Estimation of Plastic Debris Loads in Aquatic Ecosystems from Water Samples Using Hyperspectral Imaging - a Case Study for Teltow Channel, Berlin

Thomas Lanners [1,2], Mathias Bochow [2], Sascha Oswald [1]

1. INTRODUCTION

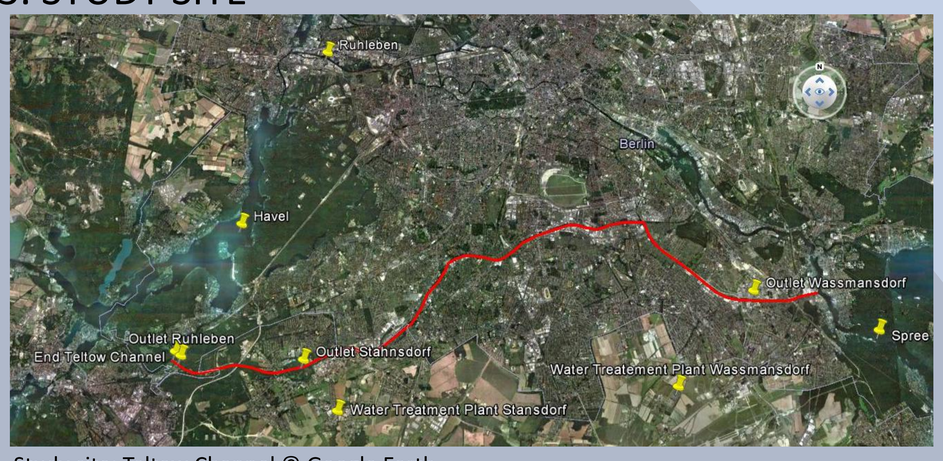
Plastic debris, as a common persistent pollutant, is accumulating in marine and coastal habitats worldwide, yet the quantification of sources and pathways for land-based plastic pollution remains uncertain. Densely populated urban areas have been shown to contribute significantly to land-based plastic pollution by draining plastic-polluted waters through river systems to the oceans (Moore et al., 2011). (Un-) Conscious littering by consumers, poor handling during polymer processing and non-existing wastewater treatment for small plastic particles from household wastewaters are only some examples why urban areas are predestinated for having a huge impact on adjacent aquatic ecosystems in regard to plastic pollution.

Up to now several studies have been carried out to show plastic debris accumulations near estuarine areas in the North Sea (e.g. Liebezeit & Dubaish, 2012). This study aims to trace back the pollution pathway to its source and uses the Teltow Channel as an ideally suited small-scale research area.

2. OBJECTIVES

- Development of laboratory methods for automated quantification and qualification of macro- and microplastics from filtered water samples using hyperspectral imaging sensor *HySpex*
- Estimation of plastic particle loads in the Teltow Channel by multitemporal sampling
- Estimation of microplastic influx from waste water treatment facilities Wassmannsdorf, Ruhleben and Stahnsdorf into Teltow Channel by sampling around outlet areas

3. STUDY SITE



Study site: Teltow Channel © Google Earth

The Teltow Channel stretches about 39 km through the south of Berlin and connects the rivers Spree (east) and Havel (west) flowing westwards. The channel is almost completely enclosed by concrete walls. Water treatment plants Wassmanssdorf and Stahnsdorf discharge about 270.000 m³/day, Ruhleben discharges from 01.04 - 30.09 into the Teltow Channel. Wassmannsdorf treats wastewater of more than 1.3 million citizens of Berlin.

4. SAMPLING & PREPARATION

Sampling starts April 2013 and will be conducted at different discharges , so it will be possible to see effects of precipitation events. Two plankton-handnets for the sides and one manta trawl for the middle of the channel with mesh sizes of less than 50 µm will be used for sampling. The flow velocity is measured simultaneously to estimate the sampled water volumes.

Next to the outlets of the listed water treatment plants, samples are taken 100 m eastwards of the outlet and 20 m westwards, so it will be possible to assess plastic particle load originating from insufficient sewage treatment.

