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HUMAN IMPACTS IN ANTARCTICA IN A CHANGING CLIMATE

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Polycyclic aromatic hydrocarbons and heavy metals content in soils of vicinities of Russian Antarctic stations

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Antarctica is considered as one of the most pristine areas on Earth. However, increasing rates of human presence on the sixth continent makes it crucial to investigate the level of environmental pollution within the vulnerable ecosystem of Antarctica. Soils have a significant role in processes of accumulation, mobilization, redistribution of chemical, and especially, trace elements in landscapes and ecosystems. The aim of this work was to analyze the levels of 17 polycyclic aromatic hydrocarbons (PAHs) and 8 heavy metals (HMs) in the vicinities of Russian Antarctic stations both in Eastern and Western Antarctica. Moreover, our work is aimed to determine the trends and reasons of anthropogenic pollution of Antarctic soils and characterization of accumulation levels of HMs and PAHs. Results show the predominance of light PAHs in all studied sites with prevalence of low-molecular polyarenes. The content of benzo(a)pyrene does not exceed the maximum permissible concentrations (adopted in Russia). At the same time the content of benzo(a)pyrene, which is a marker of anthropogenic contamination, is relatively low or equal to 0 in soils of reference-landscapes. Generally, geoaccumulation index values for heavy metals were under or slightly above the 0 level, indicating low to moderate pollution of the studied soils. However, considerable Igeo values of Zn, Pb and Cu were revealed in several samples. Results obtained in our study are especially relevant in sense of climate change effects as a long-term and gradual warming in Maritime Antarctica.

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Microplastics in the Antarctic coastal environment of Potter Cove

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Marine plastic pollution has become a global issue affecting even the most remote regions of the ocean. Microplastics pollution (plastic particles <5 mm size) in Antarctica has recently started to be studied and consequently, there are still many knowledge gaps regarding its concentrations, characteristics and potential impacts on the ecosystem. We performed the first detailed analysis of microplastic debris concentration, distribution and composition in Potter Cove (King George Island/25 de Mayo, South Shetlands, Antarctica). Four transects were sampled following the water circulation within the cove, including one in front of the Scientific Station Carlini, to characterize the plastics and infer their origin. An intensive surface sediments sampling by means of SCUBA diving was accompanied with water column (5 and 20 m depth) sampling using three complementary methods: plankton net (263 µm), 5 L Niskin bottles, and an in situ filtering device named Microfilter that allowed filtering relatively larger volumes of water (average 115 L per sample) through a 47 µm stainless steel mesh. Recovered microplastics were photographed, and measured using image analysis software (Image J) and analyzed by Raman spectroscopy to reveal their polymeric composition. Preliminary results showed fragments, spheres of different sizes and colors, being the majority smaller than 100 µm. As the primary risk of microplastics is their bioavailability to marine organisms, further studies are needed to investigate the trophic transfer, bioaccumulation and their ultimate fate in Antarctic ecosystems. Such studies are planned for next Antarctic campaigns.

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Microplastics at the intertidal of the South Shetland Islands (Antarctica)

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During several decades we have been studying marine benthic invertebrates in Antarctica. We observed plastic debris in some benthic invertebrates collected recently and thus decided to investigate how much plastic is in the sediments and water surrounding these benthic organisms. Our research group has been evaluating the presence of microplastics in the intertidal areas of several islands in the South Shetland Archipelago, where samples were collected at Livingston and Deception Islands. These samples have been studied by separating and identifying the material, characterizing and analyzing the debris obtained, and these have been also photographed and measured. A protocol was adopted to separate the plastic debris from the samples, according to the literature and our own inputs. Five samples were taken from the upper part of the intertidal zone and another five from the lower part and were stored in glass jars with alcohol. We present here the analyses of some of these samples and their plastic content.

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Brominated Flame Retardants in Antarctic Air in the Vicinity of Two All-Year Research Stations

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Polybrominated diphenylethers (PBDEs) are a group of organohalogen compounds used extensively in consumer products over the past 50 years. Their environmental behaviour of persistence and long range dispersal, combined with their biological impacts of accumulation within organisms with potential toxicological effects, has led to the banning of the majority of PBDE formulations under the Stockholm Convention. PBDEs have been reported in Antarctic biota since 2004, and in the Antarctic atmosphere since 2012. Unlike organochlorine pesticides, the Antarctic occurrence of which can be attributed solely to Long Range Environmental Transport, current and recently-used chemicals, such as PBDEs, are also finding their way to the remote Antarctic region via in-situ usage. Recent studies focusing on Antarctic research stations as emitters of PBDEs to the local environment, have evidenced local pollution and consequently implicated all Polar research stations as local sources of these compounds. In this study we conducted year-long atmospheric sampling for PBDEs in the vicinity of Troll and Casey, two all-year research stations. Significant differences in atmospheric levels of PBDEs were observed between the two stations, with elevated levels observed at Troll. Particularly levels of BDE-47 detected in Troll air were higher than those previously detected in Antarctica and similar to those found in densely populated regions such as Southern Taiwan. Whilst on-station PBDE sources at both Casey and Troll stations remain unidentified, the atmospheric PBDE levels observed in the vicinity of these active research stations emphasise the growing importance of local sources of chemical pollution for the Antarctica region.

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Microplastic in the Antarctic marine food web: a first assessment

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Microplastic pollution is known to have reached even the most remote and pristine regions of our planet including Antarctic waters. Studies show that plastic particles can be ingested by marine biota with potential adverse implications on individuals and the food chain.
Antarctica is of particular importance as many species are highly adapted to the extreme Antarctic climate and an additional stressor could raise their vulnerability. Furthermore, plankton and benthic communities from the Southern Ocean play a key role in the global marine food web.
This study focuses on the environmental consequences of microplastic ingestion for Antarctic marine invertebrates and the possible effects in higher trophic levels. Sampling took place in the Antarctic summer 2020 from three representative fjords with documented glacier retreat along the Antarctic Peninsula and on Burdwood bank in the South Atlantic.
The vulnerability towards microplastic will be assessed using traits such as feeding type, habitat, functional group and trophic level. We aim to investigate what factors influence the rate of microplastic ingestion and to determine whether it bioaccumulates through the food web. First analysis of water samples shows microplastic presence in all sampled fjords along the Antarctic Peninsula. The chemical identity of these plastics will be confirmed using Fourier-Transformed Infra-Red spectroscopy (FTIR).

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Assessing impacts of contaminated sites in Antarctica: application of toxicity tests with native soil micro-invertebrates

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Toxicity tests are used routinely worldwide to assess impacts of contaminated sites, and are fundamental to the derivation of Environmental Quality Guidelines and Remediation Targets. However, to date, few protocols have been developed using native Antarctic species, especially for terrestrial systems, and sensitivity data is limited. Plectus murrayi is a common and ecologically important nematode worm inhabiting soils Antarctic wide. Optimal culturing techniques have been developed with this species, and robust toxicity test procedures using the most sensitive juvenile stage are now standardised for site-specific Environmental Risk Assessments. Here we present results of toxicity testing for common pollutants including metals and fuels. For copper, the response of nematodes was dependent on the life history stage tested and on the duration of exposure, with sensitivity of juveniles increasing through time, and 50% lethal concentrations (LC50) of 478 and 117 µg/L at 21 and 28 d, respectively. For fuels, the toxicity of fresh and aged diesel contaminated soil (up to one year of weathering) was assessed in elutriates prepared using soil from Casey station spiked with Antarctic diesel. Exposure concentrations for hydrocarbons were quantified through a suite of chemical analyses on soils and elutriates. Toxicity was influenced by the presence of hydrophillic polar and non-polar compounds, with aged fuel generally less toxic than fresh fuel. Critical effect concentrations generated for P. murrayi, along with other terrestrial biota, contribute valuable data towards the development of Soil Quality Guideline Values and Remediation Targets for site restoration and soil reuse at contaminated sites in Antarctica.

