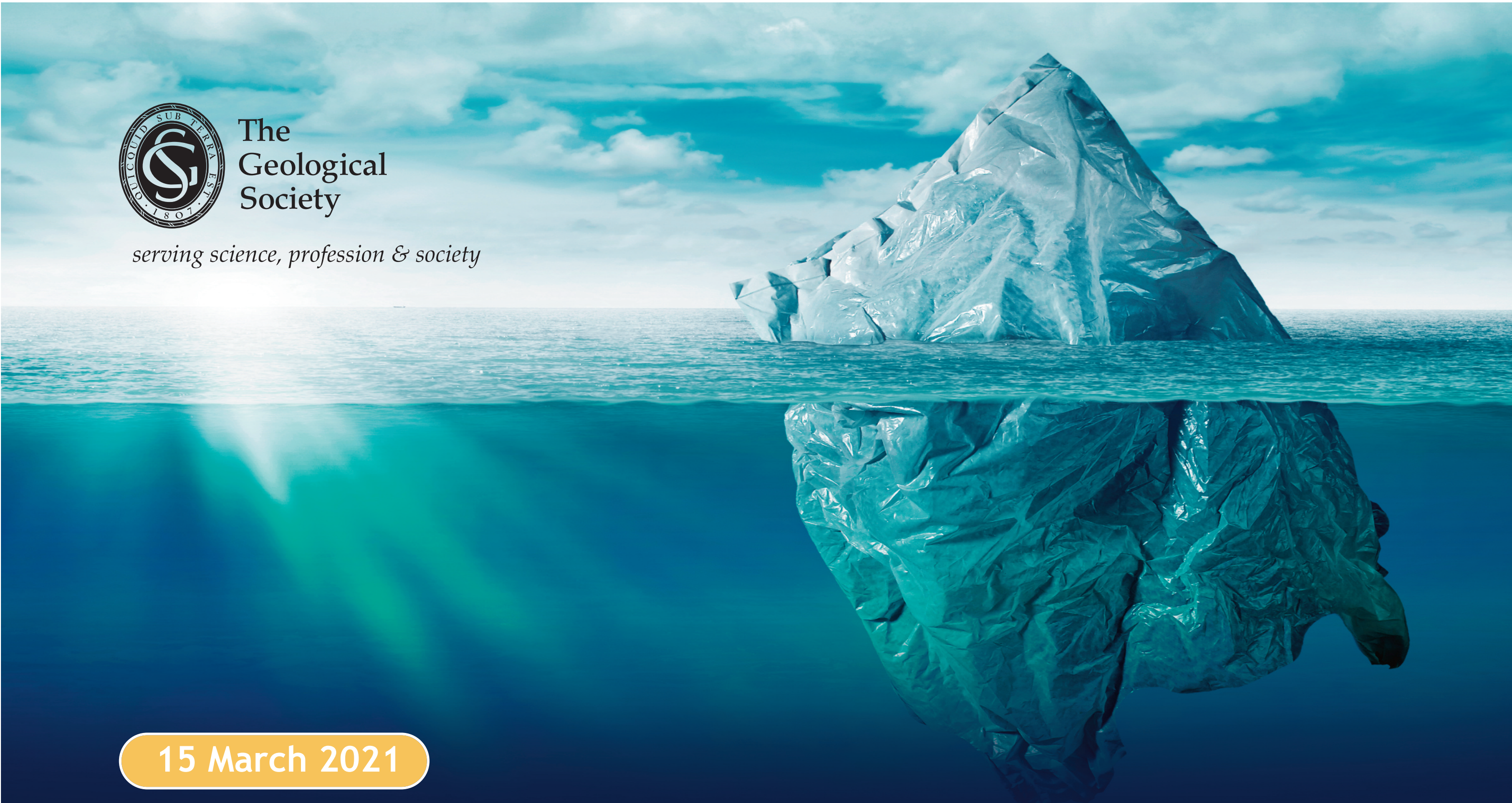

The Geological Society

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15 March 2021

Plastics in the Environment

VIRTUAL CONFERENCE

Primary Convenors

Wes Fraser (Oxford Brookes University)
Gordon Inglis (University of Southampton)
Bryne Ngwenya (University of Edinburgh)

Further information

For further information about the conference please contact:
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The accumulation of plastic debris in the environment is a global problem which may have detrimental impacts on ecosystem health. Plastics are now widely enough distributed that they may also act as an anthropogenic marker horizon in the future rock record. However, there are still many outstanding questions regarding the: 1) source, 2) transfer, 3) degradation, 4) persistence and 5) measurement of plastics in the environment.

This one-day meeting will bring together researchers from a diverse range of disciplines (e.g. hydrology, sedimentology, geochemistry, earth science, biology) to discuss the fate of plastics in terrestrial, freshwater and marine environments.

This meeting seeks to foster conversation between these different communities to facilitate a more holistic approach towards understanding plastic in the environment.

Call for Abstracts

We invite oral and poster abstract submissions for the meeting, and these should be sent in a Word document to conference@geolsoc.org.uk by Thursday 28 January 2021. Abstracts should be approximately 300 words and include a title and acknowledgement of authors and their affiliations.

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KEYNOTE ONE The challenge of understanding plastic fate and transport in a global context

Alice Horton, *National Oceanography Centre*

Plastics are widespread globally, with their persistence leading to long-term ecosystem exposure and accumulation within the environment. Plastics have even been observed within deep-sea and lake sediments and incorporated into rocks (‘plastiglomerate’) suggesting that plastics have the potential to be preserved within the fossil record. The degradation of plastics within the environment leads to the formation of microplastics (plastic particles <5 mm). Microplastics were first observed within the environment in the early 1970s, however it took over 30 years before research in this field began in earnest. Recently, the field has rapidly expanded from simply identifying presence of microplastics, to determining sources, abundances, chemical associations and ecological effects.

The wide diversity of plastic types, shapes and sizes, all of which will originate from different sources and behave differently within the environment, pose a great challenge for microplastic researchers trying to understand the fate and effects of this pollutant. Despite constantly-improving techniques for detecting and tracing plastics within the environment, 99% of all plastics produced remain unaccounted for within the environment. There is thus a critical need to grow our understanding of plastics: their behaviour, fate and chemical associations, in order to determine the real hazards they may pose for ecosystems and human health, and to implement global solutions.

This presentation will consider the challenges in understanding and addressing the issue of plastics in the environment, including sources, pathways, degradation and fate of plastics throughout terrestrial, freshwater and marine systems.

Session 1: Plastics and their interaction with organisms

Ocean acidification alters bacterial communities on marine plastic debris

Jason Hall-Spencer

Universities of Plymouth (UK) and Tsukuba (Japan)

The increasing quantity of plastic waste in the ocean is providing a growing and more widespread novel habitat for microbes. Plastics have taxonomically distinct microbial communities (termed the ‘Plastisphere’) and can raft these unique communities over great distances. In order to understand the Plastisphere properly it will be important to work out how major ocean changes (such as warming, acidification and deoxygenation) are shaping microbial communities on waste plastics in marine environments. Here, we show that common plastic drinking bottles rapidly become colonised by novel biofilm-forming bacterial communities, and that ocean acidification greatly influences the composition of plastic biofilm assemblages. We highlight the potential implications of this community shift in a coastal community exposed to enriched CO2 conditions.