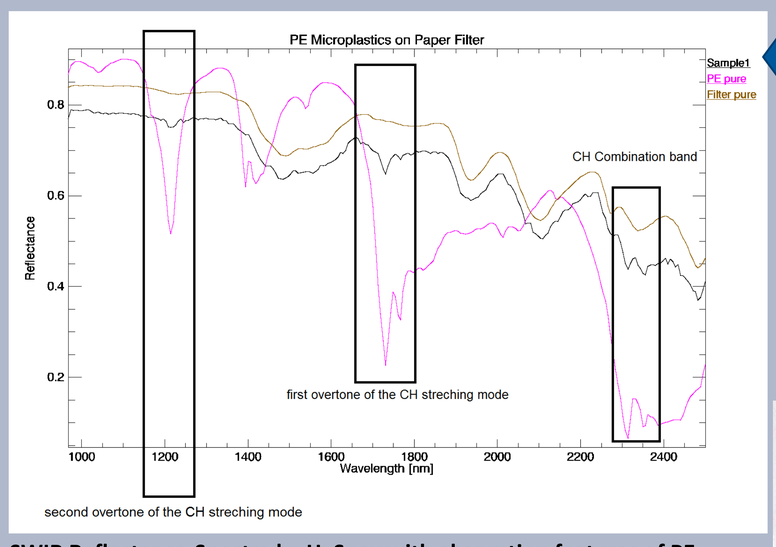
Samples will be prepared in the laboratories of GFZ Potsdam. After the elimination of organic matter we use sieves to physically separate different size classes (>2 mm, > 630 µm and < 630 µm and < 200 µm). This ensures that small particles are not covered by bigger particles since reflectance values are to be measured. The sieved fractions are filtered on paper filters with a pore size of 5 µm.

5. ANALYSIS

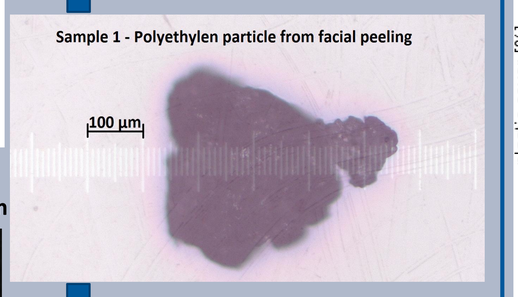
Plastic particles from filtered water samples are scanned while on the filter in the laboratory by using the hyperspectral imaging sensor *HySpex SWIR 320m-e (©Norsk Electro Optikk)*, which covers wavelengths from 1000-2500 nm of the electromagnetic spectrum. In short-wave infrared reflectance spectra (SWIR) the most-widely used polymers can be clearly identified, due to their specific molecular structures (Eisenreich & Rohe, 2006).

Spectral libraries with reference spectra for each polymer are used for image processing and automatization of processing operations will allow accurate, fast and cost efficient analysis of water samples. Using a 30 cm lens, the HySpex sensor can attain a spatial resolution of about 250 x 250 µm (= 62.500 µm²) per pixel.

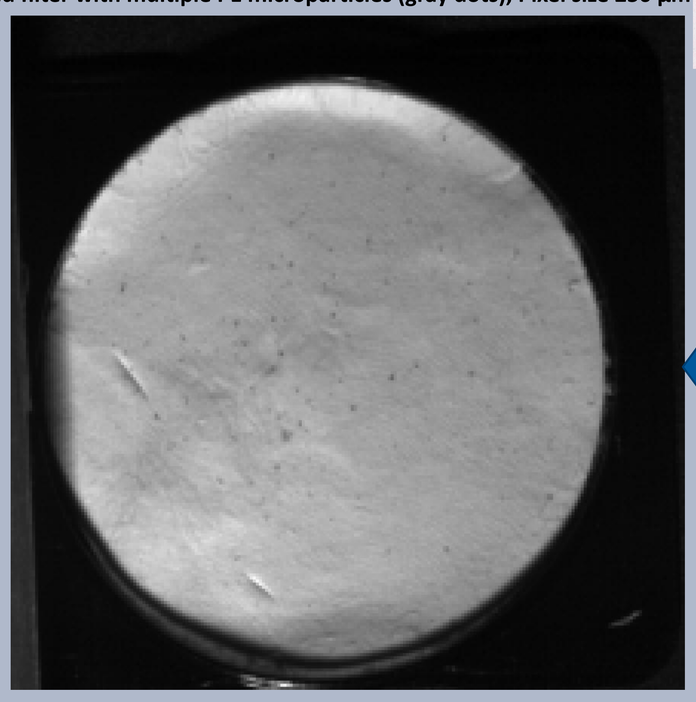
Latest studies of our research group plotted below indicate that 10% coverage or less of plastic per pixel could be sufficient for accurate spectral identification of a polymer. This would allow to qualify particles with less then 100 µm in diameter with the HySpex sensor.