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Microplastic in South Georgia Plankton: A study of the level of microplastic ingestion seen in planktonic organisms which form the base of the regional foodweb.

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Microplastics are ubiquitous in the global ocean and have even been found in remote polar environments. The ingestion of microplastic by zooplankton and krill has been well documented; this study will assess the microplastic loads of the ecologically significant keystone species, Euphasia superba, and other planktonic organisms in the nearshore waters of South Georgia. It is hypothesised that A) microplastic will be present inside the plankton, having been accidentally ingested; and B) that contamination loads will be of a level which will explain the presence of microplastic recently documented in planktivorous seabird species from the same area (Bessa et al, 2019; Le Guen et al, 2020).

Samples from the long-term plankton monitoring sites Rosita Harbour and Cumberland East Bay (CEB), dating back to 2008, will be analysed in order to estimate the change in microplastic exposure over time, which planktonic organisms in the region have been subject to.

This study will present the optimal methodology for extracting microplastics from chitinous organisms through organic digestion. Suspected anthropogenic particles, extracted from the plankton samples, will undergo polymer analysis via Fournier-Transmission Infrared (FT-IR) Spectroscopy. We predict that microplastic loads will be higher across all various taxa in plankton from CEB, as it is subject to more frequent and intense anthropogenic activity than in Rosita Harbour.

Future work will constitute examining the microplastic loads in planktivorous predators in the same region i.e. demersal and pelagic fish and their predators to assess the potential for microplastic trophic transfer.

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Anthropogenic activities are associated with shorter telomeres in chicks of Adélie penguin

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Defining the impact of anthropogenic stressors on Antarctic wildlife is an active aim for investigators. Telomeres represent a promising molecular tool to investigate the fitness of wild populations, as their length may reliably predicts longevity and survival. We examined the relationship between telomere length and human exposure in Adélie penguin chicks (Pygoscelis adeliae) from East Antarctica. Telomere length was compared between chicks from areas with sustained human activity (Petrels Island) and on neighboring islands with little or no human presence (Lamarck and Bernard Islands). Adélie penguin chicks from disturbed sites had significantly shorter telomeres than chicks from undisturbed sites in nearby protected areas. While more data is needed on the ultimate impact of human disturbance on penguin colonies, our analysis nonetheless provides important insights into colony vulnerability. We suggest to further test the use of telomere length analysis as an eco-indicator of stress in chicks of Adélie penguins, and other penguin species, among anthropized sites throughout Antarctica. Telomeres could indeed be a relatively easy to use marker to inform the Committee for the Polar Environment at the Antarctic Treaty System on the impact that Antarctic stations or recurrently visited landing sites by tourists have on bird colonies.

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Relationship between antibiotic resistance patterns found in bacteria isolated from seawater and bacteria isolated from sewage from Antarctic Stations

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In this work, wastewater and seawater samples collected from different points in Antarctica were examined for the presence of bacteria with antimicrobial resistance
The samples of sea water were collected from sites distributed around the sewage outfalls of six Antarctic stations. Wastewater samples were taken from three Antarctic wastewater treatment plants (WWTP). Additionally, control samples were collected from pristine sites.
Escherichia coli strains were isolated from wastewater and seawater and antibiotic susceptibility patterns were determined with the disk diffusion method using different groups of antibiotics: penicillins, cephalosporins, carbapenems, aminoglycosides, quinolones, tetracycline, phenicols, sulphonamides, and trimethoprim. Escherichia coli ATCC 25922 was used as the control for the susceptibility tests.
A total of 227 E. coli isolated strains were studied to determine antibiotic susceptibility (191 strains from seawater and 36 strains from wastewater). 59% strains from seawater were resistant to at least one antibiotic and 33% were multidrug-resistant. Additionally, 36% of the strains from wastewater were resistant to at least one antibiotic and 22% were multidrug-resistant. E. coli were not detected in the control samples.
E. coli strains isolated from wastewater showed patterns of antimicrobial resistance similar to those found in isolated strains from seawater near sewage outfalls. These results suggest that the presence of bacterial with antimicrobial resistance in Antarctic seawater could be the result of wastewater discharge from WWTPs from Antarctic stations.

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Amplification of Persistent Organic Pollutants at Coastal Antarctica

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Many legacy and emerging persistent organic pollutants (POPs) have been reported in polar regions, and act as sentinels of global pollution. Maritime Antarctica is recipient of abundant snow precipitation. Snow scavenges air pollutants, and after snow melting, it can induce an unquantified and poorly understood amplification of concentrations of POPs. Amplification of concentrations of surface-active and hydrophobic POPs can also occur in the marine surface microlayer (SML). Air, snow, the fugacity in soils and snow, seawater, the SML and plankton were sampled in three sampling campaigns at Livingston and Deception Islands (South Shetland, Antarctica), and analyzed for polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), perfluoroalkyl substances (PFASs), polycyclic aromatic hydrocarbons (PAHs) and organophosphate esters (OPEs). Coastal seawater mirrored the pollutant profile in snow, consistent with the amplification of concentrations in snow and the snowpack releasing POPs to seawater during the austral summer. The influence of snowpack and glacier inputs was further evidenced by the correlation between net volatilization fluxes of semi-volatile POPs and seawater salinity. In addition, there was an amplification of PFAS in the SML and aerosols, supporting the role of sea-spray aerosol as a vector for long-range atmospheric transport of PFAS. These results further indicate that amplification of concentrations in snow and the SML contribute to the generalized occurrence in Antarctica of legacy and emerging organic pollutants with a wide range of physical chemical properties and confirms the role of polar regions as a sentinels of global pollution.

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Overwintering strategy and susceptibility of an Antarctic freshwater zooplankton to anthropogenic chemicals.

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Zooplankton in freshwater lakes on all continents store dormant embryos in sediments for years to centuries, but this survival strategy may make zooplankton more susceptible to anthropogenic chemicals. Published data demonstrate that persistent organic pollutants (POPs) are accumulating in Antarctica, and exposures of Antarctic species to POPs now cooccur with a rapidly changing climate. Unfortunately, few studies provide data to help predict the impact of anthropogenic chemicals and climate change on freshwater zooplankton in Antarctica. To determine if zooplankton are exposed to common lipophilic pollutants in Antarctic freshwater lakes, we tested bottom sediments of lakes on King George Island for polychlorinated biphenyls (PCBs). The data presented here demonstrate that PCBs found in lake catchments are also found in lake sediments where dormant zooplankton are located. Permeability tests with rotenone show that moderately lipophilic chemicals penetrate embryos of the freshwater copepod, Boeckella poppei. Frozen sediments may provide a safe-zone for dormant embryos by partially immobilizing chemicals, but field data indicate that B. poppei on King George Island overwinter in both frozen and unfrozen sediments. Embryo densities are highest in sediments that do not freeze, in part because freeze tolerance is dependent on the rate of temperature change and minimum temperature. Together, these findings suggest that moderate warming in Antarctica will not present a problem for overwintering embryos of B. poppei. However, the impacts of lipophilic pollutants on zooplankton will increase if lake sediments do not freeze. An assessment of dormant freshwater zooplankton and anthropogenic pollutants along the Antarctic peninsula is needed.

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Impact of human activities on the arrival of non-native species to the Antarctic ecosystems.

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Current effects of climate change and the exponential increase of human activities make the Antarctic ecosystem have a high invasiveness. In this context of global change, quantify the biological particles (pollen and seeds) in the soil of the Antarctic Peninsula can be helpful from a conservative management. In this study, we identify and quantify seeds and the current pollen rain deposited in the topsoil in the Antarctic Peninsula region. First, we sampled topsoil in Fildes Peninsula, King George Island, an area of high human impact due to the scientific and logistical activities, we select three sectors: a strongly affected, a less visited and a with low human activity. Second, we sampled topsoil in Deception Island, Hannah Point and Hurd Peninsula in Livingstone Island and close to Arctowski Station, Admiralty Bay, King George Island with the aim of expanding the coverage area. The results indicate a direct correlation between the sites of greatest anthropization and the presence of seeds and pollen taxa of non-native species. The pollen taxa identified in most of the sites correspond to the main families of exotic species worldwide (Asteraceae, Fabaceae, Brassicaceae and Poaceae). Eight species were identified from the seeds found, corresponding mainly to the Asteraceae family, the most common being Hypochaeris radicata and Senecio jacobaea. Under the current climate change scenario, the pollen rain and seeds arrival in Antarctic soil, could be considered as an indirect measurement of the potential risk of the passive transport of propagules to Antarctica mediated by human beings.

