EQS concentrations).

	Metal Concentration in the River Nent at Alston (ug/l)		**Exceedance of Standard**
	Calculated Environmental Quality Standard ug/l	Measured Concentration ug/l	**(2017 to 2019 data)**
Zinc	19 - 88	522 - 3100	8-135x
Cadmium	0.08 – 0.25	1.24 – 8.66	15-42x
Lead	2.7 – 22.8	1.5 – 53.5	1-10x

Table 2 - Metal concentrations at Alston (data from 2017 to 2019)

The concentrations of zinc in the River Nent are not generally high enough over a sustained period to be directly toxic to fish (although they are some of the time). Concentrations above 2000 ug/l are expected to be directly toxic to fish, meaning that they would not be able to survive more than a couple of days[2]. The presence of fish in the River Nent shows that zinc concentrations are not at directly toxic levels for long enough to have an immediately toxic effect. However, chronic (long-term) exposure to concentrations below this level can still have detrimental effects caused by the accumulation of metals in the tissues of the fish, particularly gills, liver, kidneys and bone, this is known as bioaccumulation. These high levels in fish tissues can affect the number of eggs they are able to produce, the number of eggs that hatch, the quality of the offspring, and can reduce their lifespan. High metal concentrations also have an impact on the development of the egg in the watercourse after they have been fertilised.

What it means for fish

Whilst there are other factors that could potentially affect fish populations, our investigations have highlighted metal concentrations as a major contributing factor. A reduction in the concentration of zinc, cadmium and lead should contribute to reducing the long term effects, allowing fish to produce more eggs. It may not mean that fish in the River Nent will produce the expected numbers of eggs but they would produce more, therefore increasing the chances of increasing the population and allowing them to live longer.

Invertebrates introduction

Fish numbers and diversity are not the only useful indicator of water quality in rivers, invertebrates form an important part of the ecosystem and are also a good indicator of water quality. All of our rivers have characteristic invertebrates (insects and other small aquatic animals) and plants associated with them, the range of which are dependent on various environmental and physical attributes of that water course (the 'ecology of the river'). Pollutants, such as heavy metals, entering a river can change the environment which these animals and plants need to survive, and

[2] Alabaster, JS & Lloyd, R, 1980. *Water Quality Criteria for Freshwater Fish.* Butterworths, London.

subsequently the range and types of plants and animals typically associated with that river. The numbers and diversity of invertebrate populations in the River South Tyne are better than have been found on the River Nent, however, they still do not meet the expected levels for similar rivers.

Our results

Environment Agency samples in 2013 and 2016 in the River Nent at Alston showed that of the 38 families that were predicted (by the UKTAG River Assessment Method) to be present, in a similar unpolluted river, 18 were completely absent and only 4 met the expected population. For example:

May flies – 6 types were expected with populations totalling 917 per year, however, only 1 type was found with a population of 138.

Freshwater shrimp - a population of 424 was expected per year and none were found.

This trend continues throughout the majority of families that were expected to be found.

In 2017 samples were collected from 4 sites on the river Nent in Spring and again in Autumn. In all of the samples collected in both Spring and Autumn the observed number of families was below the expected number. A Mayfly family with an expected total population of 592 evenly distributed across the 4 sites in Spring was present only at the site upstream of the mine adits and only 9 individuals were found.

In 2018 the samples were repeated at the same 4 locations plus an additional 3 locations. At the 4 repeated sites the observed number of families was lower than in 2017 and at the 3 additional locations the observed number of families was below the expected number. The population of Mayfly at the initial 4 sites mirrored that of 2017 but with only 3 individuals found at the upstream site. At the additional 3 sites only 5 individuals were found.

What it means for invertebrates

Reducing the metal concentrations will lead to increased invertebrate populations which will be more diverse, preventing species die off in the area and encouraging species that are more sensitive to thrive. The absence of invertebrates in the river system can play an important role in causing algal blooms which can cause issues in their own right. Similar to the impacts on fish populations, lower metal concentrations will improve the overall health and diversity of the invertebrate populations. Improved invertebrate populations can also impact on river life beyond the water, providing a food source for birds and other animals such as dippers and some species of bat.

Summary

In summary, both fish and invertebrates in the River Nent do not meet the standards that would be expected for the locations that were sampled. The major reason for this is that these populations are continually subjected to high metal concentrations which for some invertebrates mean that they cannot survive, for other species, including fish, metals accumulate in tissues and have a chronic effect that limits population growth.

The River South Tyne downstream of the River Nent does generally contain good levels of fish that meet the expected numbers and diversity but not in all areas. However invertebrates along the whole South Tyne corridor are not present in the number or variety that would be expected.

Improving the metal concentrations will reduce the rate of metal accumulation in fish and invertebrates with the benefit of improving the numbers and the diversity of each population individually as well as the ecosystem beyond.

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