EGU Display Material (unpublished data, please do not tweet or share)

Authors:
Jack Buckingham[1]
Supervised by:
Cath Waller[1], Claire Waluda[2], Clara Manno[2], Dan Parsons[1]

1- University of Hull, Energy and Environment Institute
2- British Antarctic Survey

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

Abstract:
"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), 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 evaluate 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."

How to cite: Buckingham, J., Waller, C., Waluda, C., and Manno, C.: Microplastic in marine, nearshore waters of South Georgia: a study of background environmental levels of

microplastic contamination, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-11667, https://doi.org/10.5194/egusphere-egu21-11667, 2021.

Session:
ITS2.5/OS4.8 – 'Global plastic contamination: a journey towards scientifically informed policies and solutions'

Materials & Methods

Survey sites: Thatcher Peninsula, East Cumberland Bay (CEB) and Rosita Harbour (ROS), South Georgia
Stratagem:

- Coastal seawater sampled at 1km intervals from King Edward Point (KEP) research station and offshore at CEB and ROS. Freshwater sampled from Gull Lake. Snow sample of precipitation taken. Wastewater sampled directly from outlet pipes at KEP and Grytviken (inhabited during sampling period). (Figure 1).
- 3x3L replicates taken at each site.
- Several environmental variables observed at each site in addition (Table 1).
- Samples filtered using 70um-pore size Whatmann GF filter papers and a vacuum pump (1L per paper).
- Visual inspection using an Olympus SZX10 microscope with an Olympus UC30 camera, 2.0 lens, 11x magnification.
- Suspected anthropogenic particles measured along maximum ferret length under microscope using CellSens software.
- Polymer analysis conducted using micro-FT-IR method. Thermo Fisher Scientific iN10 Nicolet machine with OMNIC Picta software. Standard resolution 4 cm-1, scanning between wavelengths of 800-6000 cm-1, twelve scans per particle. Reference libraries included *inter alia* Hummel Polymer Library, POLYMER, Hummel Sample Library as well as bespoke control library created.
- Matches of ≥40% considered positive.

Control methods:

- In the field:
- Single sampler
- Same clothes
- Downwind of sample
- Glass jars, washed with filtered MilliQ water (samples of same MilliQ water taken for control)
- Clothing fibres collected for contamination library

During sample preparation and analysis:

- Samples of plastic items in lab taken for contamination library
- Blanks of deionised (DI) water run before filtration and between samples during filtration process
- Filtration equipment all glass washed with MilliQ water
- All work done inside a fume cupboard (although not under laminar flow)
- Atmospheric controls placed out and regularly changed
- Nitrile gloves worn throughout, wetted with DI water

- All tools made of metal and acid washed and cleaned with DI water
- Surfaces wiped using 90% ethanol and blue paper roll then rinsed with DI water and allowed to air dry