Fate of microplastics in terrestrial ecosystems: egestion and potential toxicity to earthworms

Miranda T. Prendergast-Miller[1, 2], Andreas Katsiamides[3], Mustafa Abbass[3], Stephen S. Sturzenbaum[3], Karen L. Thorpe[2], Mark E. Hodson[2]

1 Northumbria University UK, 2 University of York, UK, 3 King's College London, UK

Earthworms are regarded as key ecosystem engineers in terrestrial systems. Their burrowing and feeding activities, and the processing of soil through their guts, result in the release of nutrients, the creation of soil aggregates and micro-channels for water infiltration, and stimulate microbial communities. Microplastic pollution in aquatic systems has been widely acknowledged. However, there is growing awareness of microplastic pollution in soils. Microplastics in soils are believed to originate mainly from applications of organic wastes, such as sewage sludge and composts, but also due to fragmentation of plastic litter. Microfibres are believed to form a significant proportion of microplastic input to soils, as a result of plastic-derived fibres from domestic washing machines entering wastewater treatment plants; due to their small size, these microfibres end up in sewage sludge. A laboratory study was conducted to determine the effect on earthworms (*Lumbricus terrestris*) following exposure to microfibre particles in soil mesocosms, under controlled conditions. Impacts on earthworms were assessed by changes to earthworm weight, mortality, cast production and physiology (oxidative stress). Results reveal that earthworms ingested microplastics, as fibre particles were detected in earthworm casts. This incorporation was likely a result of their burrowing and feeding activities. Furthermore earthworms showed no avoidance of microfibres within soil. Microfibre ingestion led to a reduction in earthworm weight and cast production. Microfibres induced oxidative stress, indicating changes to earthworm physiology which could alter behaviour. These results suggest that while not fatal at the exposure concentrations tested, microfibres have the potential to alter earthworm activity with consequences for soil ecosystem function. Further work is required to fully understand all forms of microplastics in terrestrial systems: their detection, quantification, fate and impact on ecosystem processes, in order to determine the environmental risk of these ubiquitous pollutants.

Mineral formation on plastics: implication for plastic transport, degradation and persistence

Kelsey Rogers1 , Nynke Keulen[2], Yvonne Shashoua[3] , Sascha Müller, Nicole R. Posth[1]

[1]University of Copenhagen, Denmark [2]Geological Survey of Denmark and Greenland (GEUS), Denmark [3] National Museum of Denmark, Denmark

Plastics in marine water and sediments are covered by mineral encrustation and mineralized-biofilm. Depending on plastic size, biogeochemical setting, and degradation state, minerals can form on the surface of or form aggregates with plastic particles through a spectrum of mechanisms from biologically-controlled to abiotic mineral precipitation. Through SEM-EDS analysis, a variety of minerals were found on the surfaces of PE (polyethylene) and PS (polystyrene) after exposure to the water column and sediment of Svanemøllen Marina (Copenhagen) in an *in situ* experiment over the course of 18 months. Biogeochemical cycling and microorganisms themselves play an integral part in the formation of some minerals found on these plastics. Biologically-controlled minerals, such as the silica shells of diatoms, are frequently observed on plastics floating in the water. Abiotically-formed minerals, such as iron oxides, precipitate on plastics in the water column or sediment.

While we know more about how biofilm formation may enhance the transport of plastics via settling or aggregation, the quantification on the impact of mineral loading on the vertical transport of plastics in the water column is still sparse. Furthermore, the impact of mineral loading on plastic degradation or preservation through, i.e., metal-catalyzed oxidation of plastics is yet undefined. We discuss our findings from Svanemøllen Marina and possible implications for these processes here.

Flash Poster Session 1

Investigating seasonality in microplastic behaviour in coarse-grained fluvial sediments of the River Thames Catchment (UK)

Skalska, K.[1], Ockelford, A.[1], Ebdon, J.[1] and Cundy, A.[2]

[1]*University of Brighton, UK* [2]*University of Southampton, UK*

Coarse-granular river beds have been found to harbour large amounts of microplastics. Under low-flow conditions, plastic debris remains trapped within the sediment bed. However, it can be remobilised once a certain ‘flow threshold’ is exceeded. With predicted changes to the frequency, magnitude and timing of high-flow (flood) events due to global warming, it is possible that rivers may shift from being sinks of microplastics, to sources of microplastics. This has potentially significant implications for receiving waters (seas and oceans) and for the well-being of marine ecosystems.

This paper reports on an ongoing field study conducted across the R. Thames Catchment designed to improve understanding of the impact (and pattern) of various flood events on microplastic transport through coarse-granular river beds. Thirteen sites classified as rural, urban, and industrial were selected across the central part of the catchment and sediment samples were collected during summer (July 2019) and winter (Jan 2020) months to account for seasonal variations in flow. Overall, the abundance of microplastics in the <5mm fraction of the sediments, varied from 0 to 567 items kg $d.w.^{-1}$ and increased with the degree of site degradation. Fibres and fragments were dominant at most sites, with fragments becoming more abundant with the amount of plastic waste present on site. Moreover, numerous microbeads were detected at industrial sites. This suggests a number of microplastic sources, such as industrial effluent, or *in-situ* litter breakdown, contributing to the microplastic pollution of the R. Thames. Preliminary analysis of seasonal trends in microplastic concentrations across the catchment suggest a decrease in microplastic abundance after high-flow events. However, this effect depends on the interplay between prevalent flows and surface sediment characteristics, as well as dominant microplastic types. Outputs from this work provide evidence of microplastic remobilisation resulting from high-flow conditions and are pivotal for determining the role that rivers play in transporting microplastics.

Microplastic in the Antarctic marine food web: a first assessment

Julian Blumenröder[*+#], Cath Waller[*], Magnus Johnson[*], David Barnes[#]

[*] University of Hull, [+]Energy and Environment Institute, Hull, [#]British Antarctic Survey

Microplastic pollution is an increasing field of research and plastic particles and fibres have been found in almost every environment from densely populated coastlines to remote uninhabited islands and the deep sea. Even regions like Antarctica thought to be pristine are not free of microplastic pollution.

This study investigates the environmental consequences of microplastic on the Antarctic marine food web. The vulnerability towards microplastic will be assessed depending on biology, feeding type, habitat, functional group and trophic level. We try to answer the question "What influences the rate of microplastic ingestion and does microplastic accumulate along the food chain?" Additionally, we will analyse if the structural integrity of the polymer changes through the ingestion by biota.

Antarctica as sample location was chosen as it has nearly no direct plastic influx. The local biota is highly adapted to the Antarctic climate and an additional stressor could raise their vulnerability. Furthermore, Antarctic plankton and benthic communities build a key group in global food chains and microplastic intake there might have knock-on effects around the world.

Samples have been taken along the Antarctic Peninsula and on Burdwood bank in the south Atlantic. The sample sites along the Antarctic Peninsula were chosen for three representative fjords with known glacier retreat. This means that new habitats are created which were previously covered by ice. This allows for additional chronological data regarding microplastic deposit and accumulation within the benthos over the last decades.

The biological material will be dissolved to extract the plastic particles from the samples, which will consequently be analysed for their chemical composition using FTIR (Fourier-transformed infra-red) spectroscopy.