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Microbial communities as indicators of hydrocarbon toxicity in soils undergoing bioremediation in Antarctica and subAntarctic Macquarie Island

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Microorganisms are ideal indicators of polar soil health. In Antarctica, they both dominate and drive ecosystem services, particularly geochemical cycling and pollutant degradation. They also respond to environmental gradients, contamination and disturbances, making them ideal, yet complex indicators of change. In Antarctica, there is a lack of site-specific toxicity data available on which robust guidelines for both contamination thresholds and remediation targets can be derived. Active bioremediation through the use of engineered biopiles are ongoing at Casey station Antarctica, while in situ bioremediation was performed at subantarctic Macquarie Island. In both cases, a lack of suitable targets has made site restoration and soil reuse problematic. Thus, the development of risk assessments that incorporate soil microbial communities and critical soil processes are essential for adequate protection of life in these regions. Through the analysis of pristine, hydrocarbon contaminated and partially remediated soils we have obtained knowledge on what key functional groups are present in a 'healthy' soil prior to and during remediation. We used next generation sequencing, qPCR and microfluidic qPCR to develop soil microbial community indices as indicators for both the development of ecotoxicology targets, and monitoring sites undergoing remediation. We will provide evidence that the structure and functioning of soil microbial communities can be restored to a level similar to that present prior to hydrocarbon contamination and suggest that use of microbial community indices offer a less reductive perspective on contamination, providing direct links to ecosystem function.

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Anthropogenic impact on Antarctic intertidal sediments, effects on physical-chemical parameters, macro and meiofauna

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Due to its pristine character, Antarctica is an area of special interest for the study of anthropogenic effects around Antarctic bases and its relationship with the biodiversity of the macro and meiofauna. In this work, the concentration and distribution of pollutants in intertidal sediments in the vicinity of the Captain Arturo Prat Naval Station was studied. This place has historical and current anthropogenic impacts, caused by the movement of boats and discharges of treated waters. Additionally, statistical correlations were established between the different physicochemical parameters, the macro and meiofauna.
Four physical-chemical analyzes were carried out: organic matter, total petroleum hydrocarbons, total nitrogen and free phosphorus. Additionally, sediment granulometry was characterized and macro and meiofauna organisms were identified. The bay had low concentrations of nitrogen, while the concentrations of organic matter and total petroleum hydrocarbons increase in areas with greater presence of human activity. The hydrocarbon/organic matter ratio shows to be a good indicator of environmental quality, as it increases significantly at the points of greatest impact.
Statistical analysis showed that physicochemical parameters are associated with finer soil fractions, while the biodiversity of the macro and meiofauna is negatively correlated with discharges and the presence of contaminants. Nematode and Polychaeta taxa dominate in contaminated samples, while taxa such as Ostracode and Halacaridae appear in more pristine samples. This differentiation in the species found and the statistical correlations established allow us to lay the foundations for the development of sediment quality indices on Antarctic coasts.

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Invasive non-native species likely to threaten biodiversity and ecosystems in the Antarctic Peninsula region

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Antarctica is considered to be a pristine environment relative to other continents, but it is increasingly vulnerable to invasions by marine, freshwater and terrestrial non-native species. The Antarctic Peninsula region (APR), which encompasses the Antarctic Peninsula, South Shetland Islands and South Orkney Islands, is the most invaded part of Antarctica. The risk of introduction of invasive non-native species to the APR is likely to increase with predicted increases in the intensity, diversity and distribution of human activities. Taxonomic and Antarctic experts undertook a horizon scanning to identify the species likely to present the highest risk to biodiversity and ecosystems within the APR over the next 10 years. 103 species, currently absent in the APR, were identified as relevant for review, with 13 species identified as presenting a high risk of invading. Marine invertebrates dominated the list of highest risk species, with flowering plants and terrestrial invertebrates also represented; however, vertebrate species were thought unlikely to establish in the APR within the 10-year timeframe. We recommend the further development and application of biosecurity measures by all stakeholders active in the APR, including surveillance for species such as those identified during this horizon scanning exercise, and use of this methodology across the other regions of Antarctica. Without the application of appropriate biosecurity measures, rates of introductions and invasions within the APR are likely to increase, resulting in negative consequences for the biodiversity of the whole continent, as introduced species establish and spread further due to climate change and increasing human activity.

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Persistent Organic Pollutants in Lakes of Grovnes Peninsula at Larsemann Hill Area, East Antarctica

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Over the past decades, research in Antarctica has built a new understanding of its past, present, and future. Human activities are increasing in Antarctica because of various scientific expeditions. Research on Persistent Organic Pollutants (POPs) has been carried out internationally by several countries having their permanent research station to explain the impact of an ever-increasing range of POPs in the Antarctic ecosystem. Additionally, global pollution due to various newly introduced pollutants like pesticides is on use since the past century and many factors contribute to contamination even in Antarctica.
More than 150 lakes at different islands and peninsulas are situated in Larsemann Hill, East Antarctica. It is a series of islands and rocky peninsulas which consists of two major peninsulas, four minor peninsulas, and ~ 130 near-shore islands. POPs are semi-volatile toxic compounds that resist photolytic, chemical and biological degradation, can persist in the environment for a long time. POPs were analyzed in the Lakes water samples of Grovnes peninsula, Larsemann Hills during 34th Indian Scientific Expedition to Antarctica (ISEA) in austral summer of 2014 to 2015. POP's residue levels were found in lake water samples varied from 10.00 to 75.00 pg/mL. Presence of p,p'-DDT was detected in all different lakes & the highest concentration was found in L1E NG lake. The presence of POPs may be attributed to orographic effects, migratory birds, biomagnification and anthropogenic sources. The presence of POPs is an alarming situation and needs to be investigated further to maintain the pristine environment in Antarctica.

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Microplastics in Continental Antarctica

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Critical to understanding the possible threat of microplastics to the Antarctic ecosystem, is building up a dataset of plastic pollution in and around Antarctica. Until now, data collection has been focused within the marine environment, however, a vital data gap remains in the frozen continent. Microplastics presence in the snow of Antarctica may indicate aerial transportation of microplastics and allow estimations of the "impact zone" of operations in Antarctica. In a first of its kind study, we evaluate the presence of microplastics in relation to the local wind regime around Union Glacier whilst also assessing the presence of microplastics in unlikely remote locations, such as the Antarctic Plateau. Surface snow samples were collected at the camp edge, downwind and increasingly upwind, with control sites at remote altitude on the Antarctic Plateau and above Schanz Glacier. Samples have been analysed using Fourier Transform Infrared (FTIR) spectroscopic imaging. The fieldwork was carried out as part of the Airbnb funded "Antarctic Sabbatical"; a citizen science project where the researcher worked with Antarctic Logistics and Expeditions out of Union Glacier to train five international volunteers to collect the data and learn about plastic pollution and research. This talk will provide preliminary results from this novel dataset, offering new insight into our current understanding of microplastic pollution in the Polar Regions.