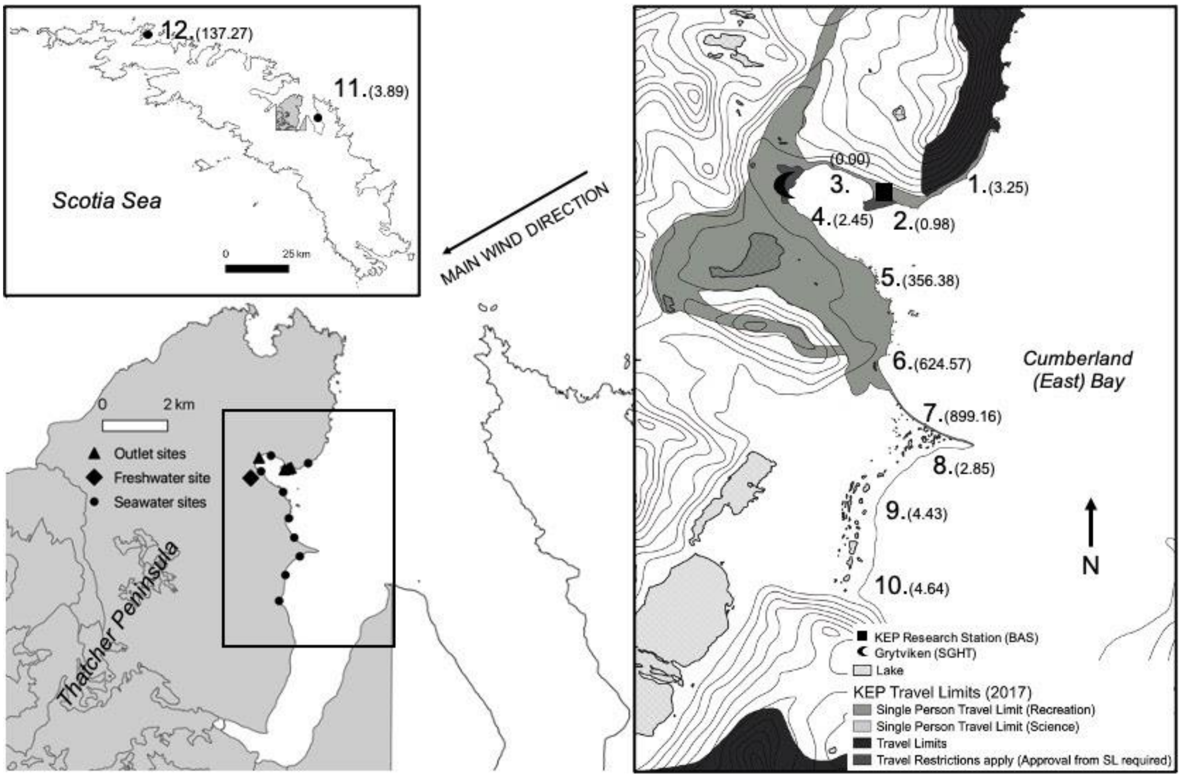

Figure 1. Study area and sampling points with predominant wind direction around the Thatcher Peninsula, South Georgia (small scale gradient), with specific British Antarctic Survey designated travel limits around KEP Station and Grytviken and the effective fetch (Lf) values in parentheses.

Table 1. Environmental descriptor variables for all sites where environmental samples were collected: grain size values from the phi scale logarithmically transferred from the Wentworth Scale; effective fetch, distance from various point sources and their relative position

Site	Grain size (φ)	Effective fetch (L_f)	Distance from KEP (km)	Distance from Grytviken (km)	Direction from nearest outlet
1. HS (*Hope Point – Sooty Bluff*)[a]	-1.6	0.98	0.03	1.08	SW
2. KEC1 (*King Edward Cove 1*)[a]	-2.7	0.00	0.65	0.37	E
3. KEC2 (*King Edward Cove 2*)[a]	-8	2.45	0.73	0.42	N
4. KEC3 (*King Edward Cove 3*)[a]	-1.1	356.28	0.71	1.28	N
5. KEC4 (*King Edward Cove 4*)[a]	-8	624.57	1.51	2.13	N
6. HH (*Horse Head*)[a]	2.3	899.16	2.11	2.73	N
7. PB (*Penguin Beach*)[a]	-5.4	2.85	3.32	4.00	N
8. ZR1 (*Zenker Ridge 1*)[a]	-2	4.43	3.93	4.65	N
9. ZR2 (*Zenker Ridge 2*)[a]	-2.7	4.64	4.59	5.38	N
10. OS (*Base of Mt. Osmic*)[a]	-4.4	3.25	0.64	1.65	SW
11. CEB (*Cumberland East Bay*)[a,b]	/	137.27	77.20	77.99	SE
12. ROS (*Rosita Harbour*)[a,b]	/	3.89	0.95	2.00	NW
13. GL (*Gull Lake*)[c]	-8	/	/	/	/

a = seawater sample; b = sample taken from a vessel, as opposed to from the shoreline; c = freshwater sample

Results

Microplastic concentrations in seawater from coastal and nearshore sites (n=12) around South Georgia ranged from 3.89 ± 7.81 - 0.56 ± 2.89 particles/L (mean ± SD). Of this, fragments constituted 52% and fibres 48% with the majority (39%) of particles in the size category ≥200µm. The concentration in plastics from wastewater coming from outflow pipes (n=3) ranges from 0.56 ± 1.15 - 1.44 ± 4.93 particles/L (mean ± SD), were evenly split (50%) between fragments and fibres and also predominantly (42%) in the ≥200µm size category. In freshwater from the Gull Lake site (n=1), the concentration was 1.11 ± 2.08 particles/L, predominantly (84%) fibres and also predominantly (67%) in the ≥200µm size category. In the single snow sample the concentration was 15.89 ± 23.71 particles/L (mean ± SD), the majority of which (89%) were fragments and 50-99µm in size.

