



Figure 1 Afon Cynon River (Wikimedia Commons, 2014)

Afon Cynon Water Quality and Pollution Survey

RESEARCH PROPOSAL

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1. Introduction

River pollution poses a significant threat to both aquatic ecosystems as well as human populations. Protecting this natural resource is of great importance, but this can only be done effectively with accurate data collected from the rivers that in need of safeguarding. The Afon Cynon is a river in the middle of the Cynon Valley in South Wales and flows through a mix of both rural and urban environments. Like many other Valleys around South Wales, it has been at the centre of industrialisation throughout the 19th and 20th centuries (Humphrys, 1972). This has led to the river being exposed to many forms of pollution such as urban and agricultural runoff as well as mine leakage. This study aims to assess the current pollution levels within the river and to assess any potential sources through targeted field testing and GIS mapping.

1.1 Aims and Objectives

There is not much publicly available data on the specific conditions of the river and where any pollutants come from. The aim of this study is to gain an understanding of where along the river pollutants are entering the water, what pollutants there are and a rough estimate as to where they originate from. This study will not give a definitive answer as to where any pollutants specifically originate but will answer what is entering the water and at what point along the length of the Afon Cynon. This will narrow down the area of potential pollution, opening up the possibility for further study.

In order to achieve this, the following objectives are to be carried out.

1. Perform point testing along different sections of the river using varied methods.
2. Use this data as well as data from previous studies on the Afon Cynon, compare results to determine at what point pollution seems to enter the river.
3. Using GIS, map out where pollutants are highest in the river to determine where they are potentially entering the water.

1.2 The Catchment

The river that is the focus of the study is the Afon Cynon which flows from Hirwaun, passing through several towns and urban areas where it finally joins on to the river Taff at Abercynon. It sits at the centre on the Cynon valley between the Rhondda valley and the Merthyr catchment. The river is approximately 15 miles long and flows through a historically industrial area (Cynon Valley History Society, 2025).

Data has been collected over the previous 20 years by the South East Wales Rivers Trust starting in the year 2000. The organization has collected a number of readings from the river such as PH, nitrogen, phosphorus, heavy metal and many others. This data can be used to compare results from this study in order to make the final findings more reliable.

According to analysis by Natural Resources Wales (NRW), the Afon Cynon is of poor quality by 2015 classification standards (Natural Resources Wales, 2016). The report is fairly vague and does not go into detail about the Afon Cynon specifically, but it says that one of the main problems within the whole South East Valleys include physical modifications such as weirs that limit fish migration, urban diffuse pollution and potentially some mine water leakage. This report gives some indication as to what the problems could be but does not go into enough details. This is why more research is needed to confirm what the pollution levels are and potential sources.

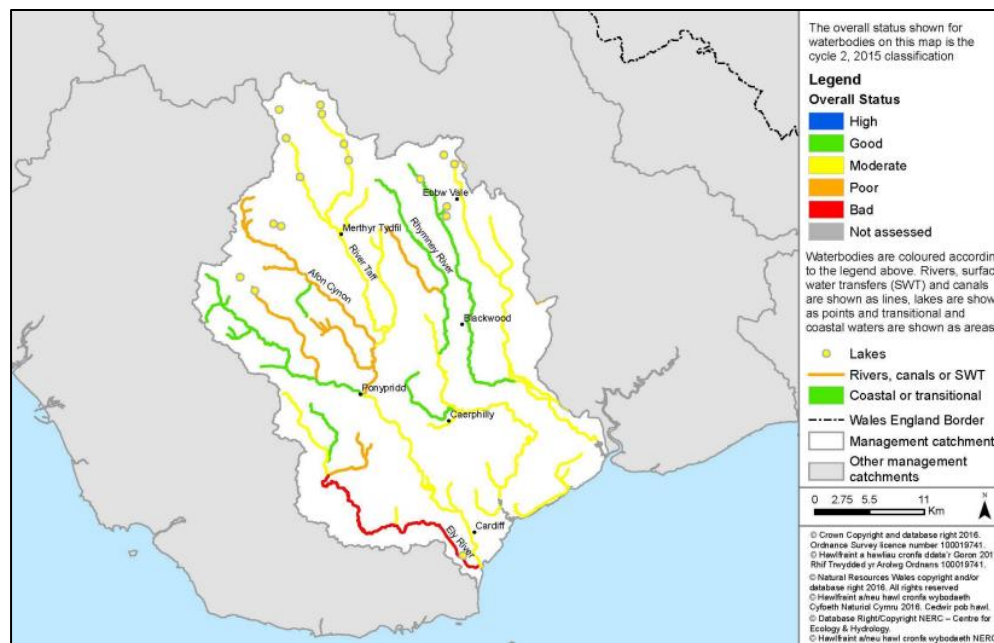


Figure 2 Status of the South East Wales Catchments as of 2015(Natural Resources Wales, 2016)