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Monitoring of freshwater lakes of Thala Hills, Enderby Land, East Antarctica

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The paper is devoted to the recent study of changes of the chemical composition of freshwater lakes and temporary ponds of Thala Hills, Enderby Land and their dependence on natural and anthropogenic factors. The region of investigation includes mainly Vecherny and Molodezshny oases.
Water sampling was carried out during seasonal Belarusian Antarctic expeditions from 2011/12 to 2017/18. The results of earlier expeditions since 60s of the XX century were used. Seven lakes and six temporary ponds located at different distance from scientific station and see shoreline has been chosen for observation. Main ions, electrical conductivity, pH as well as trace element content were included in the list of measured parameters. Heavy metals have been considered as an indicator of previous and/or current human impact. Totally during six expeditions about 40 water samples were collected and analyzed.
The mean value of measured parameters and its variability for lakes and temporary ponds are considered. It is shown that the differences in main ions content are associated with the geomorphology and, as a consequence, with the flow and processes of evaporation. In some cases, increase of heavy metals concentration in the lakes was revealed, which can be linked to anthropogenic impact including previous human activity in the oasis in late 1970s – early 1990s.
The data obtained will the basis for subsequent assessments of the vulnerability of freshwater lakes to anthropogenic impacts and climate change.

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Assessment of diesel power plants air impacts in Antarctica and their trends

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The paper is devoted to assessment of air impacts of diesel generator sets which are the main sources of energy at Antarctic research stations and the main stationary sources of anthropogenic emissions in Antarctica.
Numerous factors affect emission trends: fuel consumption rates, fuel quality changes, diesel generators properties changes, diesel generators maintenance, additional emission abatement measures etc. On an example of the Vecherny oasis, Enderby Land, East Antarctica the emissions of NOx, SO2, PM10 were estimated, surface concentrations of NO2, SO2, PM10, and levels of dry deposition of PM10 were calculated for various periods of exploration of the oasis from middle 1980s to the current time using available data on diesel generator capacities in the oasis. It has been established that the area of increased maximum hourly air surface pollutants concentrations of at the receptor points and the area of increased maximum monthly deposition of PM10 over the past 30 years reduced dramatically. A comparison of these estimates with the air quality standards and background air concentrations was made.
The proposed approach will be used in subsequent studies to obtain retrospective assessments of the diesel generators environmental impacts in other Antarctic oases. The importance of information on the quality parameters of fuels used at Antarctic stations for estimating emissions is shown. This primarily relates to the sulfur content in the fuel, which affects the emissions of sulfur dioxide, as well as particulate matter.

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Local emissions and regional wildfires influence refractory black carbon observations near Palmer Station, Antarctica

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Antarctica is often regarded as the most pristine continent on Earth. However, local human activity can be significant point sources of production of contaminants, such as black carbon (BC). In May 2015, over the Austral fall season (at the beginning of the accumulation season), surface snow was sampled at eight sites along a 1.7 km transect extending from Palmer Station, Antarctica. Two additional sites were sampled on Biscoe Point, 14 km from the station. Snow samples were analyzed for refractory black carbon (rBC) with a Single Particle Soot Photometer. rBC concentrations increased with proximity to the Palmer Station, 1.2 - 16.5 µg-rBC/L-H2O, and were higher than other studies of rBC in snow, such as in the McMurdo Dry Valleys, Antarctica (MDV) and the Clean Air Sector of the South Pole Station (CAS-SP), except on the more remote Biscoe Island, which had similar background concentrations to the MDV and CAS-SP. Palmer Station is located on the SW coast of Anvers Island on the western coast of the Antarctic Peninsula. Comparison with the Navy Aerosol Analysis Prediction System model show that wildfire smoke may have reached this region during the period of the seasonal snow deposition, suggesting the increase in rBC may be a combination of local combustion of fossil fuels and regional wildfires. Although significant increases in rBC concentrations are found, rBC is limited to a few kms from the station. These initial BC measurements from the Antarctic Peninsula show similar background levels to other locations on the continent.

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Overview of risk assessment and ecotoxicology research for improved environmental protection within the Australian Antarctic Program

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A range of contaminants, including metals, fuels and oils, pose an ongoing risk to subantarctic and Antarctic marine and terrestrial environments as a result of past and current human activities. Contaminated sites associated with fuel spills, waste disposal, wastewater discharges and abandoned infrastructure are often located on rare ice-free coastal soils and in shallow nearshore marine habitats near Antarctic stations. Assessing the environmental risk at these sites and developing appropriate site specific Environmental Quality Guidelines requires consideration of the extreme physical environment and unique properties of inhabiting biota. Standard toxicity tests, using standard test species elsewhere, are not suitable for determining species sensitivities for the derivation of Environmental Quality Guidelines for Antarctica. A suite of toxicity tests using indigenous biota have been developed by the Australian Antarctic Program to assess the effects of key contaminants on Antarctic ecosystems. Traditional and novel approaches developed include single species tests, community based assessments and alterations to soil microbial processes. Information on the response and sensitivity of Antarctic biota is being used as the basis of site-specific Environmental Risk Assessments, and to derive Remediation Targets for site restoration and soil re-use for Antarctic and subantarctic regions. A summary of this work to date and how it is used in environmental decision making to inform policy and to direct operations at Australia's Antarctic stations will be presented using examples of research conducted on fuels, metals, operational chemicals and complex effluent discharges.

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Measurements matter – assessing the risk of metal contaminants in the Antarctic terrestrial environment

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Anthropogenic impact to the Antarctic environment is concentrated to ice-free coastal environments where the majority of research stations are built. These sites also act as oases for terrestrial Antarctic biodiversity because their summer temperature and the availability of substrate and water allow for the growth of endemic mosses and lichens, and colonisation of microinvertebrates. Contaminants including lead and copper can cause toxicity to Antarctic organisms. However, the bioavailability of metals is controlled by environmental factors including soil pH, organic content, redox conditions, and mineral adsorbents. Therefore, measuring metal concentrations in soils using strong extractants (e.g. concentrated acids) without accounting for environmental factors, may lead to an overestimation of risk. Diffusive gradients in thin-films (DGT) are one method of chemical sampling that accounts for local environmental chemistry by only measuring labile metal concentrations.

This study describes a field trial deploying DGTs near Casey and Wilkes stations. The presence of contamination did not inherently reflect the risk to organisms, based on comparisons with Australian and New Zealand Government (ANZG) Environmental Quality Standards. For example, soils at one site had acid-extractable concentrations of copper and lead above ANZG standards (65 and 50 mg/kg, respectively), but DGT-labile copper concentrations of 9.9 ± 0.4 μg/L and DGT-labile lead concentrations below detection limits. Other sites had low acid-extractable metal concentrations but higher DGT-labile concentrations that are known to cause toxicity to the Antarctic nematode P. murrayi. These results and the implications of using different chemical measurement techniques to assess metal contaminants risk in Antarctica are discussed.

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Eggshells identify drivers of heavy metal exposure in penguins around the Antarctic Peninsula

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The Antarctic is a remote region of increasing interest as impacts from climate change and anthropogenic influence continue to grow. Previous studies of penguin tissue suggest that heavy metal concentrations are significantly higher for penguins in colonies visited by humans than those in more remote colonies, and that this contamination may cause genotoxic mutation through erythrocytic nuclear abnormalities. Eggshells have not previously been used to study a wide spread of trace metal exposure in Antarctic penguins, but are of interest for this purpose as they indicate exposure by reproductive female adults prior to breeding. Eggshell remnants from Adélie, Gentoo, and Chinstrap penguins were collected at 24 breeding colonies around the Antarctic Peninsula during the 2006/2007 austral summer. Trace metal analysis of 28 different essential and non-essential trace metals was performed, as well as stable isotope analysis (δ15N and δ13C). Results were compared by species, region, level of tourist visitation, and proximity to scientific base in order to delineate drivers of variation. Difference in species has the greatest effect on varying trace metal exposure, followed by visitation level, region and least of all, proximity to scientific base. Comparison to eggshell stable isotope values supports differences in species exposure as related to differences in trophic level. Presence of non-essential metal As was ubiquitous among samples suggesting ecosystem contamination, but Cu and Pb were widely undetectable. These results provide a framework for further study of foraging level and pollutant exposure of reproductive Antarctic penguins through easy and noninvasive methods.

