An Investigation into Water Quality and the Ecological Status of the Canal System Present in Galway City, in Addition to the concentrations of Heavy Metals Present in the Claddagh Basin and Eglinton Canal

By

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1. Background

Galway city contains an extensive system of canals and rivers that feed off the River Corrib. Recently, concerns have been raised over the water quality of these urbanised waterways. The study focuses on Galway's Eglinton Canal System, which includes the Gaol and St. Clare, from its start near the campus of NUI Galway, to where these branches rejoin the River Corrib at the Wolfe Tone Bridge above The Claddagh.

The purpose of this research is to obtain a quantitative analysis of the water chemistry and quality of benthic habitats of the chosen study areas within the canals system of Galway City, as the water that flows through these canals and rivers eventually reaches the Corrib river which then enters Galway Bay. The water quality in this system may be of importance as Galway Bay is listed as a Special Area of Conservation, and an area of scientific importance (Department of Arts, Heritage and the Gaeltacht, 2013). The data collected from this study will be used to determine the ecological standing of each canal in conjunction with the Water Framework Directive [WFD] (2000/60/EC).

The main water quality components relevant to this study include; phosphorus, dissolved oxygen, conductivity, pH, nitrate, and temperature. This research was carried out over a five-month period where each canal was sampled twice monthly to observe any seasonal change. The intention of this project is to acquire reliable water quality data that has not previously been obtained within the chosen areas of study. This will help identify potential contributors to any poor water quality, if any is observed by the process of nonpoint source pollution (NSP). The main areas of study include the Eglinton Canal, the Gaol River and the St. Clare River. Sediment cores from the Claddagh Basin and the upper section of the Eglinton Canal were also taken to determine the concentration of heavy metals. This was the first time sediment cores were taken from both of these areas in order to determine what influences Galway City's industrial past has had upon its aquatic environment.

2. Research Aims and Objectives

- To compare the quantitative data collected of water quality characteristics (phosphorus, dissolved oxygen, conductivity, pH, nitrate, and temperature) against the Water Framework Directive.

- To compare the levels of each water quality characteristic between different sections of the canals and between each canal.

- To determine the ecological classification for each canal in accordance with the Environmental Protection Agency's (EPA) Quality Rating System.

- To begin laboratory work for the identification of benthic organisms, once the first week of sampling is complete.

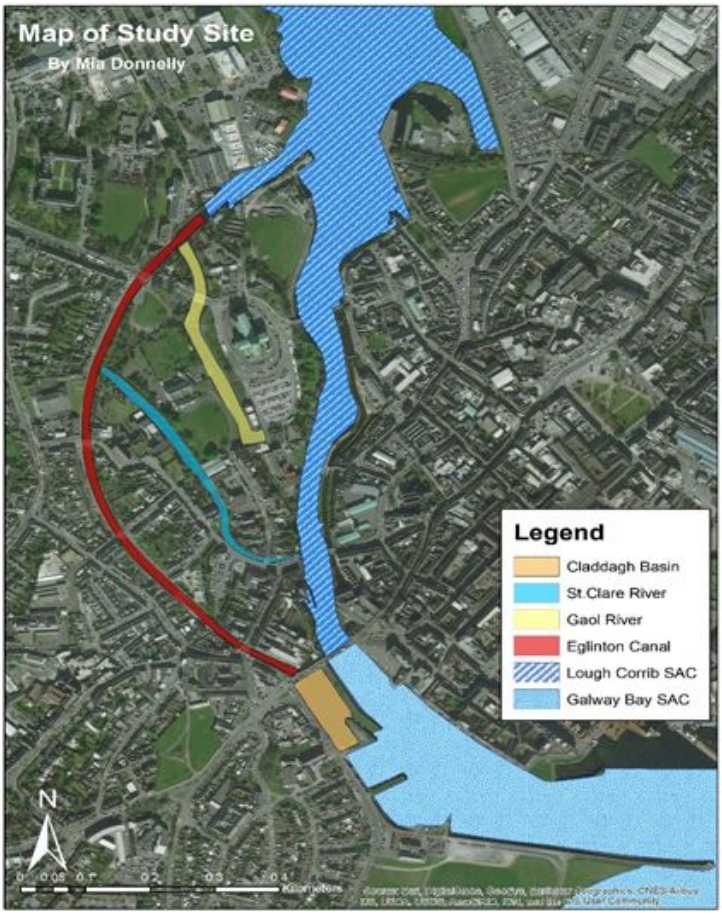
- To determine the concentration of heavy metals from each section of sediment core taken from the Claddagh Basin and from the Eglinton Canal.