2. Literature review

2.1 Potential pollution sources

There are several potential factors or sources of pollution that could be linked with the Afon Cynon's poor water quality. The first factor is potential anthropogenic structures within the river that could disrupt fish migratory patterns. Weirs are large manmade dams that control the flow of water (Mccrea, 2013) and can have a huge impact on river ecology both upstream and downstream (Kiely, 1997). A study published by Melanie Muller in the Journal of Applied Ecology, shows that weirs can change the flow of water within the river and causes waters downstream to become faster while water upstream becomes deeper and has a slower current (Mueller, Pander and Geist, 2011). This change in water speed means that the organisms that live around the structure can be drastically different depending on if they live upstream or downstream. (Dodds and Whiles, 2020). However, as the study states these effects are most noticeable within direct proximity to the structure and so won't have a large effect on the Afon Cynon as the nearest weir is downstream near Cardiff (HBR, 2016).

Another form of pollution worth looking at is urban diffuse pollution. This is the pollution that comes from a large area and not just one single point which makes it hard to track. This happens when rain washes particles within the catchment into the water ways where these pollutants can accumulate (Gray, 2017). By using methods like point testing, GIS mapping and drone surveying. It is possible to identify and manage the sources (Reaney et al., 2019).

This is not just limited to urban areas but also agricultural land. To keep up with the growing population, more fertilisers are required to grow the vast amounts of food required. This has led to an increase in the amount of nitrogen and phosphorus entering the environment (Conley et al., 2009). If these fertilisers get into water sources this can lead to algae blooms which can lead to eutrophication. This can be catastrophic for aquatic ecosystems (Martínez-Dalmau, Berbel and Ordóñez-Fernández, 2021). Of all the land within Wales, about 88% is farmland or owned by farms and so could potentially be a large contributor of diffuse pollution (Welsh Gov, 2019).

The Cynon Valley as well as many other valleys in South Wales had extensive mining operations throughout the 19th and 20th century. Therefore, there are many abandoned and disused coal mines within the catchment.

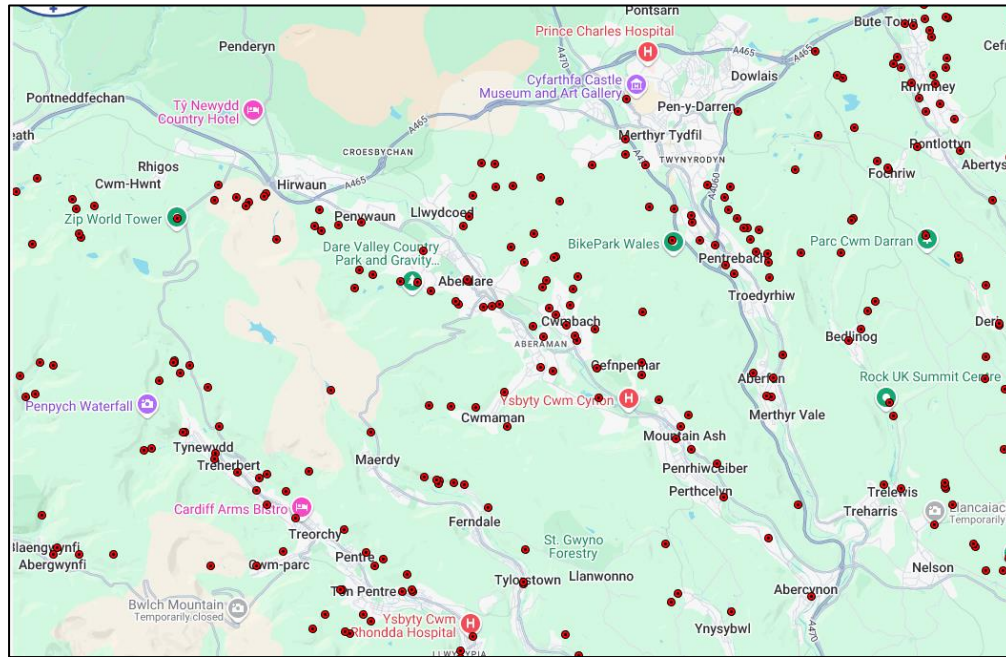
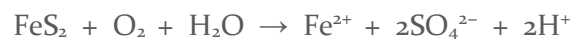


