Final Report

Research Summary

Aims:

To examine the microplastic pollution in waterways on the island of Ireland and to review the extent of microplastic pollution in food.

Introduction:

A microplastic is a plastic particle with a diameter of less than 5mm [3]. Like other plastics, microplastics do not biodegrade so they remain in the environment for many years. Microplastics are of particular interest in environmental research as their small size allows them to enter the food chain [1]. The long-term effects of microplastics on human health are yet to be discovered, however, recent studies have shown that they can have many adverse effects on aquatic fauna including reduced feeding rates and lower mobility [2]. Microplastics can also have an adverse effect on the liver and kidneys of mice causing a disturbance in metabolism [2]. Therefore, there is a possibility that microplastics could have adverse effects on human health. As there is a potential risk to human health, this area of research is extremely important and more research is needed to gain a better understanding of the scale of the microplastic pollution problem.

My research project was focused on microplastic in Irish water and in food. In the first research period, experimental work was carried out to evaluate the microplastic pollution in several different bodies of water across the island of Ireland. The plan was to continue this research in the second period however, this plan was changed due to the COVID-19 travel restrictions. Instead, to continue on a closely related theme, a literature review of microplastic in food was undertaken in the second research period.

Microplastic in water – sample collection:

Water samples were collected from Grand Canal Dock (Dublin), Lough Neagh at Antrim town, Helen's Bay (Antrim), Portmarnock beach (Dublin) and Skeagh Lough (Cavan). All water samples were stored in the research group lab space in the Advanced Microscopy Laboratory. At each location two samples were collected using two different methods, the bulk grab method and "the pillow case method". The second sample collection method, "the pillow case method", was developed during this research project.

The bulk grab method involves collecting several litres of water at the sample location which is then transported back to the lab, left to settle overnight and then filtered using filter paper. This method has been used in previous research. It is a cost-effective method and can be used to find particles down to a few micrometres in size, however, it is quite a time-consuming method.

The "pillow case method" is designed to be reproducible by school age citizen-science. The method uses a high thread count, white cotton pillow case as a filter at the sample location. Five to ten litres of the water being tested was poured through the pillow case which was then covered and transported back to the lab. Once the pillow case was dry it could be examined directly for microplastic using an optical microscope. The pillow case method was found to be a very fast, easy, efficient, and cost-effective method for collecting microplastic samples. It was able to retain particles down to 20µm in size and the white colour made a wide range of materials easily visible including plastic threads and small organic objects. This method could be very useful for citizen science projects, for example it could be developed into an experiment for secondary school students. It could also be used to obtain quick preliminary results in scientific research. The low-cost of each new pillow case means that they could be replaced between each location eliminating the chances of cross-contamination.

Microplastic in water – analysis:

The first analysis step used optical microscopy to examine the filtrate from the water samples. Optical microscopes are a standard tool available in most research labs but also in many school environments. Increasingly, small mobile-phone attachments and low-cost digital microscopes put this capability in the hands of citizen scientists. Any particle resembling microplastic (no cellular structures, homogeneous colour and fibre thickness [11]) was identified and a representative sample of these possible microplastics were selected for analysis in the scanning electron microscope (SEM). Some interesting non-plastic particles were also recovered for further analysis.

A SEM uses an electron beam to image a sample instead of a beam of light. A good vacuum is needed in a SEM so that the electrons in the beam do not collide with gas atoms. As the electrons have a very high energy, the wavelength of the electron beam is much smaller than the wavelength of light (~0.004nm compared with ~400nm) and therefore a SEM is able to attain a much higher magnification than an optical microscope. Most SEMs are also equipped with Energy-Dispersive X-ray spectroscopy (EDX). The high energy electron beam in a SEM causes electrons from the inner shells of atoms to be removed and an electron from a higher energy shell falls down to the inner shell releasing energy in the form of an X-ray. These X-rays are unique to the element, so the elemental composition of the sample can be determined. This can be helpful when identifying microplastic as the main element in plastic is carbon, so, if the main element in a particle is not found to be carbon then we know that it is not plastic. Fourier Transform Infrared Spectroscopy (FTIR) is often used to confirm that particles which have been identified as microplastic are actually microplastic and to determine what type of plastic. The initial plan was to use FTIR in this research as well as SEM and EDX to positively confirm the presence of microplastic in the samples, however, this was not possible due to the COVID-19 pandemic.