First analysis shows microplastic presents in the water in all sampled sites in the Southern Ocean.

Understanding marine microplastic dynamics using macroplastics as a proxy

Allison, N[1]; Turrell, B[2]; Dale, A[1]; Hartl, M[3]; Narayanaswamy, BE[1]

[1]Scottish Association for Marine Science, [2]Marine Scotland Science, [3]Heriot-Watt University, UK

It is estimated 4.8 to 12.7 million tons of plastic waste enter the ocean globally per year, contributing to a total minimum value of 5.25 trillion plastic particles floating on the ocean surface. Plastic debris can enter the open ocean directly, or via coastal waters and then through numerous hydrological processes is transported to the open ocean. The spatial and temporal variability of floating plastics due to the interaction between their differential characteristics and hydrological processes, complicates their quantification.

Although statistical approaches can indicate what physical forces may be important, they cannot explain the actual mechanisms involved in floating plastic dynamics, which is fundamental to understand the local, regional or global impact. Hydrodynamic modelling offers a mechanism to explore the interaction of floating plastics with hydrodynamic data, such as ocean currents, and physical forces, such as windage, and coupled with particle tracking models, the trajectories of large numbers of simulated particles can be predicted over space and time.

The dynamics of floating plastic in the marine environment is mostly influenced by three physical characteristics; the density, the surface area to volume ratio of the polymer, and the particle size. High windage plastics are understood to be horizontally transported vast distances across the ocean surface and transferred to adjacent coasts and beaches by inshore currents and winds. It is hypothesized that smaller microplastics, with a larger surface area to volume ratio, are less likely to be driven by windage, therefore may have a higher sedimentation rate.

The aim of this study is to predict, through hydrodynamic modelling, coastal areas of high depositions of macroplastic on the West Coast of Scotland, and further investigate whether such areas are linked to high levels of microplastics found in the same location.

The hidden microbial world of environmental plastic: an initial examination of the interactions between plastic and aquatic microbial communities in a freshwater environment.

Katey Valentine, *University of York*,

When plastic enters the aquatic environment, its surface is colonised by an assortment of microorganisms which form a complex three-dimensional biofilm community. Until recently however, the presence of this biofilm has been largely ignored in microplastic research. The aim of the current study was to investigate the temporal development of plastic-associated biofilms in a freshwater environment, and to assess how the presence of biofilms may alter the physical and chemical properties of plastic. A number of studies are beginning to investigate plastic-associated biofilms grown in a laboratory setting; therefore, an additional aim of this study was to assess whether biofilms grown in a controlled laboratory environment can be representative of those grown in a natural setting. Low-density-polyethylene (LDPE), polylactic acid (PLA) and glass panels were incubated in river water for twelve weeks. Samples were incubated *in situ* in a local river and in parallel, in a flow-through aquaria supplied continuously with fresh water from the river. Panels were removed and analysed after one, three, six and twelve weeks of incubation and a variety of endpoints were assessed. The taxonomic composition of biofilms from different treatments is presented, along with the mass and chlorophyll content of biofilms, and the physicochemical changes that occurred at the surface of plastic samples. Initial results suggest that material type influenced the development of biofilms, with plastic supporting a 62 – 108 % higher biofilm mass by week six than glass from the same location. The chlorophyll and pheophytin content of biofilms from aquaria samples generally increased with biofilm age; this was not observed for samples from the river and location was found to significantly influence chlorophyll levels of the biofilm. Temporal changes in the biofilm over the twelve weeks and differences between material types are apparent. The current data also suggest that biofilms grown in a laboratory setting may not be representative of those that form in the natural environment and care should therefore be taken when using artificial environments to grow and study microplastic-associated biofilms. Understanding the interactions between environmental plastic and microbial communities is essential for advancing our knowledge of microplastic behaviour in the aquatic environment and their impacts on entire ecosystems, as well as individual organisms.

Sources, transfer and fate of microplastics in the Arctic marine environment

Hollie Ball1 , Professor Crispin Halsall1 and Dr Yueng-Djern Lenn2

1Lancaster University, Bangor University2

Microplastics have emerged as a major environmental issue and have been found in even the most remote environments on earth, including the Arctic. Due to their microscopic size, these contaminants can be transported long distances, making them available to a wide range of marine biota. Arctic marine ecosystems are particularly sensitive to disturbance from man-made pollutants due to their geographical location and climatic features [1], and sea ice has now been acknowledged as an important sink and means of transport for these pollutants within the Arctic [2]. However, the main sources of plastics to the Arctic and the processes through which they are transported there are poorly understood, as are the subsequent effects of these pollutants on Arctic ecosystems. This project aims to; 1) identify the key sources of microplastic pollution to the Arctic by quantifying microplastic concentrations in seawater, sea ice and snow, and using FT-IR analysis to identify specific polymer types; 2) understand the mechanistic processes driving the transfer of microplastics between seawater, sea ice and snow through a series of spiking experiments in a mock Arctic environment; 3) understand the distribution of microplastics in the Arctic and pinpoint any accumulation zones by mapping concentration points. The findings from this study will ultimately improve current understanding of the fate of these contaminants and potential pollutant release in the Arctic, which is vital considering the current climatic changes occurring in polar regions.

[1]

Pavlov, V., Pavlova, O. and Korsnes, R., 2004. Sea ice fluxes and drift trajectories from potential pollution sources, computed with a statistical sea ice model of the Arctic Ocean. Journal of marine Systems, 48(1-4), pp.133-157.

[2] Obbard, R.W., Sadri, S., Wong, Y.Q., Khitun, A.A., Baker, I. and Thompson, R.C., 2014. Global warming releases microplastic legacy frozen in Arctic Sea ice. Earth's Future, 2(6), pp.315-320.

Session 2 - Plastics along the terrestrial-aquatic continuum

KEYNOTE River corridors as hotspots of global plastic pollution

Stefan Krause,

University of Birmingham

The total production of plastics is nearing 10 billion metric tons, half of which have been estimated to have ended up as waste in the environment. However, the total mass of plastics found in the world's ocean garbage patches that have been the focus of the scientific community and in the public eye is estimated to be less than 1 million metric tons, a paradox that leaves the whereabouts of the majority (>99.9%) of plastic waste produced so far unexplained.

We show that river corridors store a several orders of magnitude larger mass of plastics, in particular microplastics of less than 5 mm in size, than the world's oceans. Our model-based quantifications reveal that rivers do not solely function as pure conduits for plastics travelling to the oceans, but also represent long-term sinks, with in particular microplastics being buried in streambeds and floodplain sediments. This include the development of pronounced hotspots of long-term plastic accumulation, evidencing that these emerging pollutants have already developed a pollution legacy that will affect generations to come.

The principles that govern the spatially and temporally dynamic inputs of plastics into river corridors as well as the fate and transport mechanisms that explain how plastics are transport along their freshwater passage and where they are accumulated in river corridors are still poorly understood. Experimental evidence of microplastic pollution in river corridors is hampered by the absence of unified sampling, extraction and analysis approaches, inhibiting a comprehensive investigation of global source distributions and fate pathways. We have therefore initiated the global 100 Plastic Rivers programme to provide a global baseline of microplastic pollution in rivers, their drivers and controls in order to develop mechanistic understanding of their fate and transport dynamics and create predictive capacity by informing the parameterisation of global plastic transport models. Preliminary results evidence the suitability of the 100 Plastic Rivers approach and help validate our predictions of global plastic storage in river corridors.

