Katie Wilkinson Research Scholarship Report

Investigating the ecological potential of geotextile fabrics and their suitability for freshwater restoration projects.

Tim Foo

Introduction

My dissertation extended on work I had previously undertaken during a summer internship in May 2015 where I was involved in designing a research proposal investigating the sediment-trapping capabilities of different types of geotextile fabrics. Geotextile fabrics are a unique material made from synthetic or natural fibres and come in large, flexible, permeable sheets. Their primary uses are as reinforcing components, separating agents keeping soils from mixing, or as filters such as those in landfill sites.

This research proposal took place at Brightlingsea Waterside Marina in Essex (Figure 1), where the potential re-use of dredged sediment was being investigated at the Marina; localised sedimentation issues were causing damage and geotextiles presented a unique opportunity to store dredged sediment in tubes, creating a breakwater to further reduce incoming sediment but also to facilitate the development of a saltmarsh environment. This was a unique example of a project underpinned by the 'Working with Nature' philosophy to deliver mutually beneficial, win-win solutions to benefit navigation and nature.

This research was highly innovating and unique and represented a fundamental need for a shift in thinking, where engineers and environmental bodies worked together to deliver mutually beneficial, and above all, sustainable solutions to shared issues. This short experience inspired me to extend the research carried out in this project and tailor it to my own aspirations in examining a potential use for geotextile fabrics in freshwater restoration projects.

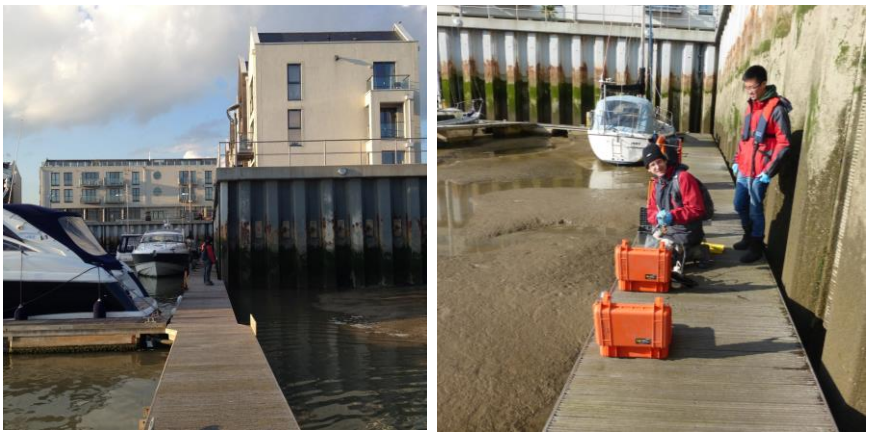

Figure 1. View from the end of the walkway at the Brightlingsea Waterside Marina (left) and shadowing Dr. Trevor Tolhurst during the pilot phases of the project (right).

Study area

My research sought to investigate how four different types of geotextile fabrics responded to being submerged at three heights and for different lengths of time in freshwater environments across Norfolk and Suffolk. Sites had to be carefully selected to have minimal anthropogenic disturbance from recreational waterway users, described in Figure 2;

1. Earlham Marshes
2. River Waveney
3. Woodbastwick Broad

The aim of this investigation was to find which types of geotextile fabrics were most suitable for freshwater restoration projects. As their engineering properties were readily described, such as their sediment-trapping capabilities and bank stabilising properties, this researched focused on the ecological benefits they delivered.