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Antarctic microbes mediating mercury transformation in aquatic ecosystems

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Excess methylmercury has the feature, in addition to its high toxicity for living organisms, to be easily incorporated, bioaccumulated and biomagnified through the food web in aquatic systems. Recently, the microorganisms implicated in the transformation of mercury to methylmercury have been found much more diverse than previously thought. Antarctic regions receive atmospheric mercury through long-range transport of foreign emissions. In a context of increasing releases of heavy metals in aquatic environments and atmosphere, it is a crucial objective to elucidate the fate of mercury in Antarctic aquatic ecosystems and the role Archaea could play in mercury transformations. Hence, microbial diversity was investigated in pristine Antarctic lakes (South Shetland Islands, Antarctic, Chile) where benthic total mercury concentration was around 14 ppm. Up to 6.3% of the active community is constituted by putative methylators and a positive significant correlation was found between total mercury concentration and putative methylator relative abundance. Putative methylator Archaea Methanoregula and Methanosphaerula have been detected but did not seem active in the studied ecosystems (RNA metabarcoding VS DNA metabarcoding). By combining molecular data and a novel approach adding enriched stables isotopes of inorganic mercury and methylmercury, mercury methylation was found to overcome methylmercury demethylation activity. Metagenomic data will allow to better decipher the mercury cycle in Antarctic lakes. This investigation represents the first attempt to disclose the implication of microorganisms in the cycle and bioavailability of mercury in Antarctic aquatic systems, in which methylation appears to be the trend.

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Adelie penguins as indicators of Antarctic marine plastic pollution? Presence of phthalates in preen oil confirms anthropogenic inputs.

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Reports of marine debris and plastic contamination within Antarctic marine ecosystems are increasing in frequency and severity. Therefore, a tool for quantifying the chemical footprint of plastic-derived contaminants such as phthalates is cruical for developing and monitoring mitigation strategies. Adélie penguins (Pygoscelis adeliae) are most likely to reflect local inputs within the Antarctic and Southern Ocean as they remain south of 60oS during winter and have highly constrained foraging habitats. As such, baseline phthalate contamination in this species is likely to be an excellent bioindicator of the chemical footprint from plastic-derived contaminants to the Antarctic environment. Three common plasticizers (dimethyl phthalate (DMP), dibutyl phthalate (DBP) and bis(2-ethylhexyl)-phthalate (DEHP)) were measured in preen oil samples that were collected from live Adélie penguins (n=67) over two field seasons (2017/18 and 2018/19). Samples were taken from colonies around Australian research stations (Mawson, Davis and Casey) as well as remote locations. A robust GC-MS/MS (gas chromatography with tandem mass spectrometry) method with detection limits below current commercial analytical detection limits (ng/g wet weight) was developed to confirm the presence of phthalates and measure baseline contamination of these plasticizers to Antarctic fauna. Potential sources of plastics to the region, including research stations, were assessed by comparing the preen oil concentrations measured at different colony locations. These results provide valuable baseline information for future assessments of anthropogenic impacts of marine debris to the Antarctic environment and can be used to guide management actions to minimise future human impacts to this remote and minimally populated area.

1534

Establishing a baseline for POPs contamination within Antarctic marine ecosystems: using blood and preen oil samples from migratory and resident seabirds.

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There is little baseline information on persistent organic pollutants (POPs) within marine environments in Antarctica, adding to significant data gaps that exist within the Southern Hemisphere. We present baseline levels of legacy and emerging POPs using blood and preen oil from four migratory species breeding in East Antarctica (cape petrel, Antarctic petrel, southern fulmar, snow petrel (n=7 each)), compared to resident seabird species Adélie penguins (n=15). Levels of polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs) as well as newly-banned and emerging contaminants, brominated flame retardants (BFRs) were established using a robust GC-MS/MS (gas chromatography with tandem mass spectrometry) method with detection limits below those commercially available (ng/g wet weight). Contamination levels followed the pattern PCBs>OCPs>BFRs, comparable to the few reports available on Southern Hemisphere species. Exposure sources in both penguins and migratory species are mainly from long-range atmospheric transport (LRAT), yet proximity to research stations may influence exposure. While levels remain at trace concentrations, higher exposure in migratory species overall is likely related to their foraging ecology and winter migratory distances. Results from this study are the first report of POPs in seabirds local to the East Antarctic and establish seabirds as a reliable bioindicator for POPs over temporal and spatial scales within the Southern Hemisphere.

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Mercury contamination in soil caused by the human activities in Antarctica

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In order to clarify the impact of human activity to the environment in Antarctica, we analyzed the mercury concentration in surface soils around Syowa station, Skarvsnes hut and Langhovde hut. Soil samples were collected by systematic and grid sampling method (100 to 200 m) around each site in 2007. Surface soil samples were obtained which passed through 500 µm sieve and mercury concentration were directory determined by CVAAS method. The mercury concentration in soil samples fluctuates from 0.2 to 13 µg/kg, and these values were lower than the average mercury content in the Earth crust (approximately 50 µg/kg). The reason of these low mercury concentration in soil was assumed that the most of surface soil around Syowa station was decomposed granite, known as the low in mercury rock than the others. The high concentration of mercury in soil samples were observed near the station buildings. Our result indicates that the human activity in the Syowa station area may cause the environmental contamination in Antarctica.

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Quantifying bioaccumulation and biomagnification in epibenthic megafauna at McMurdo Station

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Although it is known that historic contamination of marine sediments adjacent to some Antarctic research stations (e.g., McMurdo and Casey Stations) has caused changes to marine macrofaunal communities, bioaccumulation of contaminants into epibenthic megafauna communities is relatively unknown. In this study, the concentrations of several contaminants (polycyclic aromatic hydrocarbons, PCBs, DDT, metals) were determined in 10 epibenthic megafauna species collected from two areas of intense sediment contamination and two control areas adjacent to McMurdo Station, Antarctica. McMurdo Station is an ideal location for determining the accumulation of contaminants in organisms' tissues because parts of the adjacent sea floor are considered some of the most contaminated in Antarctica. Megafauna taxa collected were generally >10 cm long and include sea stars, a sea urchin, a sea anemone, nemerteans, a bivalve, and fishes. Contaminant concentrations in the species' tissues were compared with concentrations in the sediment to infer bioaccumulation rates for sediment grazers and biomagnification rates for higher trophic levels.

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Quantifying Microplastic Contamination in the Terrestrial Environment of Signy Island, Antarctica

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Plastic pollution poses a substantial and growing environmental problem. With detrimental impacts to humans, wildlife and national economies, the ubiquity, longevity and minute size of micro- and nanoplastic particles are especially concerning. Increasingly, plastics are being detected in the most remote locations on Earth, from the bottom of the Pacific Ocean to continental Antarctica. The source of this contamination and the transport mechanisms are still unclear, however. In order to develop effective mitigation strategies, quantification of the spatial and temporal variability of environmental plastics is required. As the majority of plastic waste originates on land, investigation into the terrestrial aspect of these source-to-sink pathways is particularly relevant.

In this project, pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) techniques will be developed and implemented to qualify and quantify micro- and nanoplastic distributions in terrestrial soils and sediments. These new protocols will be utilised to probe plastic concentrations on Signy Island, Antarctica. How the BAS research station and the human presence are influencing the levels of plastic shall be studied, both spatially and temporally. Long-range transport will also be investigated through analysis of sediments from beaches and deposition zones around the island. Additionally, comparisons with the long-running beach litter survey on Signy will aid in the determination of sources and transport pathways. The resulting dataset will help further our remediation efforts, with potential policy implications.