Role of saltmarsh systems in estuarine trapping of microplastics

Ogbuagu C. C.[1], Cundy A.[2], Hachem, K.[2] and Udiba U.[3]

[1]University of Nigeria, Nigeria, [2], National Oceanography Centre Southampton, United Kingdom [3]University of Calabar, Nigeria

Saltmarshes are an important natural ecosystem along many coastlines. They offer sediment stabilization and act as biofilters for a range of industrial pollutants and (potentially) microplastics. While the effects of saltmarsh systems on water flow, sediment transport and trapping are well studied, relatively little is known about the contributions of the saltmarsh halophytes, resident organisms and associated sediments to the trapping of microplastics. To address this, series of flume experiments were undertaken using sub-5mm diameter bakelite fragments and PVC nurdles added to seawater, which was then circulated over a vegetated saltmarsh bed (prepared using a cut monolith collected from the Hythe saltmarsh system, Southampton Water). The results showed that the saltmarsh bed and vegetation modified the overlying hydrodynamics, with turbulent flows and high shear stresses observed. With increasing flow velocities (≤ 0.51 m/s), only small quantities of sediments and bakelites were eroded and resuspended. For nurdles, the biogenic roughness and vegetative roughness effectively eliminated transportation within the saltmarsh system. Resident crabs were observed to be important agents in the burial, release and transport of both nurdles and bakelites. The results of this study provide evidence of the sequestration of microplastics and sediment stabilization by saltmarshes. Estuarine saltmarsh systems can act as sinks for microplastics with enhanced burial from burrowing crabs under favourable flow conditions.

High accumulation rates of small and low-density microplastics in river bed sediments

Jennifer Drummond[1], Uwe Schneidewind[1], Angang Li[2], Timothy Hoellein[3], Stefan Krause[1], Aaron Packman[2]

[1]University of Birmingham, UK. [2]Northwestern University, Illinois, USA. [3] Loyola University Chicago, Illinois, USA.

Rivers are considered a major source of plastic to oceans, but there is little understanding of the accumulation, export, and residence times of microplastic particles within riverine systems, even though their presence in river bed sediments is ubiquitous. Small microplastics less than 1 mm are often not measured, but when analyzed are always found in high abundance in aquatic environments. This smaller size fraction has been previously assumed to transport downstream with minimal interaction with river bed sediments because of their low gravitational settling velocity, but recently shown to be most strongly influenced by the bidirectional flow or hyporheic exchange between surface water and sediments in rivers, and therefore accumulation in river beds is expected. We focus on the less studied yet more abundant small microplastics, that have a higher surface to volume ratio and therefore higher likelihood to serve as a vector of harmful pathogens and more available for uptake by organisms, influencing ecosystem health. Here we develop a stochastic model to simulate microplastic transport in rivers considering exchange from the water column to transient storage areas (i.e., due to hyporheic exchange and/or gravitational settling), immobilization, and remobilization as the major processes that control microplastic dynamics in freshwater systems. We first validate the model with a field study to assess if the known stream hydrologic conditions and range in accumulation timescales (i.e., 1 mo to 1 year) could account for the high numbers of small microplastics measured in streambed sediments downstream of a WWTP effluent. We then quantified microplastic export, accumulation rates, and residence times in global river networks by assessing the range in hydrologic conditions for small creeks to large rivers with mobile-immobile model simulations.

Distribution and concentration of microplastics in an estuarine to shallow marine transition zone: the Mersey Estuary and Liverpool Bay.

Edward Keavney[1,2], Ian A. Kane[2], Michael A. Clare[3], Euan L. Soutter[2].

[1] University of Leeds, [2]University of Manchester,UK [3]University of Southampton,

Microplastics are increasingly recognized in the sedimentary record however, there is still much uncertainty about the processes that transfer microplastics from terrestrial to marine settings, and how they control microplastic distribution and concentration. Previous studies have identified microplastics in rivers, and others in the deep sea, yet few have focused on estuaries - a critical transition zone between the two. Using new sediment samples, we show how sedimentological processes and geomorphology control microplastic transfer and accumulation in estuarine settings. In excess of three-times more microplastics were observed in the Liverpool Bay than in the Mersey Estuary channel. Of the fifty-seven sediment samples taken from across the distinct depositional environments of the study area, the six samples from the Liverpool Bay contained 61% of the total observed microplastic count. Complex hydrodynamic and geomorphological processes active in the Mersey Estuary inhibits the long-term storage of high concentrations of microplastics, resulting in microplastics being flushed onto the deeper shelf (Liverpool Bay) component of the system. The new data demonstrate the importance of characterizing fundamental properties of microplastics, as they play a strong control on whether microplastics will become locally concentrated or more widely dispersed at the transition zone from fluvial to marine transfer. These results underline the importance of incorporating sedimentological processes in characterizing and quantifying the global microplastic cycle.

Seasonal Trends in Microplastic Abundance in the Southampton Water estuarine complex, U.K.

Stead, J.L*, Cundy, A.B*, Hudson, M.H*, Thompson, C.E.L*, Williams, I.D*, Russell, A.E.*

**University of Southampton, U.K.*

Estuaries are believed to be a primary zone of transfer for microplastics, however, there are limited studies quantifying this transfer. As a result, there is limited knowledge of the potential impacts of microplastics on estuarine ecosystems, which are some of the most productive ecosystems globally. Additionally, few studies modelling global plastic inputs include an element of estuarine trapping, yet the ‘estuarine filter’ – the combination of processes by which the supply of sediments and other contaminants to the sea is moderated in estuaries – is known to retain contaminants in estuaries. This could be one of the reasons why open ocean sampling suggests a proportion of ‘missing plastic’.

There are a wide range of processes involved in the estuarine filter and which may be moderating the abundance of microplastics in estuaries. These include the input of microplastics to the estuary. Riverine fluxes of plastics are the focus of increasing study, with links made between increased plastic fluxes and flooding events. In order to investigate the effects of river flow and rainfall, four month-long sampling campaigns were carried out at two estuarine sites in Southampton Water, UK. The sites are defined as open-estuarine mixed, and river-influenced. Microplastic abundance was measured twelve times/month at each site, and combined with rainfall, river flow, suspended sediment and salinity data. Results indicate relationships between microplastic abundance in both the sea surface microlayer (SML) and at 5 cm water depth and these forcing factors. These include a relationship between salinity and microplastic abundance in the SML; and a relationship between tidal height and microplastic abundance at 5cm water depth. Results vary between sampling periods, suggesting seasonal influences on the abundance of microplastics in Southampton Water. Suspected microplastic counts range between 5 – 296 n/L

Session 3: Plastics in the marine realm

Microplastics in the environment - a sedimentological challenge

Ian Kane[1], Michael Clare[2], Florian Pohl[3], Edward Keavney[1], Ginevra Oertel[1], Arthur Garforth[4], Aleksander Tedstone[4], James Rothwell[5]