There was no significant difference in microplastic concentration (particles/L) between sites (Kruskal-Wallis test, chi-squared = 0.92633, df = 2, p-value = 0.09878), between "habitats" (Kruskal-Wallis test, chi-squared = 1.4741, df = 2, p-value = 0.4785), between zones just within the marine environment (Kruskal-Wallis test, chi-squared = 0.85073, df = 2, p-value = 0.6535), or between "input" and "environmental" samples (Kruskal-Wallis test, chi-squared = 0.72878, df = 2, p-value = 0.6946). Nor was there any significant difference between any of these groupings when only microplastics made of positively buoyant materials were considered.
A Spearman's correlation was run to assess the relationship between the concentration of buoyant microplastic particles (n/L) present at a site and the shortest distance between said site and the nearest outflow point source. There was a negative correlation but the relationship was not statistically significant, r_s = -0.04434843, p = 0.8911; as was the correlation between the distance and the percent of the microplastics present that were buoyant, r_s = -0.3553058, p = 0.2571.

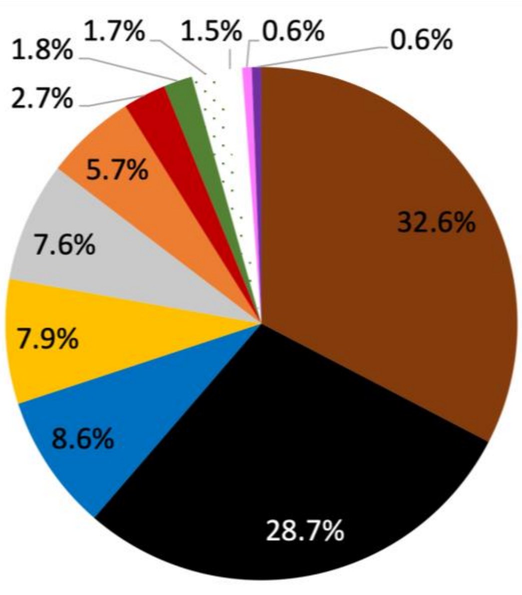

Figure 2. Colour breakdown (% of total) of microplastics across all samples from all "habitats" (seawater, wastewater and freshwater).