- To determine if heavy metal concentrations change depending on the depth level of each sediment core taken.

3. Study Area

The main areas of research for this study include the Gaol River (376m) the St. Clare River (483m) and the Eglinton Canal (1,183m) of Galway city's canal system. These areas were designated for water quality testing and benthic health on a continuous basis while, one area along the Eglinton canal was selected for sediment coring. The Claddagh Basin was designated for water quality and sediment cores to determine the presence and concentration of heavy metals deposited from previous industrial activities along Galway cities waterways.

Each canal runs back into the Corrib River before entering Galway Bay at the Claddagh, while water from the Claddagh Basin enters directly into the Bay. Both the canals and the Claddagh Basin are not protected under EU legislation.



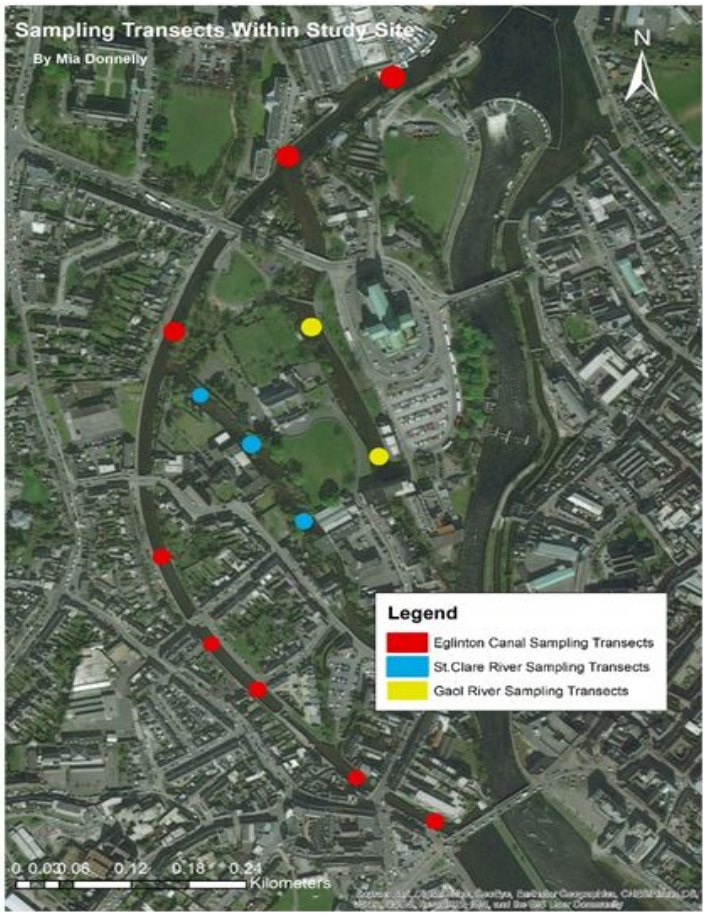


Figure 1.*(above) shows the location of study site in relation to the surrounding SACs.* ***Figure 2.*** *(above) depicts a close up version of the study site with sample transects identified for the Gaol River, St. Clare River and the Eglinton Canal.*

4. Methods

To achieve the research aims and objectives of this project sampling on each of the canals began in February 2018 and continued fortnightly until July of the same year. The order of procedures was replicated at each transect; beginning with depth and flow measurement followed by water quality characteristic (dissolved oxygen, conductivity, pH, nitrate and temperature) testing using a YSI Pro Plus (Manufacturer). Phosphate water samples were taken and tested in GMIT laboratories. The recorded data from the YSI for water quality characteristics with depth and flow measurements were analysed and were compared to the EPA's water quality parameters and WFD. Samples of benthic habitat were collected using a D-net, placed in sealed plastic buckets and returned to the lab for formal identification in accordance with the EPAs' quality classification system.

Two cores from the Claddagh Basin were extracted using a Glew mini-corer while the sediment core taken from the Eglinton Canal was taken using a Eijkelkamp 50 cm peat sampler. The cores were sectioned on the bank of the Eglinton canal in 1 cm intervals, placed in labelled sample bags and returned to the lab for processing. All samples were dried and reduced to a fine powder which were analysed using a field-portable XRF spectrometer. The levels of each metal present were compared to the EPA's water quality parameters (EPA, 2001) and the Dangerous Substances Directive [DSD](06/11/EC).