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Microplastics are anthropogenic sedimentary particles. Understanding their distribution across the Earth is therefore a problem that sedimentologists are uniquely equipped to investigate. Recent studies have found microplastics at high altitudes, delivered as wind-blown dust, in river systems, in lakes, in coastal areas, on the sea surface, in sea ice, suspended in the oceanic water column, and on the deep seafloor. Microplastic density ranges from lower than that of water, to nearing that of quartz. Microplastics also have a wider range of shapes and surface areas than naturally-occurring minerals; hence, their distribution within geophysical flows and their deposits may differ to that of natural mineral particles. Microplastic fragments are broken-down from larger macroplastics, manufactured microplastics include beads and pellets, but perhaps the dominant microplastic in the environment is microfibres. While ‘fresh’ microplastics are relatively inert, through time they can accumulate biofilms and various toxins. Characterisation of contaminants, and polymer type and size (including sub-micron particles), via a suite of chemical analysis techniques, will allow assessment of the full impact of this problem. Due to their bioavailability, these contaminated particles readily enter the trophic web. Based on a number of case studies, we provide insights into the transport, and types, of microplastics from source, via river systems and estuaries, through shallow marine environments and into deep-water. We will focus on the deep-marine ‘sink’ and the role of gravity and thermohaline flows. Using this analysis we identify challenges that sedimentologists can address in terms of microplastic distribution and fate, and how this can be used in conjunction with mitigation efforts to address the environmental microplastic challenge.

The influence of depositional environment on the abundance of microplastic pollution on beaches in the Bristol Channel, UK

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Despite being a ubiquitous environmental contaminant, with a significant range of reported negative impacts on the marine environment, large gaps still exist in our knowledge of the distribution of microplastic pollution on beaches. We conducted a detailed assessment of the extent and variability of 1 – 5 mm microplastic pollution present at the most recent high tide line of 16 beaches in the Bristol Channel, covering a coastal extent of ~230 km. Microplastic was present at 15 of these beaches and across the study area a total of 1446 particles of suspected microplastic were extracted using a cascade of sieves and visual identification. The most common microplastics recovered were fragments (74%) and industrial plastic pellets (13%). We used Fourier-Transform Infrared (FTIR) spectroscopy to analyse 25% of recovered particles, 96.5% of which were confirmed as plastic, with polyethylene (61%) and polypropylene (26%) the most common polymers.

Our analysis of beach environments indicate that microplastic burdens were higher on lower energy beaches with finer sediments, highlighting the importance of depositional environment in determining microplastic abundance. By accounting for the effect of sediment size on microplastic abundance we are able to highlight how secondary factors affecting microplastic transport to beaches in the region may include wind driven and tidal currents, and the proximity to microplastic production, leakage or influxes. Finally, we identified two likely origins of microplastic in the Bristol Channel; the urban areas of Bristol and Avonmouth in the Severn Estuary, and the wider Atlantic.

Microplastic in marine, nearshore waters of South Georgia: a study of background environmental levels of microplastic contamination

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Microplastics are ubiquitous in the global ocean and have even been found in remote polar environments, including in Arctic snowfall and Antarctic subtidal sediments. Levels in some areas of the Southern Ocean have been shown to be 100,000 times higher than predictions.

This is the first comprehensive survey of microplastic in the nearshore waters of South Georgia, a sub-Antarctic South Atlantic island noted for its biodiversity. Microplastic has been previously documented in resident populations of higher predators. This is likely to originate from their food, but the degree to which their prey is exposed to microplastics from background environments has yet to be examined.

Surface water samples were collected from 12 sites at 1km intervals around the accessible shoreline of the Thatcher Peninsula, South Georgia, including adjacent to the outflow pipes of the research station, King Edward Point (KEP). Additionally, samples were taken directly from: (i) outflow pipes at KEP and Grytviken (a nearby whaling station, occupied in summer by the South Georgia Heritage Trust museum staff), in order to determine the level of local input from anthropogenic wastewater systems; (ii) Gull Lake, a freshwater system isolated from oceanographic influence; and (iii) directly from falling snow to examine the potential risk of atmospheric transfer of microplastics via precipitation. Preliminary results using FT-IR spectroscopy have confirmed over 24,000 suspected anthropogenic particles/fibres as being microplastic. Microplastics were present in every sample, from every site and range in size from 0.05-3mm.

Here we present the following results:

1. the amount of microplastic in the background environment to which local biodiversity is exposed and;
2. the similarity between the microplastic profiles of an anthropogenic point source and the local environment.

Fishmeal as a source of environmental microplastics

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Microplastic presence in marine biota is of concern. Seeing as fishmeal is composed of a quarter of global marine fish landings and there is increasing evidence that many wild fish stocks are exposed to microplastics, research on microplastics in this foodstuff is emerging. Fishmeal is mainly composed of fish and fish trimmings, and is used worldwide as feed for poultry, pigs and aquaculture, thus having major importance in global food security. Fishmeal is a complex medium that is rich in oils, proteins and minerals of varying quantities, making it a challenging medium to extract microplastics from. Several methodologies to extract microplastics from fishmeal were trialled.

A NaCl density separation 'overflow' technique provided recovery rates of 71.3±1.2% from whitefish fishmeal. Further recovery trials of this and other methods with five different fishmeal types (trimmings, sardine and anchovy, krill, tuna and salmon) found that a NaCl 'overflow' with added dispersant and a KOH digestion provided the highest recovery rate with all fishmeal. However, recovery rates were lower than from whitefish- 15% (krill) to 60% (salmon). In addition, a negative correlation was found between organic content of fishmeal and recovery rate. The NaCl density separation technique was used to investigate microplastic contamination in two commercial fishmeal samples (whitefish), on average 123±16.5 microplastic kg^{-1} were found. This consisted of fibres (42.1%), microsheets/films (36.8%) and fragments (21.1%). Most non-fibrous particles were polyethylene and most microfibres were rayon. Fishmeal has the potential to be a direct pathway for microplastics into aquaculture systems. Marine aquaculture uses 2.5 million tonnes of fishmeal annually, therefore from the information gathered in this study, fishmeal could release approximately 300 million pieces of microplastics per year into the sea (with further releases to land, via animal feed). Based on microplastic mass information in scientific literature, this would equate to 10-1670kg of microplastics.

Deep-sea circulation creates seafloor microplastic hotspots

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An estimated 8.3 billion tonnes of non-biodegradable plastic has been produced over the last 65 years. Much of this is not recycled or effectively disposed of, has a long environmental residence time, and accumulates in sedimentary systems worldwide; often in the form of microplastics, which pose a threat to important ecosystems and potentially human health. While microplastics are known to pervade the global seafloor, the processes that control their dispersal and concentration in the deep sea remain unknown. We present an analysis of seafloor, sediment and microplastics data from the Tyrrhenian Sea to show that thermohaline-driven currents, which create extensive contourite drifts, also control the seafloor distribution of microplastics. Our findings indicate that contourite drifts may be globally important repositories for microplastics, with higher concentrations than other better-known microplastic hotspots, such as canyons and deep-sea trenches. Several previous studies propose that microplastics are transported to the seafloor by vertical settling from surface accumulations. Instead, using numerical modelling, we demonstrate that the spatial distribution and ultimate fate of microplastics is strongly controlled by the same near-bed currents that supply oxygen and nutrients to a range of deep sea benthos. Our findings suggest that deep sea biodiversity hotspots are also likely to be microplastic hotspots, thus compounding the threats already faced by such vulnerable, but globally important biological communities.