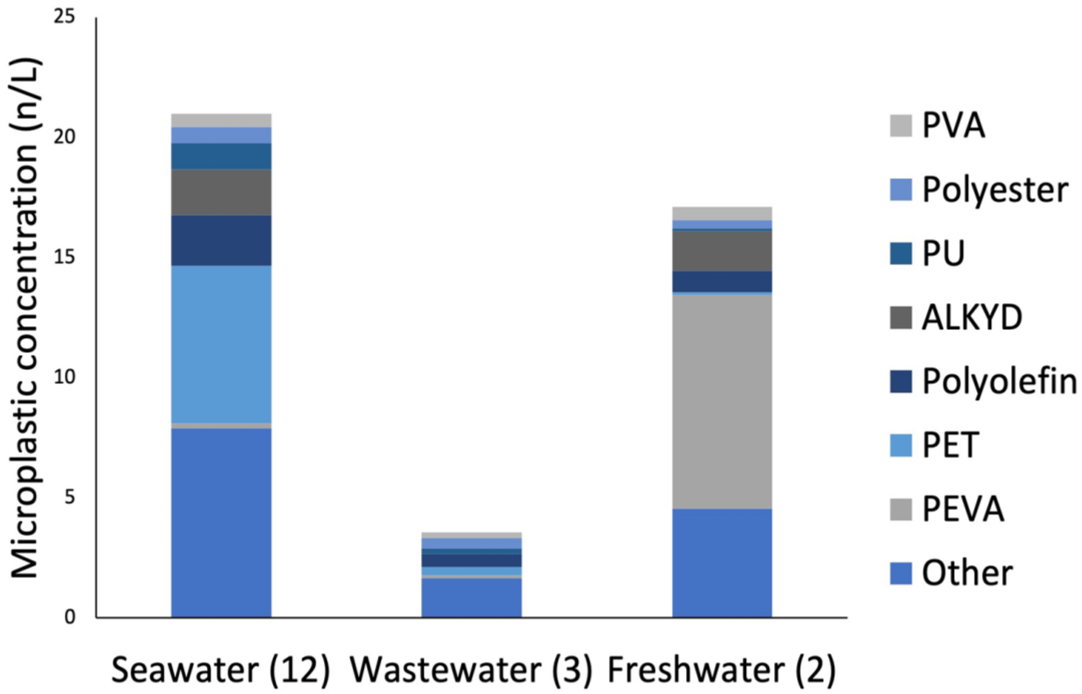

Figure 3. Concentration (n/L) of top five most common polymers observed across all samples from all "habitats" (seawater, wastewater and freshwater), with the number of samples taken from each habitat in parentheses.

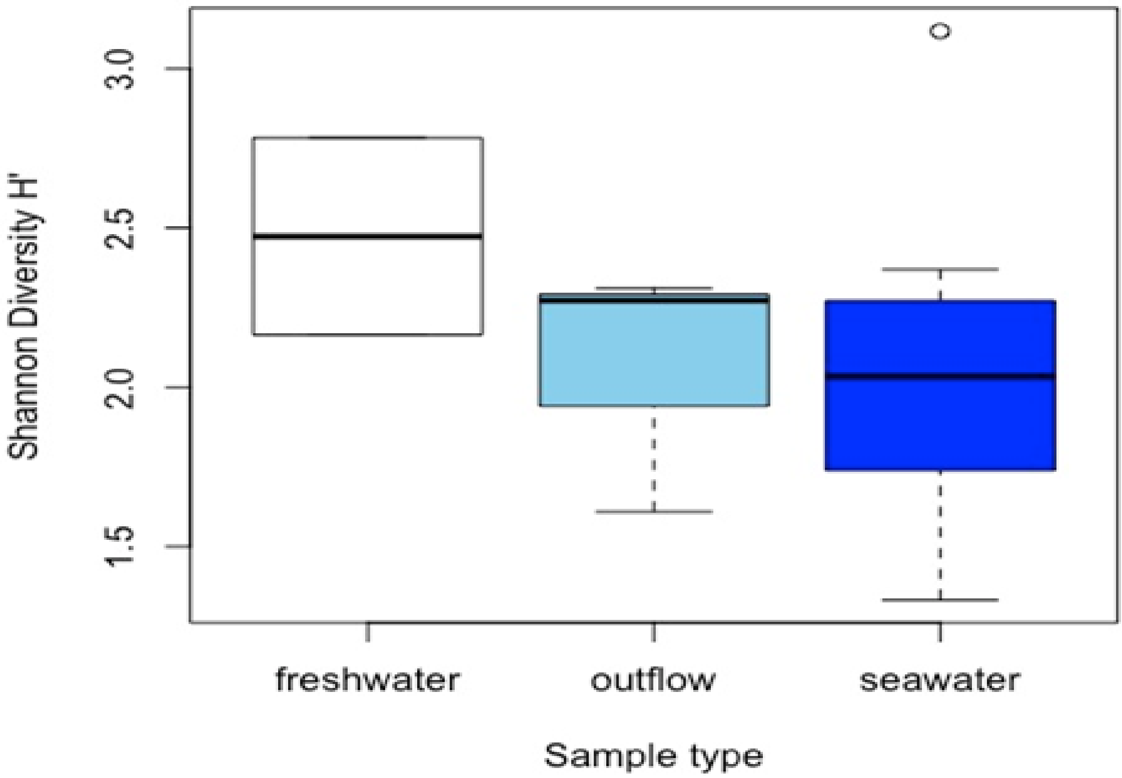

Figure 4. Boxplot Shannon-Wiener diversity of mps categorized by material, colour and type (fragment/fibre)