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The Toxicity of Cu, Cd, and Pb to the Antarctic Terrestrial Nematode, Plectus murrayi

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Ice free areas make up <1% of the total land area of the Antarctic continent and are generally in coastal areas. These ice free areas are hotspots for terrestrial biodiversity and are also popular locations for scientific research facilities. As such, they are subject to human impacts, particularly soil contamination. Environmental Quality Guidelines are used to regulate soil assessment and remediation, however, Antarctic specific guidelines are currently lacking due to the limited number of test organisms and standardised toxicity tests available. This study aims to add to the limited database of terrestrial toxicity data available for metals, using established toxicity test methods for the Antarctic terrestrial nematode Plectus murrayi. Clean soils collected from Casey station (East Antarctica) were used to create porewaters, which were spiked with the metals copper, cadmium and lead, both individually and in mixtures, to make concentration series. Immobility of juvenile nematodes was assessed as a proxy for death for up to 21 days exposure. Survival decreased with increasing concentrations of copper, cadmium, and lead. Differences in toxicity were observed between the three metals, with dissolved metal concentrations of ≥63, ≥121, ≥124 µg/L causing a significant ($p<0.05$) decrease in survival relative to controls, for copper, cadmium, and lead, respectively. The 50% lethal concentrations with 95% CIs were estimated at 181 (115 – 252), 747 (471 – 1028), 1063 (634 – 1634) µg/L, for copper, cadmium, and lead, respectively. Critical effect concentrations for metals for P.murrayi will be used in the development of Antarctic specific Environmental Quality Guidelines.

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Gear loss by longline fishing vessels in the CAMLR Convention Area

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Monitoring the incidence of marine debris is important to understand trends and distribution of human impact in the Southern Ocean. In order to quantify the contribution of fishing activities on rates of debris accumulation it is beneficial to record marine debris directly from the source. Given the difficulty in determining whether terrestrially observed marine debris originates from fishing activities, monitoring gear loss rates reported by fishing vessels contributes significantly to the CCAMLR marine debris program. Lost gear has been routinely reported for every haul in CCAMLR longline fisheries catch data since 2007 and, this reporting also includes the location of each haul and so allowed the spatial distribution of lost gear to be accurately mapped. These data can be used in spatial analyses to assess the relative rates of gear loss as a function of gear type and area of operation; in particular whether there are certain areas and/conditions that are associated with elevated levels of gear loss. Monitoring and analysis of trends in fisheries -derived marine debris will increase understanding of the potential impacts such gear loss may have on the marine environment.

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Microplastic in sea ice from the rapidly warming Western Antarctic Peninsula

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Whilst the polar regions were previously thought of as pristine, we now know plastic pollution is ubiquitous, reaching both Arctic and Antarctic waters. Arctic sea ice can contain plastic particulates at levels orders of magnitudes higher than some of the most polluted regions across the globe, due to the ability of sea ice to scavenge plastic particulates, and act as a sink for plastic debris. In the Southern Ocean surrounding Antarctica, plastic has been found through the water column, in sediment and in an array of marine biota. Here, for the first time, we explore the presence of microplastic in sea ice cores collected from the Bellingshausen Sea, western Antarctic Peninsula (WAP). Microplastic fragments are identified via focal plane array FTIR analysis and characterised in terms of type, abundance and size, with fibres analysed separately. Our study adds new insight to the distribution and fate of microplastic in a region of rapid warming and decreasing sea ice extent and duration. We present results to date of this ongoing study and discuss the risks of retreating sea ice releasing scavenged microplastics to ice-reliant biota such as the keystone species of Antarctic krill, of which the WAP supports large populations.

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Anthropogenic radioisotopes (90Sr and 137Cs) in Antarctic fauna and flora

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90Sr and 137Cs are two most important anthropogenic radionuclides, which half-life is about 30 years. The main source of this isotopes were fallouts from atmospheric nuclear weapons testing in the 1950s and 1960s. Although the Antarctic is considered a pristine area, this part of globe has been also contaminated. Total input of these radionuclides was estimated as about 1% of the total emissions into the environment. Despite the fact that almost 60 years have passed since their main source, the activity of these isotopes is still measurable in the Antarctic. In order to explain this phenomenon a study was performed at King George Island in 2018. The sampling stations were located in the close vicinity of glaciers and farther away from them, beyond their direct impact. The average activity of 90Sr in water was 0.2 Bq m-3 and 0.34 Bq m-3 for 137Cs. Activity of 137Cs in sediment in Admiralty Bay was about 1 Bq kg-1, except in places close to glaciers (14 Bq kg-1). Similar trend occurred in case of soil where activity of 137Cs ranged from 0.7 to 9.4 Bq kq-1. The highest were always near the glacier. Average activity of 137Cs in plants was abour 3.4 Bq kg-1 and were similar to activity of samples collected in this area 16 years earlier. This analyses suggests that glaciers are secondary source of these isotopes, which may disrupt their transformation in the environment.

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Bioaccumulation of mercury in the first chains of Antarctic marine coastal food web (Admiralty Bay)

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Recent studies have found that the Antarctic is a sink for mercury (Hg). Atmospheric mercury depletion events stimulate Hg deposition and its incorporation in the marine food web. This metal can also be sequestrate in the snowpack along all Antarctica. Therefore, this region should be considered as a giant cold trap of mercury. The ice sheet in West Antarctica is now in a state of dynamical imbalance and the rate of ice loss is five times greater than was thought. Therefore melting ice sheet and glaciers should be considered as an important secondary mercury source for the Antarctic, which can result in an increase of Hg concentration in marine biota. The aim of the research was to identify methylmercury (MeHg) sources in Antarctica and determine their potential for accumulation in the marine trophic chain. Sampling was conducted in the Admiralty Bay in December 2018. As part of the research marine samples (water, suspended particulate matter, phyto- and zooplankton) were collected. Total mercury, methylmercury and labile Hg concentration were determined in the samples.

Mean MeHg concentration in Admiralty Bay was 15 pg/L, the highest values were measured in the vicinity of melting glaciers. MeHg in water occurred mainly in dissolved form (>70%), thus promoting the accumulation of Hg for plankton. Higher values of MeHg concentration were measured in phytoplankton (mean 204 pg/L) than in zooplankton (mean 143 pg/L). Different factors influence the accumulation of MeHg in both groups of plankton.

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Comparative analysis of mercury presence and distribution in soils within two ice-free areas of the northern Antarctic Peninsula region

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Mercury (Hg) can reach the environment through natural and human-related sources, threatening ecosystems world-wide due to its well known harmful effects. Relatively pristine terrestrial ecosystems in ice-free areas of the northern Antarctic Peninsula region are not exempt of its influence. The cold maritime climate with frequent freeze–thaw cycles in summer, parent material, geomorphological context and biological influence are important factors affecting the soil processes and development in this region. The objective of this work is to study the distribution of total Hg content in soil profiles of Fildes Peninsula (King George Island, South Shetland Islands) and Punta Cierva (Antarctic Peninsula). Samples were obtained during two field expeditions, physical and chemical analyses were carried out for the different soil horizons and multivariate factorial analysis and non-parametric tests were applied. Results show that there were no significant differences in Hg content in the upper layer of soils between both areas. However, there were significant differences in deeper horizons for soils at Punta Cierva which were related to abiotic and biotic factors influenced by periglacial processes. A strong relationship between Hg concentration and distribution existed when organic matter and certain clay minerals such as smectite content increased and binds Hg within the corresponding soil horizons. Determining Hg content in soils from remote areas such as the northern Antarctic Peninsula region provides knowledge on Hg behaviour as a global pollutant and is an important issue in the Minamata Convention on Mercury to predict potential (re)emissions or retention under a climate change scenario.