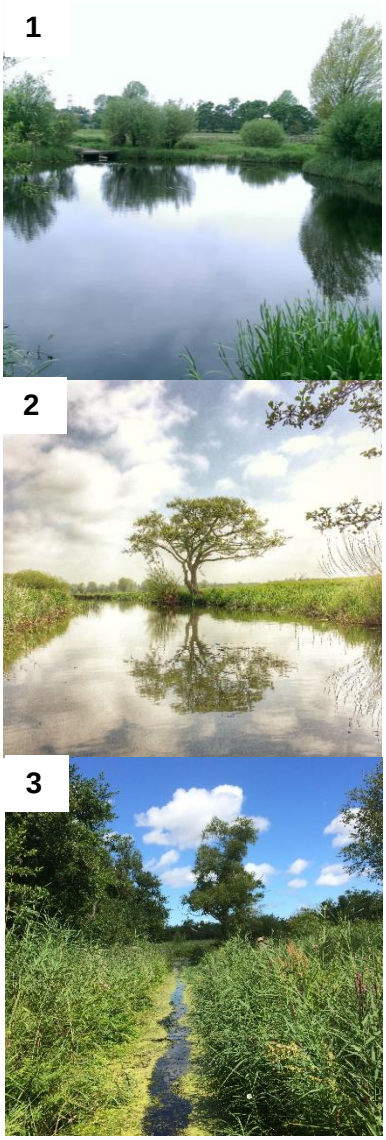

Figure 2. Photos taken at each of the three sites. **1.** A recently improved pond at Earlham Marshes Millennium Green. **2.** View from a canoe on the River Waveney close to the site. **3.** View along the dyke at Woodbastwick Broad.

Methodology

Rationale
To investigate their ecological benefits, a literature review was first undertaken to understand how different types of geotextile fabrics would function when submerged. They (geotextiles) were found suitable substrates for many benthic invertebrates but also suitable surfaces for adhesion by algae, such as diatoms. By facilitating both sediment deposition and attracting macro-invertebrate and algal species, it was confidently assumed that this would enable the successional development of freshwater flora and fauna. It was expected that non-woven geotextiles would be the best geotextile for use in freshwater projects, owing to its 'hairy' structure which had lots of interstitial spaces suitable for algae and macro-invertebrates to live in, away from predators.

Geotextiles
Four types of geotextile fabrics were investigated; a woven, non-woven, hybrid and a bio-based fabric (Figure 3). To investigate how these fabrics responded, individual 'replicates' were cut using a heat cutter for the synthetic fibres, and scissors for the natural fibres, creating moreorless equal sized replicates to be submerged.

Frame design
The challenge in the project was designing a suitable frame that different replicates could be attached to, submerged at different heights and sampled at different timescales, whilst considering the effects of

Figure 3. Examples of the geotextile fabric types used in the study. From left to right: a woven geotextile, a bio-based hemp fibre geotextile, a hybrid geotextile (non-woven on one side and woven on the other), and a woven 'felt' geotextile.

flow variations, aspect, and allochthonous and autochthonous influences.

It was my design to create triangular prism shaped frames; these had three separate outward 'faces', upon which plastic tubes could be affixed horizontally and could hold different replicates facing vertically downwards. This enabled individual tubes to be removed at convenience and individual replicates to be examined, without compromising the integrity of the supporting frame or disturbing the other replicates (Figure 4).

Sampling

These frames would be sampled once a month for three months, where each sampling month the three rows on a single face would be removed. At each sample round, each replicate was subjected to a multitude of tests. The first test was using a 'Pulse Amplitude Modulated' (PAM) fluorometer, which determined how much biomass was present on a replicate and how healthy it was. This was a specialist, non-destructive measurement of chlorophyll α and allowed strong inferences to be drawn from the collected data. After the PAM test had been complete, each replicate was placed into an individually labelled plastic zip-lock bag and taken back to the laboratory. Here, samples were repeatedly washed and submerged to dislodge any macro-invertebrates and those with greater than 1mm were fixed in a solution of 70% ethanol and identified at convenient times. As such there were two parameters being measured; algal biomass and biodiversity. The minimum fluorescence (F_o) readings were taken from the PAM device as a measure of amount, and the invertebrates, once identified to a family resolution under a microscope, were measured using the Shannon Weiner diversity index and presented alongside taxonomic abundance.