5. Results

5.1 Overall Water Quality

All water quality characteristics collected from sampling were compared against the WFD in order to give an indication of ecological status present within the canal system of Galway City. The data collected from this project shows that the water quality does not meet legislative standards set by the European Union. The accumulation of this data collected shows a clear change in water temperature, DO%, conductivity, nitrate and phosphate concentration, while pH remained mostly constant over time. The average monthly temperature for the Gaol, St. Clare River and Eglinton canal changed dramatically during the sampling period with temperatures recorded reflecting weather conditions as average air temperature for Galway city fell below the previous years average temperatures for February and March, when there was record snowfall in Ireland and then increasing above previous years in June to the hottest June in forty years. All temperatures recorded from February to May agree with the WFD and EPA standards but those recorded in June surpass the limit set by the EPA of 25°C and therefore do not agree with the WFD.

The average pH observed from February to June in the Gaol River, St. Clare River and Eglinton Canal were all above 8.03. The pH remained constant over time and did not show any seasonal change. This data is in alignment with WFD as standard for pH is 8.5 C. The average DO% observed from February to June shows a continuous decline in oxygen saturation over time. The Eglinton Canal and St. Clare River remained above the EPA standard of 60% for the duration of the sampling period and is in compliance with the WFD. In contrast, the Gaol River remains in accordance with the WFD from February until mid June, before decreasing below the standard of 60% on the 29th of June. The levels of conductivity for the Gaol River, St. Clare River and Eglinton Canal were all observed to be below the WFD limit of 1000µs/L. There were no seasonal changes in conductivity during the sampling time frame. This shows there is little influence of tide frequencies in Galway Bay on the rivers and canal system.

The average nitrate concentrations continuously increased during the sampling period from February to June. The recommended standard of the WFD and EPA for nitrates is 50 mg/L, the concentrations of nitrate within the Gaol River, St. Clare River and Eglinton Canal were substantially higher than the desired level set by the WFD. The average nitrate concentration for the Gaol River was below the WFD standard during the month of February. All sampling dates after February were above the standard, peaking at an average of 187.60 mg/L. The St. Clare River remained below 50 mg/L until April when average nitrate levels were 66.81 mg/L and continued to increase to 94.46 mg/L in early June. The Eglinton Canal followed a similar trend as the St. Clare River, the nitrate concentrations remained below the standard until April when average concentrations were 85.16 mg/L. All three waterways had a peak in nitrate concentration during the sampling date June 15th of 184.60 mg/L for the Gaol River and 137.23 mg/L for the Eglinton Canal and 94.46 mg/L recorded for the St. Clare. The higher concentrations during April to June may be a result of nutrient leaching from agricultural land that exists along the banks of the Corrib River, which is the main source of water for the rivers and canal. High nitrate levels can cause eutrophication or 'organic enrichment' of the water if it is not managed properly.

Phosphate concentrations were measured during the months April to June. All three waterways were compliant with the WFD and EPA as Phosphate concentrations remained below the standard of 0.5 mg/L during the sampling period. Phosphate concentration that occur over 0.5 mg/L will also contribute to the likelihood of organic enrichment and thus may deteriorate the quality of the water. As phosphate is a limiting factor in lotic (flowing water) and lentic (still water) waters and is an essential element for aquatic life, the level observed show that phosphate is being assimilated and removed from the ecosystem.

Relationships between average water temperature and average nitrate concentrations were observed along with similar relationships seen for average water temperature and DO%. From each waterway there is a notable trend of increasing nitrate concentration with increasing temperature. With the continuous increase of nitrate to the Gaol River, St. Clare River and the Eglinton Canal, the sampling dates also overlap with the same time frame for spreading fertiliser on agricultural land. Nutrient loss to water sources from land that has been fertilised leads to the accelerated growth of plants and algae, cause eutrophication and impact the ecological standing of a water body. In Ireland the EPA suspect that agriculture caused 53% of river and surface water pollution during 2010 – 2012 (Forde, 2018; Fanning et al., 2017). This may contribute to the high concentrations of nitrate observed from March onwards. Figure 2 below is an example from the Gaol River that shows the relationship between rises in average temperature and average nitrate concentration over the same time period.