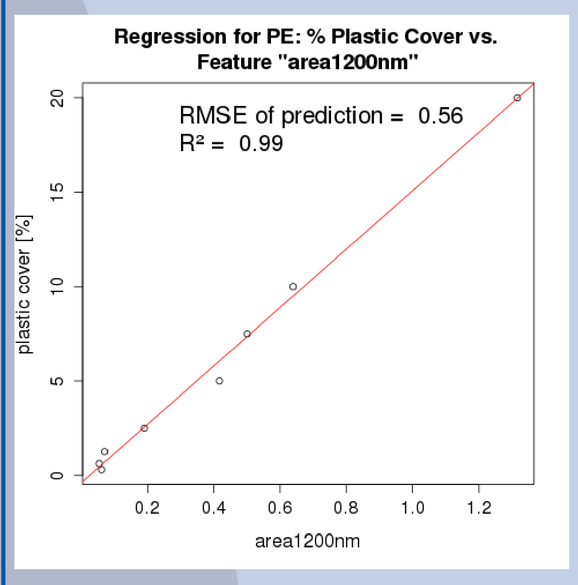


↑ SWIR Reflectance-Spectra by HySpex with absorption features of PE

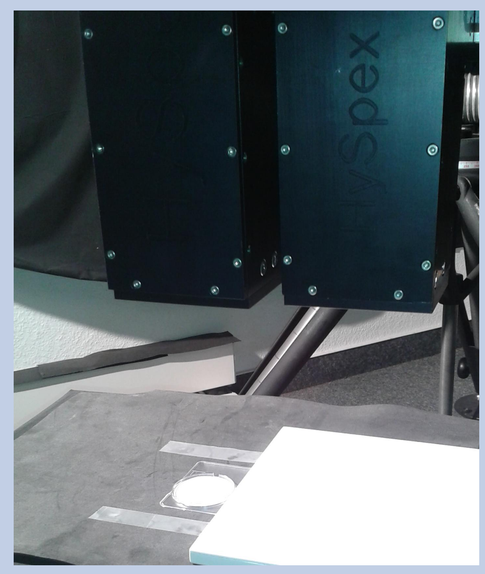


↓ Scanned filter with multiple PE microparticles (gray dots), Pixel size 250 µm





% Plastic Cover vs. continuum removed area of second CH overtone stretch (around 1200 nm)



HySpex camera in the laboratory scanning a filter with Polyethylene particles

6. SUMMARY AND OUTLOOK

Hyperspectral imaging for quantification and qualification of polymers can provide accurate and fast analysis of filtered water samples. The detection limit is sufficient for the identification of most microplastics originating from household wastewater, e.g. from personal care products, such as peelings, or artificial textile fibers which are not filtered in wastewater treatment facilities. This study aims to provide sufficient data for policy-makers to take measures against the increasing land-based plastic pollution of aquatic ecosystems and is collaboratively carried out by GFZ Potsdam and the University of Potsdam.

Furthermore the same imaging and image processing techniques can be used to detect plastic accumulations in the environment. The HySpex sensor system of GFZ Potsdam is also used for airborne high-resolution remote sensing applications. In April 2013 our workgroup will start a field survey to assess the detection limits of airborne hyperspectral imaging for plastic debris accumulations on beaches and for floating plastic debris on water bodies.

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[1] Institute of Earth and Environmental Sciences, University of Potsdam [2] Helmholtz-Centre Potsdam, German Research Centre for Geosciences (GFZ), tlann@gfz-potsdam.de