Flash Poster Session 2

Coastal accumulation zones in NW Scotland, implications for the circulation of plastic in the environment

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The NW coast of Scotland and in particular the area surrounding Cape Wrath has historically received lots of debris washing up on the shoreline. According to witnesses, since at least the 60s plastic has been observed on different beaches, slowly accumulating. Starting in April 2017, a weekly weighting of the debris found on the beach of Balnakeil Bay illustrates the scale of (macro) plastic incoming at a rate of 3-5 kg/day (1-2t/a). Other surveys showed that many other coves and beaches of the area underwent similar pollution rates or worse. In these areas, pervasive pollution can be observed within the beach profiles but also inland, affecting dunes fields and soils alike.
We have conducted hydrodynamic simulations of the area based on the plastic densities measured offshore and state-of-the-art oceanographic models. The models illustrate how a combination of tide and wind system pushes plastic to accumulate in the coastal area and inland, away from the ocean. The model also shows how tidal system in sea lochs act as suction area and concentrate floating plastics in their vicinity. The sedimentary cycle associated with the storm-dominated coastline is also responsible of embedding deeply plastic debris in the coastal profile. Such land accumulation zones are under-represented in the literature. Coastal accumulation zones could contribute to a very large portion of the 99% of plastic “stock” missing on the planet.

Characterising and Modelling the Transfer of Macroplastic Debris in Rivers

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Plastic accumulation in the marine environment is a major concern given the harmful effects and longevity of plastics at sea. Although rivers significantly contribute to flux of plastic to marine systems, plastic transport in rivers remains poorly understood and estimates of riverine plastic flux derived from field measurements and modelling efforts are highly uncertain. In this study, a new probabilistic model of plastic transport in rivers is presented which describes the main processes controlling displacement to predict the statistical distribution of travel distances for individual items of buoyant macroplastic debris. Macroplastic transport is controlled by retention in temporary stores (or traps) created by vegetation, bank rough ness elements and other obstacles. The behaviour of these traps is represented in the model via a series of Bernoulli trials conducted in a Monte Carlo simulation framework. The probability of retention or release from traps is described using physical characteristics such as the type of vegetation, channel width or channel sinuosity index. The model was calibrated using a tracer experiment with six replicates, conducted in a small 1.1 km river reach. For each replicate, 90closed air-filled plastic bottles were injected at the upstream end of the reach and the location of each bottle was recorded several times over a 24-hour period. Bottles were chosen as 'model' macroplastic litter items given their high usage and littering volume. Travel distances were low (the average distance travelled over 24 hours was 231 m and no bottles travelled more than 1.1 km, the length of the study reach) and variable (the coefficient of variation for the replicates ranged between 0.54 and 1.41). The travel distance distributions were controlled by the location and characteristics of discrete traps. The numerical model described the observed travel distance distributions reasonably well (particularly the trapping effect of over hanging trees and flow separation at meander bends), which suggests that modelling plastic transport for longer reaches and even whole catchments using a stochastic travel distance approach is feasible. The approach has the potential to improve estimates of total river plastic flux to the oceans, although significant knowledge gaps remain (e.g. the rate and location of plastic supply to river systems, the transport behaviours of different types of plastic debris in rivers and the effectiveness of different traps in different types of river system).

Sources, Sinks & Solutions for Impacts of Plastics on Coastal Communities in Viet Nam

Michel Kaiser, *Herriot Watt*

Seabird breeding islands as sinks for marine plastic debris

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Seabirds are apex predators in the marine environment and well-known ecosystem engineers, capable of changing their terrestrial habitats by introducing marine-derived nutrients via deposition of guano and other allochthonous inputs. However, with the health of the world's oceans under threat due to anthropogenic pressures, such as organic, inorganic, and physical pollutants (i.e., plastics), seabirds are depositing these same pollutants wherever they come to land. Using data from 2018-2020, we quantify how the Flesh-footed Shearwater (*Ardenna carneipes*) has inadvertently introduced physical pollutants to their colonies on Lord Howe Island, a UNESCO World Heritage site in the Tasman Sea and their largest breeding colony, through a mix of regurgitated pellet (bolus) deposition and carcasses containing plastic debris. The density of plastics within the shearwater colonies ranged between 1.32 – 3.66 pieces/m^2 (mean ± SE: 2.18 ± 0.32), and a total of 688,480 (95% CI: 582,409 – 800,877) pieces are deposited on the island each year. Our research demonstrates that seabirds are a transfer mechanism for marine-derived plastics, reintroducing items back into the terrestrial environment, thus making seabird colonies a sink for plastic debris. This phenomenon is likely occurring in seabird colonies across the globe and will increase in severity as global plastic production and marine plastic pollution accelerates without adequate mitigation strategies.

The impact of bio-modulated flocculation on the fate and ecological risk of microplastics in river-estuary transition zones

Freija Mendrik, Roberto Fernández, Christopher Hackney, Cath Waller, Robert Dorrell, Grigorios Vasilopoulos and Daniel Parsons

The fate of plastics remains fairly unknown, with plastic fragments floating on the surface of oceans representing less than 1% of plastic pollution entering these environments annually. There are several removal mechanisms that have been suggested for microplastics (<5mm) including ingestion by biota, biofouling and/or aggregation with organic material leading to flocculation and a change in particle density that can impact trajectory and fate of the material. Furthermore, despite the widespread recognition that rivers dominate the global flux of plastics to the ocean, there is a key knowledge gap regarding the behaviour of microplastics in transport and its pathways from rivers into the coastal zone, especially in regards to how biofilm formation and aggregation influence particle fate. This prevents progress in understanding microplastic dynamics and identifying zones of high accumulation, as well as curtailing the evolution of effective mitigation and policy measures. To predict transport, fate and biological interactions of microplastics in aquatic environments at a global scale, the factors that control these processes must be identified and understood.

A laboratory settling experiment was therefore conducted to understand how polymer type, salinity, suspended sediment and biofilm formation influence microplastic particle settling velocities and transport. The results presented herein explore the role of biofilms on the generation of microplastic flocs and the impact on buoyancy and settling velocities. Settling velocities were then combined with field flow data from the Mekong River, one of the top global contributors to marine plastic pollution, allowing predictions of areas of microplastic fallout and hotspots. The results also highlight potential areas of ecological risk related to the dispersal and distribution of microplastics across the river-delta-coast system including the biodiverse Tonle Sap Lake. Future work involves further aligned fieldwork within the Mekong River that details the particulate flux and transport of microplastics throughout the vertical velocity profile.

Session 4: Analytical advances, opportunities and challenges in plastic research

Multiple digestion cycles' method with Fenton reagent for microplastic detection in wastewater and sludge samples

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Microplastic particles represent an emerging class of contaminants in our environment. Despite the exponential increase of microplastic research worldwide, no consensus has been reached yet as to standardized methodologies for the quantitative and qualitative assessment of these pollutants across different environmental matrices. As a result, the evaluation of the potential eco-toxicological impacts of microplastics on terrestrial and aquatic species has become a pressing concern. Moreover, the variety of methodologies adopted for the extraction and characterization of microplastics from the environment further hinders the comparison of results across studies. Wastewater treatment plants are considered one of the primary land-based routes of microplastic emission into rivers and oceans.