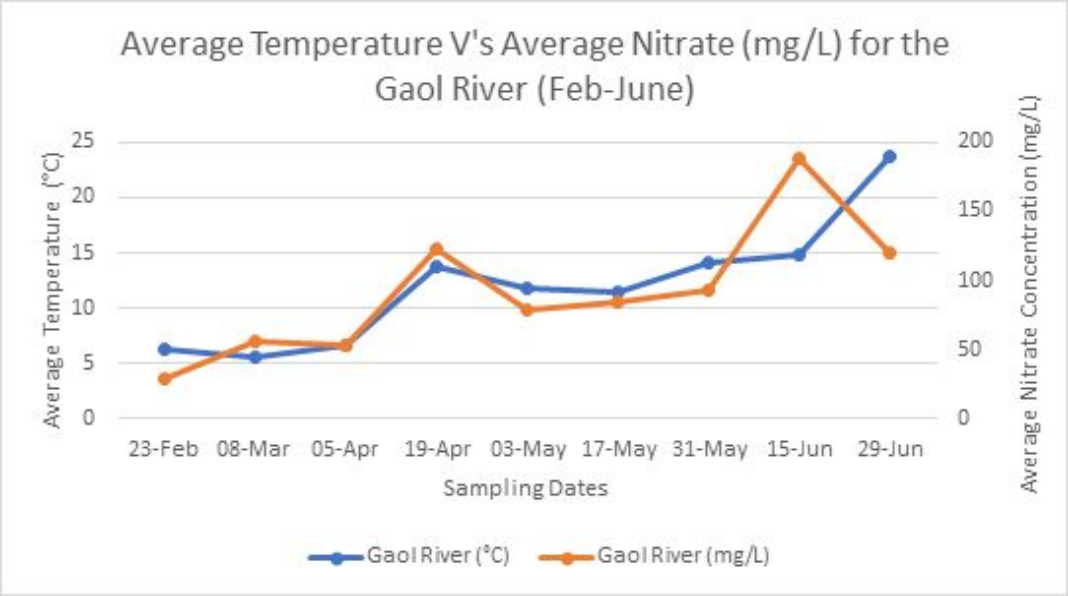


Figure 2. *Comparison of the average temperature and the average nitrate concentration for the Gaol River during sampling.*

Similarly, there is a decline of DO% occurring in April for the Gaol River, St. Clare River and the Eglinton Canal which may have been contributed to by increase of oxygen demand from biological organisms. Previous studies carried out have indicated that an increase of 2°C in temperature can lead to decreases in change in dissolved oxygen availability. Figure 3 below is an example of average temperature and average DO% observed for the Gaol River.

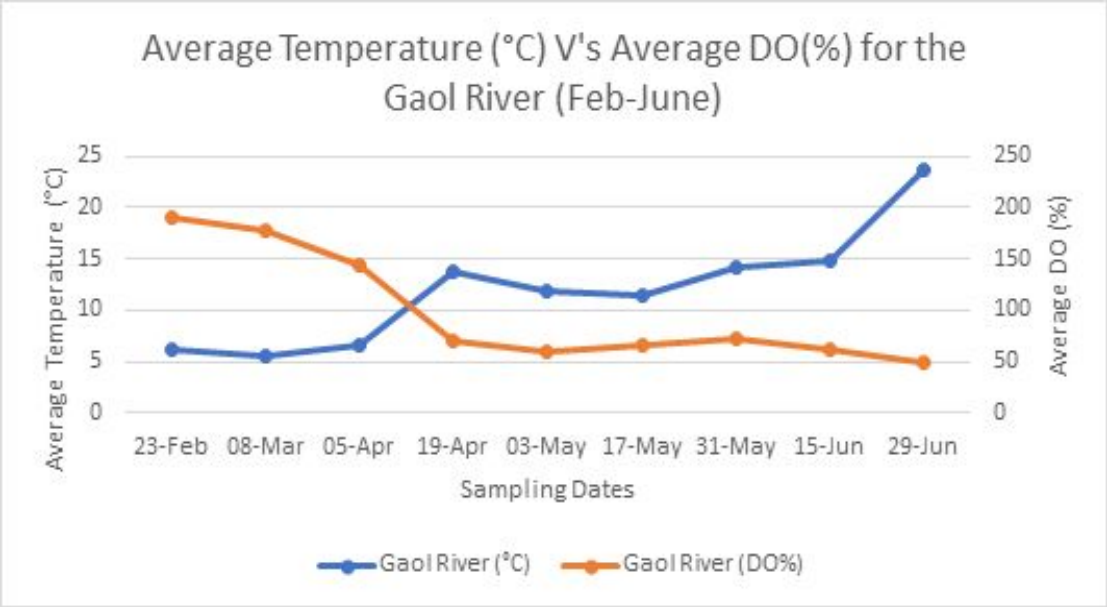


Figure 3. *Comparison of the average temperature and the average DO% for the Gaol River.*

5.2 Benthic Community

Benthic habitat specimens collected from the Gaol River and St. Clare River were largely dominated by tolerant and very tolerant taxa. Continuous sampling of the benthic habitat from these two rivers showed the abundance of each taxon and how it changes over time.An observation that was made during sampling of the St. Clare River from April onward was that a large amount of benthic sample taken consisted of fallen plant material from tree cutting which was carried out in March. The tree cutting and fallen debris altered the benthic habitat, which can be seen from the decline of abundance in each taxa present in February and the disappearance of other taxa. Overall the benthic communities of both rivers were depleted throughout the sampling period.