Multivariate analyses of microplastic assemblages revealed that profiling microplastics by material, colour and type best describes their distinct abundance over all “habitats”. When profiling the data by fewer categories (*i.e.* without colour and type), describing abundance across different vectors (i.e. zone or environmental vs input), or only utilising data for buoyant microplastics, the differences were less clear. Figure 5 shows that different habitats are statistically characterised by different polymer types, but that there is also a higher level of similarity in profiles across habitats than within habitats (ANOSIM, $p = 0.003$, $R = 0.43$). Pairwise comparison of the habitats shows that microplastic profiles in seawater and wastewater are statistically distinct, as are profiles in seawater and freshwater (in both cases, $p = 0.033$) but that profiles in freshwater and wastewater are not significantly different ($p = 0.3$).
Across the three habitats, when profiling microplastics by material, colour and type, dissimilarity is high, ranging from 92% between seawater and wastewater to 99% between freshwater and wastewater (SIMPER, 91.59% and 98.71% respectively)

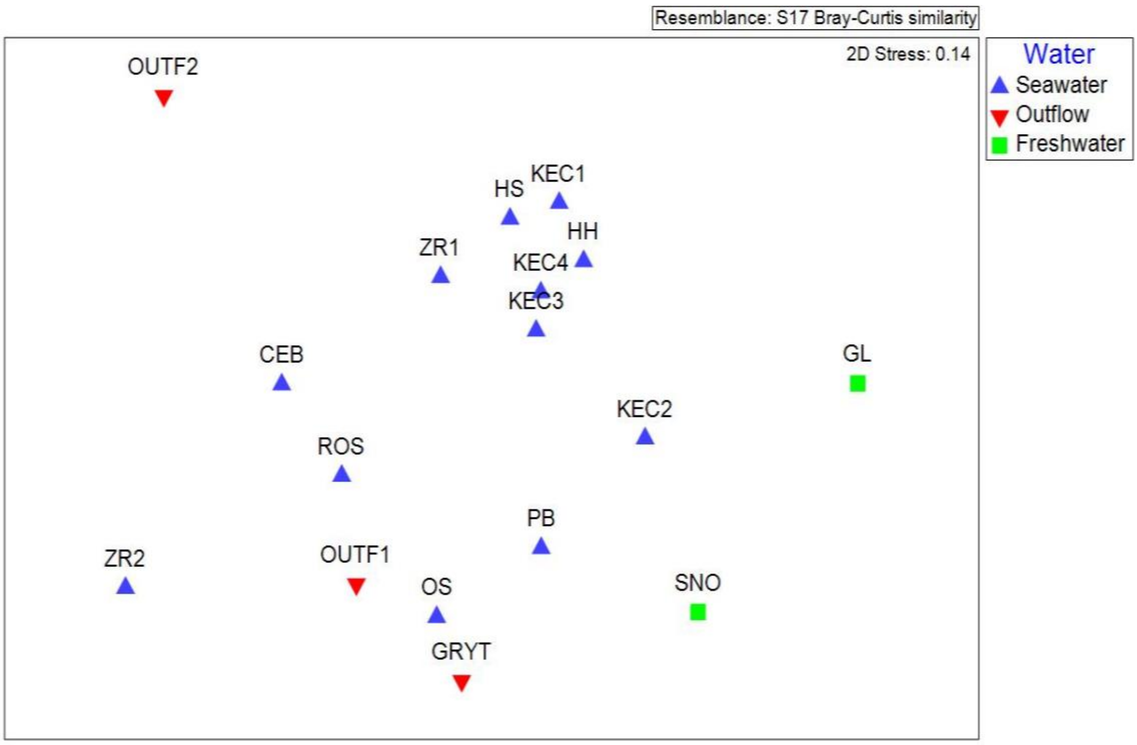

Figure 5. Non-metric multi-dimensional scaling (NMDS) of microplastic communities, within three geographically distinct “habitats” (seawater, wastewater and freshwater), when profiled by material colour and type (fragment/fibre).

Pairwise correlation analysis between the explanatory environmental variables (Fig. 6 black text) and the total and buoyant concentrations of plastics, fibres and non-fibres (Fig. 6 red text) revealed few significant relationships. There was significant positive correlation ($p<0.05$) between effective fetch and the concentration of fibres and fragments, when considered separately, and the concentration of buoyant fragments but no significant correlation between effective fetch and the total concentration of plastics (Figure 6).