As technology in microplastic research advances, it is critical to establish effective methodologies to better understand the role that wastewater systems play to eventually assess the impact of microplastics in the environment. Our specific focus has been on the application of Fenton reagent for the optimization of the organic matter removal from wastewater and sludge samples where high organic content makes the detection of microplastics difficult. The presence of organic interferences hampers spectroscopic analysis, which currently represents the characterization technique most widely used for microplastic detection. Our study builds upon previous work which has introduced the concept of sequential digestions with Fenton reagent for wastewater samples. We have optimized the performance of a multiple digestions' cycle and carried out recovery experiments in three different matrices (raw sewage, final effluent and sludge) to validate the method. After the multiple digestions step, density separation was performed for the removal of the inorganic matter followed by the characterization of the samples at Fourier Transform Infrared spectroscopy for microplastic detection.

Flume studies help to uncover the transport of polyamide microplastics at the sediment-water interface.

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Microplastic particles in freshwater environments are increasingly recognised as an emerging contaminant that is harmful to aquatic life and can remain in the environment for a prolonged time. These particles come in a range of sizes, shapes and chemical compositions. Their physico-chemical characteristics along with the prevailing environmental conditions define their fate in riverine environments, including transport, deposition and resuspension mechanisms as well as degradation and particle aging.

Here, we study the fate of polyamide (PA) particles using recirculating flumes to represent small and shallow riverine systems. Twelve recirculating flumes (dimensions of 200 x 42 x 15 cm) filled with gravel or sand and 47.5 L of freshwater were exposed to polyamide fragments (sizes: 150-250 um and 400-600 um, pre-stained with Nile Red), red nylon fibres (500 um, 1.7 dtex) or a mix of both. After initial flow and water level measurements, 20 mL-samples were taken at three distinct locations per flume over the next 4 to 24 hours at predefined intervals. Sample vials were then filtered over 0.45 um GF/D filters and analysed by stereomicroscopy.

Our findings show that fibres and fragments settled out of the water column within the experimental time (24 hours). Distinct depositional patterns of microplastic particles on the sediments could be identified. Particle size and shape had a noticeable influence on settling and subsequent re-suspension behaviour. Our results can help in the characterisation of microplastic transport in natural stream environments, specifically in perennial streams with low flow velocity.

Colour-quantitation of microplastic particles using multispectral imaging flow cytometry

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Continuously increasing plastic production, poor degradability, and ineffective recycling contribute to the global plastic pollution [1, 2]. Many, non-standardized methods, therefore, try to target microplastics in different size ranges and shapes for further risk assessment and evaluation [3–5]. Color-information as well as geometry and texture are relevant fundamental parameters for further toxicity studies and analysis through optical or mass spectroscopic (MS) methods. With further fragmentation of the particles their number increases exponentially while their mass is decreasing. Hence, the result of imaging techniques will be dominated by small particles while the results of integral techniques such as MS will be dominated by large particles. Therefore, the measurement methods and analysis approach to assess microplastics have to be defined in the beginning to ensure that they serve the research goal. However, analytical and comparable assessment requires standard operating procedures (SOPs) and instrumentation [6].

In our system, we use the advantage of imaging flow cytometry (IFC) combined with a gradient bandpass filter (GBF) to scan the microplastic particles in the microfluidic channel, where multispectral image data of each particle is measured in-flow. The GBF is implemented into a microscopic system, which collects a monochrome bright field image of the microplastic particles travelling through a microfluidic channel. Through the overlay of spectral properties with the spatial flow-axis, acquired multispectral image data can be reduced significantly. The advanced image processing algorithm can detect and track several particles simultaneously over the field of view (FOV). The gained particle information includes its quantitative color information, phase contrast as well as shape and size. Hence, we introduce an innovative method, which is able to measure fast-flowing particles with high spatial and spectral resolution, which allows population assessment of a microplastic sample to determine further steps of analysis. While there is still room for improvement in our setup, the first experiments show already potential for real-time analysis, discrimination and decision-making for e.g. sorting applications.

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Collaboration and infrastructure are needed to develop an African perspective on micro(nano)plastic pollution

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Our current understanding of environmental micro(nano)plastic (MNP) pollution is driven by field and lab-based studies performed predominantly by and in wealthier countries. However, mismanaged waste and its consequences affect low- and middle-income countries over-proportionately. Polymer identification has become a reporting standard when investigating environmental MNP pollution and is increasingly seen as a requirement for publication. This is because polymer identification confirms visual accuracy and offers insight into possible pollution sources. Evidence suggests that studies on MNP pollution in Africa are critically limited by the scientific infrastructure available, especially as none of the equipment used for polymer identification or their replaceable parts are manufactured on the continent, making routine and mandatory maintenance of such facilities difficult and cost-intensive. Here we will discuss how researchers in Africa navigate such a rapidly evolving field, for example by collaborating with external partners who have polymer identification facilities. We will discuss the use of low-cost extraction tools, screening techniques and identification keys, as well as how developing research networks and analytical nodes that showcase the African perspective can facilitate a more inclusive conversations around the harmonization and standardization of methods currently mainly available to the Global North.

Flash Poster Session 3

The effect of the use of different starches in the physico-chemical characteristics of thermoset bioplastics

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The use of commodity plastics has increased significantly over the last years worldwide. They are inexpensive and have multiple applications. However, single-use plastics are produced with non-renewable materials, and they are usually not recyclable. They end up in landfills or are disposed into the environment, which is detrimental to animal and human health. Recently, there has been an effort to generate different bioplastics, such as starch-protein blend thermoset bioplastics (SPBB) to replace single-use plastics. Current SPBBs use non-sustainable starches, such as potato which compete with food production and lack the physico-chemical characteristics to be good alternatives to the currently used plastics. This study aims to assess how the physico-chemical properties of generated SPBBs change when different starches are used in their formulation. The molecular structure of seven starches (Swamp Taro, Wheat, Sago, Glutinous rice, Tapioca, Potato and Kuzu) was analysed using Fourier Transform Infrared Spectroscopy (FTIR) analysis. After that, all bioplastics' colour and roughness were measured using a colourimeter and a roughness tester. Preliminary results showed that all starches shared similar profiles with variations in the 1,500 cm-1 section of the spectrum. Bioplastics were then generated using in their formulation all seven starches, and the concentration of starch was optimised until structurally sound bioplastics were generated. Colour tests showed that Swamp Taro and Sago starches led to darker bioplastics, with more red tones than the other starches that produced bioplastics with whiter tones. In addition, the roughness test showed that Swamp Taro and Potato starches produced significantly rougher SPBBs than Sago and Tapioca starches, which produce much smoother SPBBs. In conclusion, the physico-chemical analyses performed indicate that the starches investigated can be used as raw ingredients for the generation of SPBBs in an array of these plastics' applicabilities. Further studies need to be done to identify what other bioplastic characteristics are changed by incorporating these starches in their formulation.