Figure 3 Map Indicating Location of Disused or Abandoned Mines Within the Catchment (Northern Mine Research Society, 2025)

This means that there is the potential for mine water leakage. This is where water is able to enter and flood disused mineshaft, subsequently leaking out (Acharya and Kharel, 2020). This water is often contaminated by mine spoil left over within the mine, typically Pyrite and other sulphides. When this mixes with water the following reaction takes place;



(Akcil and Koldas, 2006)

Alongside the formation of ferrous iron and sulphate ions, hydrogen ions are also formed. A property of hydrogen is that when mixed with water, it will decrease its PH, turning it acidic which will put more pressure on ecosystems within the water (Bartram and Ballance, 2020). This allows heavy metals to dissolve more easily into the water such as aluminium and magnesium (Wolkersdorfer, 2022).

2.2 Pollution Measurement Methods

There are several methods of measuring the general water quality of a water source. One method is using biological indicators such as macro invertebrates. These organisms make great indicators of pollution as they cannot move long distances easily and are very sensitive to many forms of pollution (Jeffries and Mills, 1995). There are many different metrics of measuring the water quality using macroinvertebrates, all of which have their own advantages and disadvantages. The Chandler biotic index differs from other indices as while other indices group organisms only into simple groups based on tolerance, e.g., tolerant, moderate or sensitive. The Chandler index also takes into

consideration the number of individuals present, giving a more accurate score (Gray, 2017). If you combine all the scores together this will give an overview of the general health of the river. So, while it will give an accurate score it requires lots of knowledge on macroinvertebrate identification (Washington, 1984). Kick sampling also has the benefit over other survey methods such as chemical analysis as when testing what chemicals are present within the river, only the current condition of the river is being measured (Sabha et al., 2022). While when kick sampling, the overall health of the river can be analysed. This is because if pollution has caused the decrease in macroinvertebrate populations, it will take significant time for them to recover without dedicated restoration efforts (Pilotto et al., 2018).

As previously discussed, farmland can be a substantial polluter for rivers through the runoff of fertilisers such as nitrogen and phosphorus. Another method of comparing pollution levels is by calculating the trophic state index of the river. This is a method of comparing water qualities and helps to calculate whether a river is nutrient rich (Eutrophic) or nutrient poor (Oligotrophic) (Carlson, 1977). In order to calculate the trophic state index, water samples need to be tested for the concentration of the following substances;

- Chlorophyll-a
- Total Phosphorus
- Total Nitrogen

Once it has been determined whether the water source is Nitrogen limited, Phosphorus limited or balanced, the following formulas can be used;

All Calculations:	TSI (chl a)	$= 16.8 + [14.4 \times \ln(\text{chl-a})]$
Nutrient Balanced:	TSI (TP)	$= 18.6 \times [\ln(\text{TP} \times 10000)] - 18.4$
Nutrient Balanced:	TSI(TN)	$= 56 + 18.8 \times \ln(\text{TN})$
Phosphorus limited:	TSI ₂ (TP)	$= 10 \times [2.36 \times \ln(\text{TP} \times 1000) - 2.38]$
Nitrogen limited:	TSI ₂ (TN)	$= 10 \times [5.96 + 2.15 \times \ln(\text{TN} + 0.001)]$

Then the final TSI can be calculated using the following formulas;

Nutrient Balanced Lakes;

$$TSI = \{TSI(chl-a) + [TSI(TN) + TSI(TP)]/2\}2$$

Phosphorus-Limited Lakes;

$$TSI = [TSI(chl-a) + TSI_2(TP)]/2$$

Nitrogen-Limited Lakes;

$$TSI = [TSI(chl-a) + TSI_2(TN)]/2$$

Using the following guide it can be determined whether the water is Oligotrophic or Eutrophic;

0-59	Oligotrophic	Good
60-69	Mid-Eutrophic Eutrophic	Fair
70-100	Hypereutrophic	Poor

Acid mine drainage may be more difficult to definitively prove, especially if it is trace amounts. One of the main byproducts of acid mine drainage is the release of heavy metal particles within the water as well as PH changes downstream of the source (Gray, 2017). Researchers studied the long-term changes of the outflow of 3 abandoned mining sites within Wales and to test for AMD, they measured the heavy metal contents downstream of the mines (Aaron M.L. Todd et al., 2024).