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Metal pollution and remediation at Casey Station, Antarctica – two decades of chasing heavy metals from soil through water to marine sediment

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The cleanup of the Thala Valley legacy landfill by the Australian Antarctic Division in 2003/04 represented the first large scale remediation of a contaminated site in the Australian Antarctic Territory and to date, the only one where 'heavy metals' such as Cu, Pb, and Zn have been the major environmental culprits.
Prior to this 'dig and haul' operation, much effort was devoted to measuring contamination at the landfill and in marine sediment adjacent to the site and demonstrating the impacts of pollutants on the near-shore benthic ecosystem. Chemical and biological monitoring of the benthic environment has continued in the ensuing years to evaluate changes following removal of the contaminant source.
Concurrent with monitoring, research was undertaken into ways to mitigate the risk posed by terrestrial metal contamination by in situ chemical fixation of contaminated soil using phosphate and silica treatments, and management of meltwater with permeable reactive barriers.
The way we tackle current and future metal contaminated sites in Antarctica, e.g. the abandoned station at Wilkes, Mawson Station, and other potential sites linked to future station and infrastructure upgrades, will be guided by the Thala Valley experience and the overall strategy evolved during this project.
This paper will overview the site assessment performed before and during the landfill cleanup, the marine environmental monitoring program, and metal remediation research, highlighting what we have learned and has (or hasn't) worked well, and identifying some of the improvements, innovations and advances necessary to meet future challenges in Antarctica.

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The environmental impacts of sewage outfalls in coastal Antarctica: a case study from Davis station, East Antarctica

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An environmental impact assessment of the Davis Station sewage outfall was done to provide information to upgrade wastewater treatment facilities. The aims were: 1) Determine the properties of wastewater; 2) Assess the hydrodynamic characteristics of the marine environment; 3) Describe the nature and extent of impacts. Wastewater was high in BOD, nutrients, solids and contaminants. Levels of faecal indicator bacteria were double that of typical domestic sewage. Wastewater was lethal to local marine invertebrates at dilutions as low as 3%. Thirty sites were surveyed for sediment chemistry, sewage biomarkers, and micro and macrobiological impacts. Hydrodynamic analysis indicated that wastewater was generally dispersed in a narrow plume along the coast in the direction of the prevailing winds with some retention around the outfall. Faecal bacteria and contaminants were detected in sediments up to 1.5 km from the outfall. Dispersal rates were insufficient to prevent accumulation of contaminants in local habitats. Histopathological deformities were observed in fish, consistent with exposure to wastewater contaminants. There was evidence of impacts on macrobiological communities, and uptake of sewage into the food chain. Genes for anti-biotic resistance have been introduced into the marine environment in non-native bacteria, seawater, sediment and found in a filter feeding mollusc. Following from this study the Australian Antarctic Division is installing new facilities at Davis and other stations which will treat wastewater to the highest standards. The minimum requirements of the Madrid Protocol are insufficient to prevent environmental degradation and this situation is likely to be common at Antarctic coastal stations.

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Textile fibers in Southern Ocean ecosystems: a new contaminant of emerging concern?

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Textile fibres are ubiquitous contaminants. Their widespread occurrence has been commonly reported in plastic pollution studies, with the misleading belief that they largely derive from wear and tear of synthetic fabrics. As of today, however, an extensive characterization of their composition has never been performed. We present the results of a circumpolar survey performed in 2016/17 during the Antarctic Circumnavigation Expedition. Fibres were found in all water samples collected (n=263) with a median concentration of 1.2 fibres·l^{-1}. Higher concentrations were found at latitudes >60°S (1.27 fibres·l^{-1}) if compared to samples collected between 40°-60°S (1.09 fibres·l^{-1}). A sub-sample of 910 fibres were analyzed to determine their polymeric composition. µFTIR revealed that 90.4% were natural fibres of animal or plant origin. Most were cellulosic (75.9%) or wool fibres (14.5%), while only 9.6% where synthetic. The relative proportion of synthetic fibres also noticeably increased at latitudes >60°S (12.6% vs 8.6%). In addition, the presence of microfibres was also examined in 47 King Penguins fecal samples collected during the same survey in South Georgia. Microfibres were found in 77% of the samples with most fibres (88%) being of natural origin (e.g. cotton, wool) and with faeces of incubating penguins being twice as contaminated as samples from chick-rearing birds. Besides emphasizing the need for full chemical identification of these particles before classifying them as microplastics, our results demonstrate the widespread occurrence of natural and synthetic fibres in the Southern Ocean, a widespread contamination whose implications for Antarctic ecosystems are still completely unknown.

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Modulation of the freshwater diatom community structure by pollution and different climate characteristics (Antarctic vs temperate climate)

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The diatoms have a ubiquitous presence in oceans, lakes, freshwater streams and soil and they are responsible for up to 50% oxygen production. Moreover, the diatoms are a good indicator of the water quality, being very sensitive to pollution and climate changes.
In this study, we analysed the diatoms communities from East Antarctica (Larsemann Hills- 69°23'S 76°22'E- freshwater streams) and Romanian (Fagarasi Mountains - 45°36'N 24°37'E - Balea and Capra glacial lakes). The temperature changes from Antarctic environmental conditions to temperate climate conditions mimics the global warming and they could be extrapolated to predict the environmental effects of the global warming.
SEM analysed diatoms from Antarctic and Romanian locations showed differences in density and type of populations which were linked to the pollution (especially with metals) and overall environmental temperature. The diatoms population diversity and density from Romanian glacial lakes was higher compared to Antarctic freshwater streams which corroborated to a higher temperature and metal environmental pollution.
Diatoms species Achnanthes, Planothidium, Navicula, Pinnularia were common populations in Antarctic freshwater streams and Romanian glacial lakes, but Achnanthes and Pinnualaria were more abundant in glacial lakes. Diatom species Psammothidium, Luticola, Craspedostauros, Diadesmis were present only in the Antarctica, but Fragilaria, Hantzschia and Amphora were found only in Romanian glacial lakes. The specific presence of some diatoms in a particular location only could suggest an adaptation mechanism of diatoms to temperature change and metal pollution.
This research is a tribute to Teodor Gheorghe Negoita, the Romanian leader of Antarctic Station Law-Racovita during 2005-2011.

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Obtaining insight in atmospheric trace organic compound concentrations and trends in Dronning Maud Land, East Antarctica by means of long term passive and active air sampling.

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Antarctica's atmosphere is often regarded as pristine, however emissions from other continents in the southern hemisphere impact the air on Antarctica. Transport, chemical transformations and deposition are are poorly constrained in this region. Since the Austral summer of 2017 the air in Dronning Maud Land, near the Belgian research base Princess Elisabeth Station, is sampled by means of high volume sampling (HVS) where aerosol associated and gas phase compounds are collected separately. Additionally on 7 sites stretching 250km from the Antarctic plateau edge (2350m a.s.l.) to the King Baudouin Ice Shelf by the Southern Ocean, temporary sampling stations were installed. These consist of passive PUF-type samplers (Tisch, USA) for semi-volatile organic compounds and a protective shelter containing Tenax TA sorbent tubes (Markes, UK) collecting volatile organic compounds (VOC's). By exposing both for a year, a time integrated sample is obtained. With mass spectrometric analysis 70 volatile organic compounds and 16 EPA PAH's were detected on the different locations. The largest number of detected VOC's can be related with the atmospheric oxidation of aromatic components whereas primary pollutant levels are a factor 10^2-10^3 lower. This indicates the importance of the influx of foreign organic compounds which are transformed during atmospheric transport. The generated results will be combined with isotopic data gained from snow sampling on each of the 7 locations, time resolved aerosol count and properties, and back trajectory (FLEXPART) modeling to determine possible source regions of organic chemicals in East-Antarctica as well as defining atmospheric transport and transformation mechanisms.

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Polychlorinated Biphenyl Fingerprint in Clams and Fishes Winter from Quarters Bay, Antarctica

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A surprise discovery in the 1980's documented contamination of marine sediments in Winter Quarts Bay, McMurdo Station with polychlorinated biphenyls (PCB) which can exist as 209 individual congeners. The PCB fingerprint reported match Aroclor 1260, a product that was used in transformers, hydraulic fluids, fiberglass, fire retardant varnish and de-dusting agents. Study to documents bioavailability of these PCB to 10 epibenthic megafauna species were undertaken. As an expantion of this study the fingerprint of PCB in bivalve clams and fishes was used to determine the extent of bio-magnified and de-chlorination. Bivalves (e.g. clams) are used to document contamination at a specific site as they are not motile and are low in the food web. In contrast fish are motile and at the apex of the food web. By looking at the fingerprint of these congeners in sediments compared to clams and fish changes over time with the source were determined. As expected both clams and fish bio-accumulate PCB with fish exhibiting higher concentrations. Fingerprinting of the PCB in the clams and fish both document that dechlorination as reported for some temperate sediments is not occurring and that 30 years after PCB were discovered in Winter Quarters Bay they still can be attributed to Aroclor 1260.