Microplastic in water – results:

The most common type of microplastic identified in all samples was in the form of fibres. Microfibres were present in large numbers in all samples but they were particularly abundant in the highly urban Grand Canal Dock sample. Some microplastic fragments were identified in each sample and a number of other interesting microparticles were also found in the samples. A large number of iron microspheres were discovered in the Grand Canal Dock and Lough Neagh samples. These microspheres are likely from construction as the sparks given off when welding could produce such particles and there were nearby construction sites at both sample locations. Interestingly, this implies that these welding particles were able to be carried tens of meters on the wind and they are a size which could easily be inhaled. Two brown porous microspheres that were later identified as diatoms were found in the Lough Neagh sample. Due to time restrictions and the COVID-19 pandemic the samples from Skeagh Lough and Portmarnock were not fully analysed.

Microplastic in food – table salt:

Microplastic pollution in table salt is a new area of research that only began in 2015 [5]. Since then a number of studies have estimated the microplastic content of different types of salt from different regions of the world. The majority of the reports analysed have discovered microplastic in every salt sample [3]. Some studies noted that sea salt tends to contain the most microplastic followed by lake salt and then rock salt [4],[5], this is likely due to the fact that the seas are highly polluted with plastic whereas rock salt comes from underground and so it is much more protected from microplastic pollution. By combining the results of these studies and by considering the average yearly salt consumption per person it is found that the average person consumes between 26 (assuming only rock salt is consumed) and 115,632 (assuming only sea salt is consumed) microplastic particles a year due to eating salt [5],[6]. There is a huge variation in these results, this is partly due to the fact that the microplastic content in sea salt and rock salt was found to be very different but it could also be due to different levels of plastic pollution in the salt production sites and the different methods used by researchers.

Microplastic in food – bivalves:

Bivalves such as mussels and oysters are types of shellfish consumed by humans. They are filter feeders which means that they ingest whatever particles are in the water. In general, the entire soft tissue of bivalves is consumed by humans so any microplastic that the bivalves have retained will be ingested by humans, for this reason, microplastic pollution in bivalves is of particular concern. One study analysed the microplastic contamination of bivalves from a fishery market in China and found that they contain between 2.1 and 10.5 microplastic particles per gram of soft tissue [7]. Another study tested one species of mussel form a mussel farm in Germany and found that it had an average of 0.36 ± 0.07 microplastic particles per gram of soft tissue [8]. Oysters from Belgium were also tested and were found to contain an average of 0.47 ± 0.16 microplastic particles per gram of soft tissue. These results suggest that the top European bivalve consumers ingest an average of 11,000 microplastic particles a year [8]. However, this report noted that no microfibres were found as the concentrated nitric acid used to dissolve the bivalve tissue also dissolved any microplastic fibres so these results are likely an underestimation of the level of microplastic pollution. By considering the results from the report on microplastic in bivalves from China it is estimated that the top European bivalve consumers ingest up to 276,000 microplastic particles a year. The difference in these results is due to the concentrated acid used in the European study but it could also be partly due to higher levels of plastic pollution in China [5].

Microplastic in food – packaging:

Microplastic can also enter our food through packaging [9],[10]. A recent study found that plastic tea bags release approximately 14.7 billion microplastic and nanoplastic particles into a single cup of tea [9]. This level of microplastic pollution is very worrying as it is orders of magnitude higher than the microplastic pollution in other foods, however, plastic tea bags are not very common. Disposable plastic cups and take away delivery containers are another source of microplastic in food [10]. Two different types of polypropylene containers used for take away food delivery were tested for nanoplastics. One type of container was found to contain 1.2±0.5mg of nanoplastic per container and the other type was found to contain 8±1mg of nanoplastic per container. Disposable polypropylene cups were also tested and were found to contain 0.06±0.02mg of polypropylene nanoplastic per cup [10]. The nanoplastic particles were removed from the containers and cups by simply adding deionised water and shaking. This implies that if the containers are not washed before use then the nanoplastic will end up in the food and if they are washed before use they will enter the environment and they will likely end up in the Ocean where they could be consumed by bivalves or end up in salt.