2.3 GIS

Geographic Information Systems (GIS) is great for river management and is used regularly by land managers and environmentalists. A study published by Hayder H. Kareem in the International Journal of Water uses GIS software to model the hydrological characteristics of the river Usk in South Wales (Kareem, 2023). It is a great example of how GIS can be used to map out the topography of the river catchment. This can be combined with Land Use Land Cover (LULC) mapping to monitor what the land around the river basin is being utilised for to identify potential sources of pollution within the catchment (Sekharan et al., 2022).

3. Methodology

3.1. Approach

Testing will take place over 5 preselected sites that cover the length of the river (Figure 4) with the first site being as far up stream as is safe and accessible. Each site is accessible on foot and is either publicly accessible or permission has been granted by the landowner.

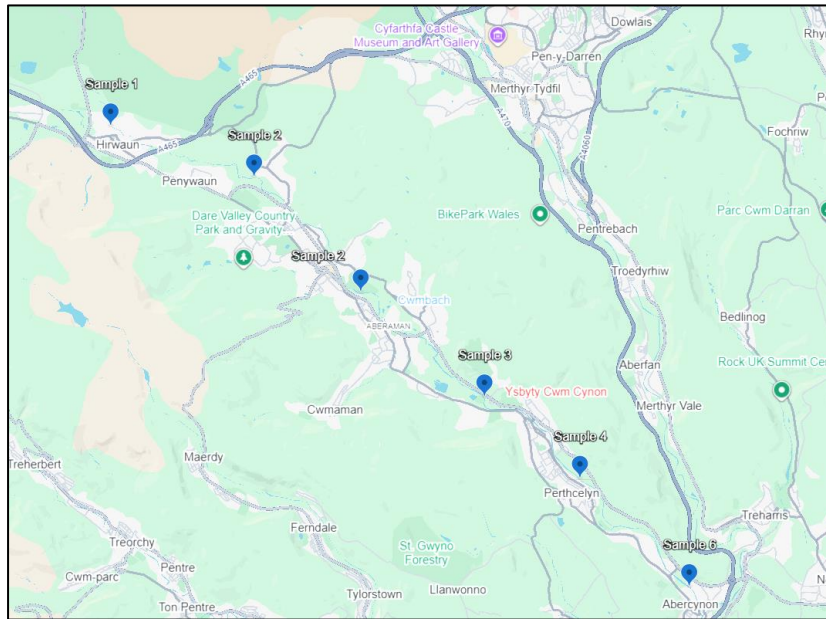


Figure 4 5 Points that will be sampled in this study (Google Earth, 2025)

At each site a kick sample will be performed to collect the macroinvertebrates. This will be performed by placing a kick sampling net in the river and agitating the sediment, dislodging the macroinvertebrates where the current will push them into the net. These will subsequently be stored in an ethanol solution to preserve them for lab analysis. They will then be identified using microscopes and sorted into groups based on species with a score assigned based on the Chandler biotic index.

Water samples will also be collected at each site which will be tested via spectral analysis for the following;

- Total Nitrogen
- Total Phosphorus
- Chlorophyll-a
- Heavy metals

The nitrogen, phosphorus and chlorophyll-a will be used to calculate the TSI to determine the levels of eutrophication. These can then be compared with each sample point to see if there is significant eutrophication along a certain stretch of river.

PH will also be tested at each site which when combined with the amounts of heavy metals will give an indication to any potential acid mine drainage if the PH drops and

the heavy metal contents rise. This is not enough to conclude acid mine drainage is occurring but it will allow a base for further study going forward.

Once all data has been collected and processed, it can then be mapped onto the watercourse using GIS software in order to visualise where pollution seems to be entering the river. Combining this with LULC and topographical mapping could allow for the sources of pollution to be narrowed down to a much smaller area and will allow the opportunity for further study on locating specific sources.

3.2. Evaluation

This study is important as there is currently very little publicly available data on the Afon Cynon and to safeguard against the different forms of pollution, the data must be available. The Afon Cynon is the start of the much larger river Taff and so in order to limit ecological harm downstream, the problem must be limited from the source.

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