Sources and concentration of micro and macro plastics in the water column and coastal sand in Jangamo Bay, Mozambique

Francesca Trotman, *Love The Oceans NGO, Mozambique*

This study will investigate the possible sources and concentration of plastics in the water column and sand deposited on beaches through Jangamo District, Mozambique. This study builds on existing research collected by Love The Oceans NGO (LTO) which has found over 78% of waste collected on coastal beaches in Jangamo is plastic. LTO's data suggests large concentrations of plastics widely distributed along the coastline of Mozambique, possibly by ocean circulation through the Indian Ocean Garbage Patch and more local gyres. It is suspected that the northern estuarine outlet in Inhambane could be a large contributor to local ocean trash, which then breaks down in the water column and can be consumed in large quantities by known filter feeders in the area like whale sharks, *Rhincodon typus*. Samples of beach sand will be collected along Inhambane's coastline to investigate possible plastic sources, and water samples will be collected from vessels to determine micro plastic concentration in the water column, combined with megafauna filter feeder sightings data. LTO's beach clean data, largely consisting of macro plastics, may be utilised for the study. Plastic ingestion rates for megafauna will be estimated using filter-feeding capacity and microplastic concentration. Results of this study will help inform conservation action in the area and the development of upcycling and plastic recycling projects for rural communities in Mozambique.

Quantitative identification of microplastic using an automated mineralogical and infrared approach

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Plastic pollution is an increasing environmental concern, with millions of tons of plastic accumulating in the world's oceans annually. While large pieces of plastic are a well-known problem and can cause entanglement and injuries from ingestion to marine life, smaller (<5mm) particles of plastic, known as microplastics, are less visible and may present an even bigger challenge to marine ecosystems. Microplastics are categorized in two groups; primary microplastics are originally created as small particulates, and secondary microplastics which are created through the abrasion of larger plastic over time. Microplastic particles are often present as anthropogenic grains occurring as a significant proportion of beach sand. Consequently, microplastic particles can be treated as sedimentological grains using mineralogical techniques to determine the scale of plastic pollution in the environment. Automated mineralogical tools, such as Quantitative Evaluation of Minerals by Scanning Electron Microscopy (QEMSCAN®), combined with Micro-Fourier Transform Infrared spectroscopy (μFT-IR) are able to accurately quantify the amount of microplastic in a known sample volume and also identify the composition, range of 'grain'-sizes and morphologies (for example, fibres, hemi/spheres etc.) of the plastic particles. Using beach sand samples collected from the Conwy Estuary in North Wales, United Kingdom, we present an integrated workflow for the mass, rapid screening of samples for the presence of microplastic using QEMSCAN®, supplemented by μFT-IR to identify the composition of the plastics. Beach sand samples were mounted in a non-plastic medium and scanned using a QEMSCAN® Quanta 650F. iDiscover software was used to provide information about the 2D textural, morphometric and mineralogical composition of the scanned data, quantifying the amount microplastic present in the samples. This was followed by μFT-IR spectroscopy to identify polymers by verifying the specific spectral bands of microplastics found within the beach sand samples against a known polymer database. This workflow demonstrates how geological techniques can be redeployed to quantify anthropogenic grains within sedimentary deposits. The results of this work show the ease in which plastic grains can become incorporated into the depositional environment and, given the long degradation time of plastic particles, how they can persist in the sedimentary record.

Controls on microplastic deposits in stratigraphy non-cohesive sediments

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Microplastic particles present within the aquatic environments interact with natural sediments as they are entrained, transported, and deposited. Microplastic particles are formed from polymers that have positive, negative and neutral buoyancy properties, due to the large range of plastic types manufactured and used across society. The fate of microplastics within sedimentary environments is governed by the physical, chemical and biological processes. Microplastic particles studies have shown that a significant volume of microplastic particles result from the defragmentation of high-density plastic, such as Polyethylene Terephthalate (PET), Nylon (PA), Polyvinyl Chloride (PVC), etc. This research study the controls on how these negatively buoyant microplastic interact with natural sediments as they settle, stratify and deposit into a substrate under controlled experimental conditions.

A set of 15 experiments were designed to investigate the settling process of negatively buoyant microplastic particles in non-cohesive sediment mixture. For the experiments the glass spheres were used as a representative sand with a uniform size distribution (D_{50}=110μm). The experiment consisted of adding three-way mixtures and thus variable volume concentrations of nylon fragments (D_{50} =700 μm, ρ= 1.15 g/cm^3), sand (glass spheres) and water in a cylinder settling tube (7 cm diameter and 25 cm height). During each experimental run, the mixture was shaken for 1 min and until thoroughly mixed. The system was left to rest to allow the mixtures to settle for a 24 hours period. The substrate settled within the cylinder was then frozen at -20 °C. The thickness of the deposit and the distributions microplastic within the sediment substrates were quantified.

Sediment layers within the substrates were categorized into four groups: A) entirely microplastic, B) high microplastic - low sand content, C) low microplastic-high sand content and D) entirely sand. The height of the high microplastic - low sand content (substrate B) decreases as the relative volume fraction of sand increases. The formation of the layer of low microplastic - high glass content (substrate C) is function of the content of microplastic-sand and is not formed high contents of sand. The experimental results highlight the relative importance of microplastic concentrations controlling the distribution of plastic material with the deposits, which have a range of implications of the measurement of the concentrations in the fields as well as the spatial distributions deposits of microplastic in natural environments.

Microplastics in the ocean: Accumulation in marine sediments and vertical transfer through intertidal food webs

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This project aims to better understand the fate of microplastics (plastic fragments of < 5mm) in the marine environment. Microplastics (MP), have been found from highly urbanized areas to the remote Antarctic [1–3]. It is starting to become clear that MPs are ingested by many marine organisms, but the implications of this are not yet known. Some animal groups are particularly poorly-studied, most notably marine invertebrates [4,5]. For my PhD, I am focussing on assessing MP ingestion by invertebrates from different trophic levels and feeding groups [6] with the goal to model trophic interactions. For this project I will sample a range of different intertidal habitat types (e.g. sand, mudflats and vegetated saltmarshes) in the Humber estuary (UK) as well as benthic animal species; comparing the amount and nature of MP found. In a first instance, this will allow me to determine factors favouring the settlement of plastics and identify pathways of pollutants in marine food webs. This addresses existing gaps in our understanding of the fate of marine microplastics and of the threats to animals and humans through seafood consumption.

[1] Cincinelli et al. Chemosphere 175 (2017)
[2] Barboza et al. Marine pollution bulletin 97 (1-2) (2015)
[3] Marine pollution bulletin 124 (1) (2017)
[4] Bour et al. Environmental pollution (2018)
[5] Sá et al. The Total Environment 645 (2018) 1029–1039.
[6] Setälä et al. Marine pollution bulletin 102 (1) (2016)

The effects of microplastics on chemical toxicity to aquatic organisms: a review

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Microplastics are ubiquitous in both marine and freshwater systems and can acts as a physical contaminant, as well as interact with chemicals present in the environment. There is some controversy regarding the interaction between microplastics and chemicals present in the environment, and whether or not microplastics act as a vector for the introduction of chemicals into aquatic biota. Therefore, we conducted a quantitative review to determine how the hydrophobicity of chemicals, as well as the size of microplastic particles influences the effect that microplastics have on chemical toxicity. We collated data from 47 laboratory studies that assess the effects of microplastics, chemicals and their combination on several ecotoxicological responses of freshwater and marine organisms. The findings provided by this study suggest that the interaction between microplastics and chemicals is far more complex than just considering hydrophobicity of chemicals and size of microplastic particles. Further research is required to better understand the mechanisms that influence the interaction between microplastics and chemicals, and to generate a proper risk assessment regarding microplastic toxicity in the aquatic environment.

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