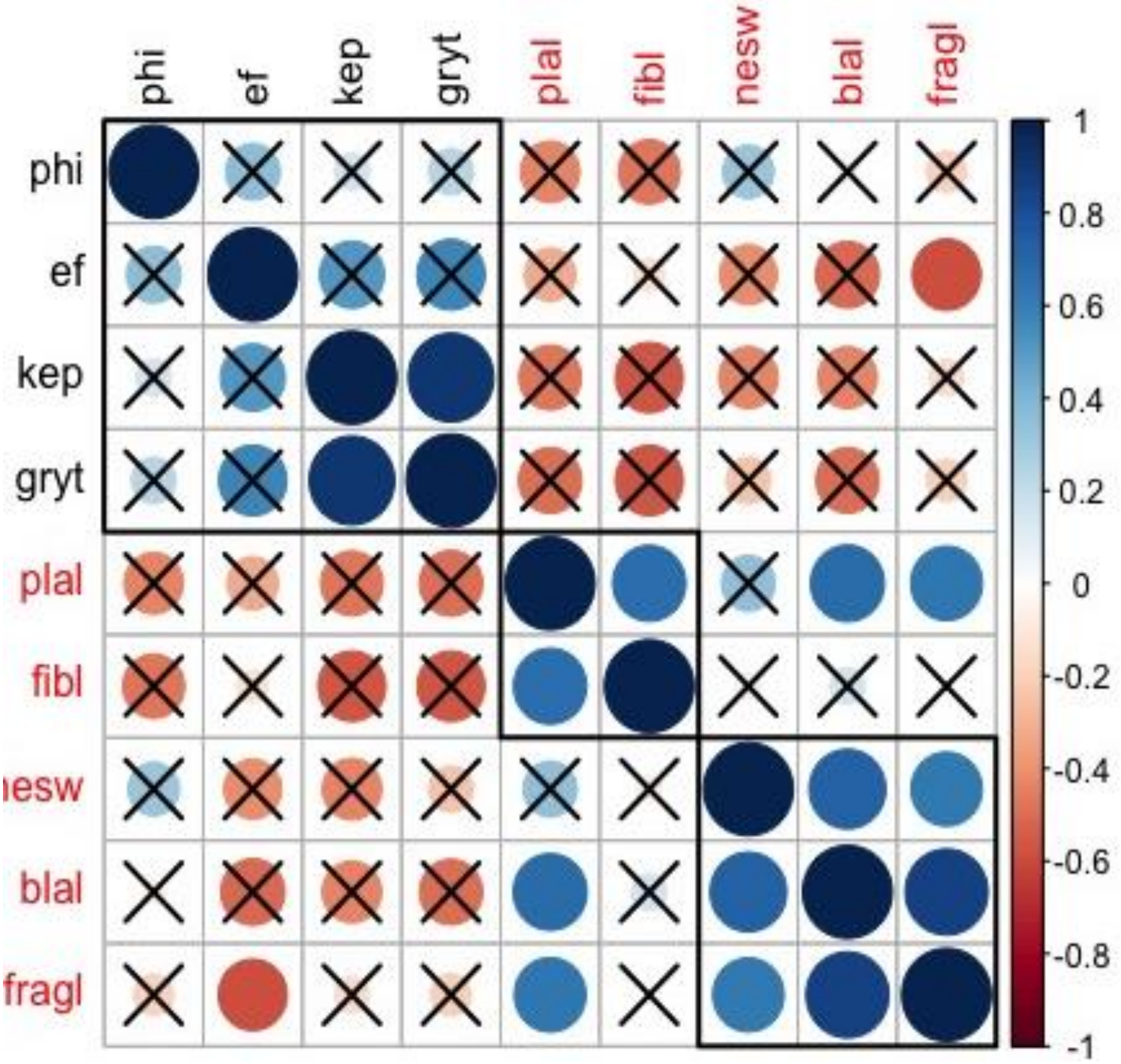

Figure 6. Pairwise correlation (Spearman rank coefficient; higher correlation= larger circle; blue=positive, red= negative correlation) between environmental variables (black text) and mp conc. (red text). “X” = non-significant ($p>0.05$) correlations. Frames group similar indices via an analytic hierarchy process.