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The Antarctic Peninsula- Canary in the Coal Mine?

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The northern Antarctic Peninsula (AP) is a hotspot for physical change around Antarctica. The stressors range from global issues (such as climate change mediated increased sea temperature, sea ice losses, ice shelf disintegration, glacier retreat, local freshening of surface waters and benthic disturbance due to ice scour) to increased anthropogenic activities (predominantly tourism, research and krill fishery). These combined stressors are having a significant impact on both the physical environment and biological communities. The AP experiences the highest human footfall anywhere in Antarctica and this is likely to increase further in the future. Our ability to detect change in the AP is typically greater than elsewhere (research station and vessel density) but monitoring is highly variable in timing and targets. This presentation aims to evaluate the key drivers of change in this area (marine and land based pollution from research and tourism, potential increase in krill fishery close to predator colonies, human interactions with marine wildlife and introductions and potentially introductions of non-native species) and assess the impacts of these predicted anthropogenic inputs on marine ecosystems. Interactions between stressors are likely to become very important, eg species at thermal limits are likely to be more vulnerable to other factors, such as direct human impacts. The data presented here forms part of the Local Drivers of Change chapter of the first Marine Ecosystem Assessment for the Southern Ocean (MEASO) and contributes to the SCAR Plastics Action Group impact assessment.

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Thirty years of marine debris in the Scotia Sea, Southern Ocean

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The incidence and impact of anthropogenic marine debris has been monitored at two sites in the Scotia Sea since the late 1980s. Between 1989 and 2019, 10,112 items of beached debris were recovered from Bird Island, South Georgia. Plastic was the most commonly collected material (97.5% by number; 89% by mass). At Signy Island, South Orkney Islands, debris items were recovered from three beaches (during the austral summer only) between 1991 and 2019. In total 1,304 items were collected, with plastic again the most commonly recovered material (84% by number; 80% by mass). The impact on wildlife has also been investigated with 1,397 Antarctic fur seals reported entangled in man-made debris since 1989. However, due in part to legislation to limit the use of plastic items, the number of entangled seals has reduced significantly since 1994. Plastic items have been found associated with seabirds at Bird Island, with Wandering and Grey-headed albatrosses the most likely to be affected. Current plastic loads seem unlikely to have an impact on birds and seals at the population level but our results nevertheless affirm that marine plastics are a major, trans-boundary animal-welfare and environmental issue. Our work highlights the prevalence of anthropogenic marine debris (particularly plastic) in the Southern Ocean and the importance of long-term monitoring efforts in cataloguing marine debris and identifying trends. It also demonstrates the urgent need for a wider understanding of the extent, scale and impact of marine debris across the entire Southern Ocean.

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Microplastics in Antarctic marine food web: evidence from penguins

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There is growing evidence that microplastic pollution (<5 mm in size) is virtually in all marine ecosystems, including in the Antarctic. Microplastics have been found in water and sediments of the Antarctic but little is known of their ingestion by higher predators. The goal of this study was to assess the occurrence of microplastics in a top predator, the gentoo penguin Pygoscelis papua, from the Antarctic region (Bird Island, South Georgia and Signy Island, South Orkney Islands) and hence evaluate the potential for microplastic transfer through Antarctic marine food webs. To achieve this, the presence of microplastics in scats (as a proof of ingestion) was investigated to assess the viability of a non-invasive approach for microplastic analyses in Antarctic penguins. A total of 80 penguin scats were collected and any microplastics they contained were extracted. A total of 20% of penguin scats from both islands contained microplastics, consisting mainly of fibers and fragments with different sizes and polymer composition (mean abundance of microplastics: 0.23 - 0.53 items individual−1 scat, comprising seven different polymers), which were lower values than those found for seabirds in other regions worldwide (Bessa et al. 2019 Sci. Rep.). No significant differences in microplastic numbers in penguin scats between the two regions were detected. These data highlight the need for further assessment of the levels of microplastics in this sensitive region of the planet, specifically studies on temporal trends and potential effects on penguins and other organisms in the Antarctic marine food web.

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Mercury pathways along the Southern Ocean food web: are they changing?

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Although Antarctica is seen as the remote and pristine continent, the levels of contaminants in the Southern Ocean have increased significantly. Mercury is one of the pollutants that is found in higher concentration than expected in the Southern Ocean waters. With this study, we aim to describe the mercury distribution along the Southern ocean food web and to evaluate if there are any variations on the mercury pathway to top predators over the last decade. To do so, we analysed sampled of several taxonomic groups from POM, crustacean, cephalopods fish and top predators, that were collected in two non-consecutive, 10 years apart, sampling years. This presentation will be focused in the path of mercury since it gets absorbed in the micro algae to the levels that it reaches in the long living top predators, using stable isotopes analyses as proxy for trophic level. We will also look into the ecological differences found between the two sampling years that would have an effect on mercury bioaccumulation pathway. Establishing the base levels of mercury in the Southern Ocean food web is crucial to better understand how this pollutant will may this fragile ecosystems.

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Microplastics in Chinstrap penguins from Antarctic Peninsula

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One of the anthropogenic pressures in the Antarctic region comes in the form of pollution, which can directly or indirectly impact the environment. Microplastics are poorly studied in the Antarctic despite being known that they can cause injuries, cumulative toxicity, increased mortality and decline in wild populations elsewhere in the World. Penguins, as they are widely spread around the Antarctic region, can be used as Antarctic bioindicators of microplastics in the marine food web. As microplastics may come via ingestion of prey, we assessed the diet of Chinstrap penguins from Antarctic Peninsula areas in breading colonies at Hannah Point and Rongé Island, analysing their scats, searching for prey and microplastics, following the methodologies developed by Bessa et al. (2019). Each scat was analysed to identify their prey (e.g. Antarctic krill), as potential source of microplastics, followed by the digestion of all the organic matter with KOH and then filtering. Beside that in every scat we analyse Antarctic Krill and measured carapace length of each one, in order to determine the diet of Chinstrap Penguins. The filters were looked under a microscope for microplastics. A total of 29 Chinstrap scats were analyzed, from which a total of 72% of scats contained potential microplastics, mainly fibers and fragments with different sizes. All potential microplastics will be analyzed (polymer identification) to confirm their synthetic origin. This work shows, for the first time, that potential microplastics is present in chinstrap penguins from Antarctic Peninsula, providing further evidence that microplastics are in Antarctic food chains.

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The ubiquitous spread of plastic pollution in the Antarctic Peninsula has already reached the Antarctic spiny plunderfish stomach

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Despite the evident spread of plastic in some marine ecosystems of Antarctic Peninsula, its ingestion has hitherto not been documented. Here, we present evidence of plastic items in stomach contents of the benthic fish Harpagifer antarcticus from Fildes bay (King George Island) and we perform an assessment of potential sources considering qualitative characteristics of plastics found. Our results indicated that of the 36 processed fish, 11% of them had ingested plastic items. Fiber form constituted 100% of the ingested plastic types, with sizes ranging between 1.6 to 150 mm and dull or shiny appearance in a wide spectrum of colors (i.e. blue, red, white, black). Polymer types inferred were: polyvinylchloride, polystyrene and polyethylene. These outcomes reveal a new pathway of plastic transfer through Antarctic benthic food web and confirm strong relationship between fibers and nearshore areas with high levels of human activities. Finally, our results alert us about the threats of plastic pollution related to anthropogenic land-based operations in the Antarctic, where actions of remediation are lacking.

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