Conclusion:

Microplastic is present in both fresh water and salt water in Ireland. Microfibres are one of the most common types of microplastic pollution which suggests that reducing the production of synthetic materials such as polyester and nylon clothing could help minimise the microplastic pollution problem. As well as microplastic, iron microspheres were also found in the water samples from Grand canal Dock and Lough Neagh. The presence of these microspheres was not expected and it was determined that they were likely from construction. Microplastic is not just present in water, it is also present in the food we eat. Mussels and oysters have been found to contain microplastic particles in their soft tissue which can result in a yearly microplastic consumption of up to 276,000 microplastic particles for the top European bivalve consumers. Salt, which is used extensively by people all over the world also contains microplastic. On average people can consume up to 115,632 microplastic particles a year due to eating sea salt. Food packaging has been discovered to be yet another source of microplastic in our food which implies that reducing single use plastic is not just beneficial to the environment but can also help to minimise the microplastic consumption of individuals. It is clear that microplastic is present in our environment and in our food therefore more research is needed to determine the consequences of microplastic on human health and the environment. The results of this research suggest that environmental microplastic pollution and human microplastic consumption could be minimised by moving towards a more sustainable future in which the use of plastic in food packaging and fabric production is reduced.

Leadership Development

I decided to apply for the Laidlaw programme as I recognised the fantastic opportunity provided by this programme. I saw the programme as a way for me to further develop both personally and academically. I had always hoped to complete a summer research project in order to gain new research skills and I felt that completing a project of my own would help me to decide on my career path. When I heard about the Laidlaw programme, I knew it was the perfect opportunity to not only develop my research skills but also to gain invaluable knowledge about leadership. I realised the importance of taking every opportunity to develop personally and academically, particularly as a young person starting out on a career path.

The Laidlaw programme helped me to gain new skills and also to develop my existing skills. During the course of the programme my research skills really improved. I got better at reading and analysing scientific literature and I learned the importance of detailed note taking. At the start of the first research period I found it quite hard to find information in the literature and I would spend a long time looking through many different articles and reports before I could find the information I needed. By the end of the second research period I was able to find useful reports quite quickly and I was able to identify the necessary information within the report much more efficiently. I also noticed that my notes from the second summer were much more detailed and contained more useful information while still being precise.

Before starting on the Laidlaw programme, I had little opportunity to develop my networking skills. Contacting people by email or other online forums was not something I was comfortable with before commencing my Laidlaw journey. During my research I had to contact a number of people from different disciplines for help and advice. At the start of my project I contacted some microplastic experts for advice in developing my experimental method, I also contacted experts in the fields of diatoms and micrometeorites to help me identify some of the microparticles that I discovered. I realised that having contacts in research is extremely useful when trying to complete a project and it can save a lot of time.

I found the leadership training very useful, it helped me to understand my own leadership style and the areas that I need to improve on. I feel that my confidence in myself and in my leadership ability has grown throughout the experience. The entire process of completing the Laidlaw programme helped me to develop my communication skills in numerous areas. The interview gave me a good insight into what might be expected of me for future interviews. The video and vocal coaching gave me more confidence in my oral communication skills. Producing the poster and final report helped me to develop my written communication skills.

I feel that the skills I have learned and developed during the Laidlaw programme will help me to succeed in my future career. The programme has allowed me to begin improving my leadership, research and communication skills which will help me in my future professional development. When I start my career, I will already have many of the skills required to succeed thanks to the Laidlaw programme.

I think that my experience in the Laidlaw programme will also help me in my personal development. The skills that I have developed in the areas of leadership and communication would be very useful in the future if I want to take up a committee position in a sports club or society or when getting involved in volunteering.

I feel that the Laidlaw programme could benefit from some more report writing sessions to help us to develop our research communication skills further. As my degree involves very little academic writing, I think that an academic communications session at the beginning of the programme could have been useful. I also believe that some more leadership sessions spread throughout the year would be great to help us continually develop our leadership skills. In my opinion, expanding the Laidlaw programme to other universities in Ireland would be a good idea as a number of my friends from other universities would have liked the opportunity to participate in such a programme.

I would definitely recommend The Laidlaw Undergraduate Research and Leadership Programme to other undergraduate students.

References:

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