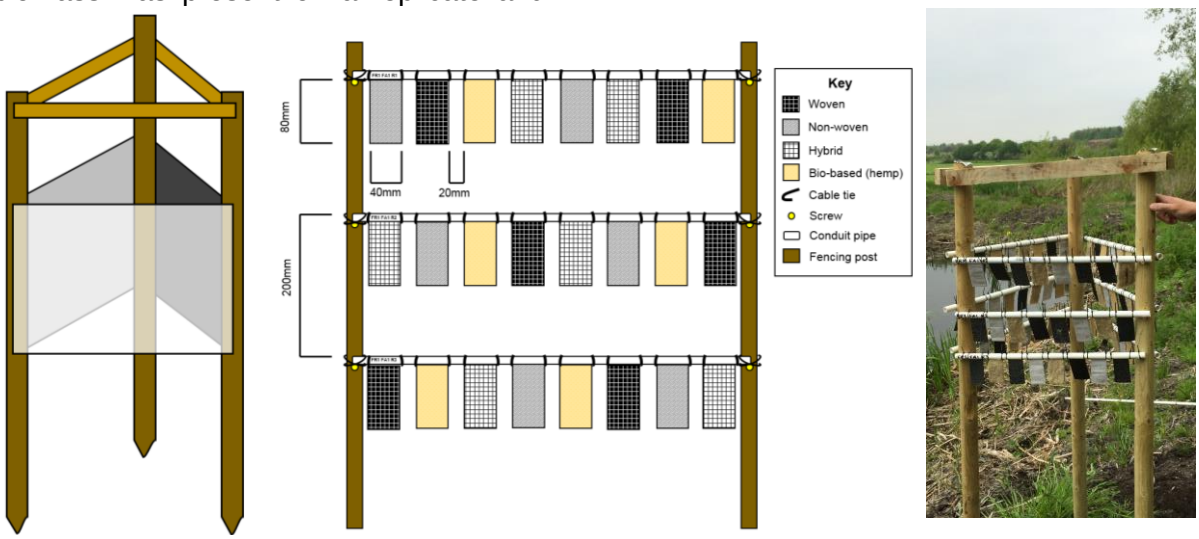

Figure 4. Plan of the supporting frame (left). Layout of an individual 'face' on the supporting frame (middle). Completed frame (right). Geotextiles are slotted into the conduit pipes which had been split open on their horizontal axis on one side and were affixed into place using cable ties.

Results

A total of 338 taxa were collected and identified during the study, separated out into 15 families. The PAM results from this study indicate that non-woven geotextiles attracted a significantly higher amount of macro-algae at Woodbastwick ($\rho<0.05$), but not at Earlham or the River Waveney. There was a significant positive relationship between the amount of macro-algae and biodiversity indicators (i.e. Shannon diversity and taxonomic abundance) at the River Waveney ($\rho<0.01$), but not at Earlham or Woodbastwick. There were no significant relationships between geotextile type and either biodiversity indicator, although large differences were observed between geotextile types and row heights. Ultimately, while the results were not significant, results indicated that non-woven geotextiles did tend to attract more macro-invertebrates and algae at most sites, but more importantly that all geotextiles responded positively to being submerged in different freshwater environments, reaffirming the initial suspicions that they can be colonised by flora and fauna and are suitable for use in freshwater restoration projects.

Acknowledgements

This dissertation would not have been made possible without the charitable contributions made by the Katie Wilkinson Research Scholarship. The sheer amount of raw materials and travel required to carry out the voluminous project was covered by the scholarship, and this helped to inspire me to make full use of the resources and carry out the fieldwork and analysis to the best of my abilities, knowing there was interest and motivation behind my project.

The experience of carrying out my dissertation has taught me valuable life and academic skills and has been one of my proudest achievements throughout my academic career. The ability to effectively manage my time was a standout lesson learned from this process; as I was working full time during my Year in Industry when the fieldwork was being completed, it required lots of time management and organisational skills to orchestrate fieldwork days, where at each site I had to meet partners who would assist me with the fieldwork, as well as head to the laboratory in my spare time to complete the arduous identification process.

Fieldwork skills were also developed through this endeavour; having to work in different freshwater environments each presented their challenges, and I had to use waders at several sites, avoid wet soils, cold water temperatures and even cows! The support from my connections across the counties was incredibly important, and I have established strong relations with stakeholders and other interested parties who gave me invaluable advice on the research process and heart-warming feedback upon this project's completion.

The Katie Wilkinson Research Scholarship has been an invaluable aide, not just financially, but emotionally too in motivating me throughout this process to produce a project to the best of my ability. When I received a first for the assignment, I was incredibly humbled and pleased to have met all my expectations, and this project has helped me improve my employability too, giving me great examples to talk about in job interviews and is at the forefront of my CV. The lessons learned and experiences gained throughout this dissertation have been fundamental in my career development which I hope to transpose through to graduate employment.

The scholarship has allowed students to research topics they are truly interested in, and it is clear to see that students have pursued topics that could not have been done without the generosity of the charity. I hope my experience helps motivate others to carry out research that they are strongly interested in, and I have learned so much and created so many memories throughout this process.

Thank you.