The most interesting find within the benthic sample for the Gaol and St. Clare Rivers was the appearance of the critically endangered European Eel (*Anguilla anguilla*).

Figure 4. *Showing one example of the European eel (Anguilla anguilla) caught from the St. Clare River in May. It measured 9.4 cm in length and 0.6 cm in width. This individual was still transparent in areas along its body.*

5.3 Heavy Metal Concentrations

The average heavy metal concentrations for each sediment core were identified for the Claddagh Basin and Eglinton Canal. The metals copper (Cu), Nickel (Ni), Lead (Pb), Selenium (Se), Molybdenum (Mo), Titanium (Ti), Barium (Ba), Cobalt (Co) and Zinc (Zn) were detected in both cores from the Claddagh Basin. Additionally, Mercury (Hg) was present in core one from section 10 cm to 17 cm and not in any part of core two. In accordance with the Dangerous Substances Directive [DSD](67/548/EEC), Mercury and all associated compounds must be eliminated from the environment due to the threat to biological and human health.
The metals Cu, Ni, Pb, Se, Mo, TI, Ba, Co and Zn were also detected in the first 30 cm of the upper core of the Eglinton Canal. The same metals were detected in the lower core along with the addition of Arsenic (As) in 101-102 cm section and 103-104 cm section.

The metals identified are listed within the Dangerous Substances Directive [DSD](67/548/EEC) and Sewage Sludge Directive [SSD](86/278/EEC), as effluent from slurry pits may enter an aquatic ecosystem as build up within the sediment over time. Cu, Ni, Pb, Se, Mo, TI, Ba, Co and Zn are listed within the Dangerous Substances Directive [DSD](67/548/EEC) as having a deleterious effect on aquatic life, which may leave them susceptible to a predisposition for certain diseases or disorders.

The assessment and monitoring of heavy metals within an aquatic environment is vital for the management of that water way. In this case, it is associated with a river and basin both within close proximity to two ecologically important SACs, Lough Corrib and Galway Bay Complex. The release of heavy metal contaminants into the habitat by disturbing sediment could impact the health of benthic communities already established within the immediate area and may have impacts on species and habitats of the qualifying interests of both SACs.

6. Recommendations

This five month study of the Gaol River, St. Clare River and the Eglinton Canal has determined that all three waterways are moderately polluted with reduced diversity and abundance of benthic habitat. Water quality parameters are consistently over the limit set by the EPA, and may be impacting important species and habitats. Minimal seasonal change was observed in water quality alone but this may have been contributed to unusual changes in weather, which the water quality mirrored. The heavy metal concentrations detected within the Claddagh Basin and upper section of the Eglinton Canal pose a threat to the overall ecological health to the rivers and canal if sediment is disturbed and contaminants such as Mercury are released back into the environment.

The main contributors of nitrate and phosphate to the canal system are agricultural practices that are ongoing within the Lough Corrib and Corrib River catchment areas. Runoff from agricultural land into an aquatic environment can lead to eutrophication and the growth of cyanobacteria. Both can result in risks to water resources, such as drinking water, fisheries, livestock and human health. Adequate management of these waterways is essential to prevent further deterioration and loss of habitat. I would recommend a review study with a longer monitoring program over a year long time period, to identify other spikes in nitrates outside of the peak fertilisation period on farmland. This would continue to monitor the water quality and the health of benthic communities within the canal system over a year long period. A review of agricultural land practices within the catchment area to help assess the impacts of waste waters and the timing of the application of fertilisers on surface waters. The application of filters on waste water outlet pipes and the maintenance septic tanks from householders may reduce harmful effluent entering Lough Corrib or the Corrib River, in turn reducing its impact with the Eglinton Canal system.

Local stakeholders from communities that live and work with the catchment area of Lough Corrib and the River Corrib could be consulted to identify any localised problems within the catchment area. Local business owners within Galway city should be made aware of the benefits of a healthy waterway can have on business and the local community.

The accumulation of sediment within the Gaol River and St. Clare River is substantial in areas. Any removal or disturbance of the sediment could destroy the benthic community already present and recovery of these areas could take a prolonged amount of time. This may also displace the habitat for the European eel, in turn reducing their survival rate. Movement of sediment may also pose a risk of releasing heavy metal contamination back into the canal system. Therefore I propose deeper sediment cores to be undertaken within the Claddagh Basin, Eglinton Canal and the Gaol and St. Clare Rivers, where possible.

7. References

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