Beach-cast algae management issues: application on field as fertiliser and associated risks of environmental pollution with microplastic and associated pollutants

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Background and Introduction

Plastics have become an essential part of our everyday life since the beginning of their mass production in the 1940s. With the increasing world population, the demand for plastic products is rising. As a result, the amount of plastics (and microplastics) that enter the surrounding environment including beach-cast algae is increasing. Beach-cast algae is often seen as just another waste item to be managed by removing it thus removing also nutrients and plastic/microplastic from seaside and sea, but it has also an important role in the beach ecosystem in coastline of Baltic Sea, e.g., helps alleviate the effects of beach erosion, many species depend on beach wrack as a source of food, living space and nursery. Meanwhile, it has significant potential as a remediation measure to improve coastal water quality (by removing nutrients, heavy metals etc.) and as a resource., e.g., fertiliser. In fact, in Latvia beach-cast algae application on fields as fertiliser is one of the historical methods in order to improve the quality of the soil. Actually, it is proved that algae in soil works as a biostimulant for plant seeds to develop, but recent research shows that plastic abundance in soil negatively impacts cell development of plant seeds and roots.

The **aim of this study** is to try to access pros and cons of beach-cast algae application on fields as fertiliser in Latvia taking into account their content of: nutrients (TotN, P, K, S, TotC), microplastics and associated pollutants (e.g.,heavy metals, plastic leachates etc.).

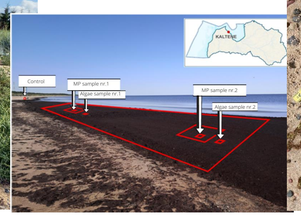
Materials and Methods

Sampling

From August 31 – September 9, 2021 sampling was performed in the Latvian coastline of Baltic Sea and Gulf of Riga. In five places beach-cast algae samples were taken for species identification (and detection of dry weight), chemical analysis of nutrients and heavy metals and for microplastic detection in beach-cast algae together with control sand samples where beach-cast was not abundant.

Algae wrack measurement

Sampling scheme - example from Kaltene



Frame (0.20x0.2 cm) for algae sampling

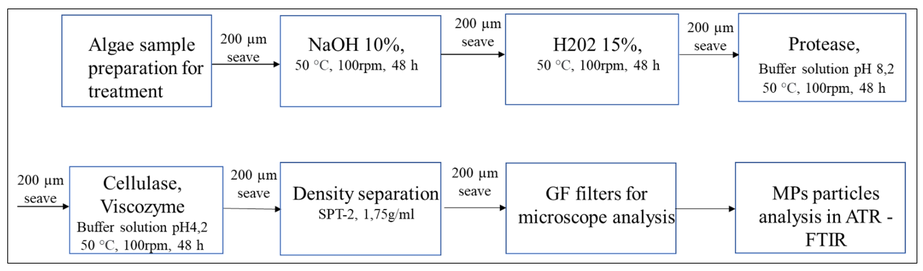
Beach-cast algae sample analysis for species identification and their dry weight detection

At beach-cast algae sites, two macroalgae samples were collected using a 0.2x0.2 m^2 metal frame. The samples were collected close to MP sample sites for collecting similar species as in MP sample. In that way it could be possible to later find correlation between algae type (for example, filamentous) and amount of MP. In laboratory the samples were analysed by sorting macroalgae according to species, placing each species on aluminum foil and drying the foil with algae in 60°C for 48 h. After that, the dry weight of each species is taken.

Algae microscopic analysis and separation of species

Sample treatment for MP analysis

Microplastic sample preparation from beach-cast algae included several steps including treatment with sodium hydroxide (10 %), peroxide (15%), enzymes (protease, cellulase, viscozyme) and two steps of density separation (SPT - 1,75 g/ml). Control sand sample treatment included only density separation (SPT - 1,75 g/ml). For both microplastic sample matrixes final step is filtration on GF/C filters for visual identification under the microscope and analysis. All particles, excluding fibers, that could be handled manually were picked up from for further chemical composition analysis. Thereafter, these particles are analysed with the ATR-FTIR spectroscopy method. Please see detailed sample treatment scheme in right side .



Chemical content analysis of beach-cast algae

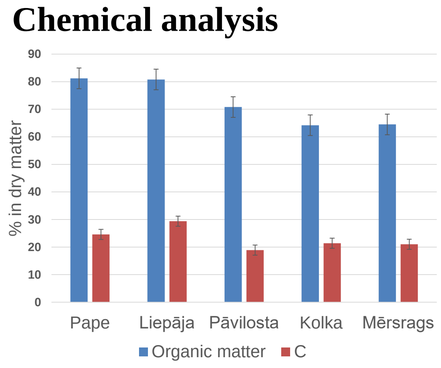
For all chemical analyses, dry weight of sampled beach-cast algae was determined.

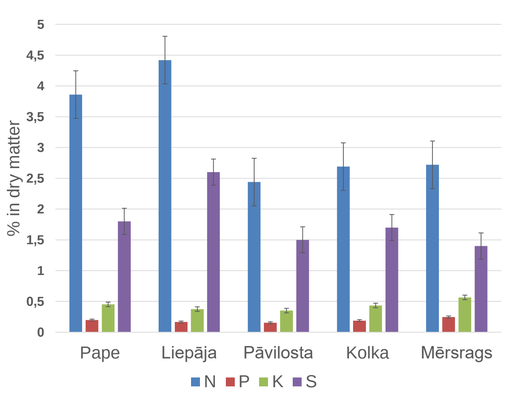
For total phosphorus and potassium determination analyses were used from ash (4 hours at 400°C) extract in HNO_3 solution. Total phosphorus (P) was analysed by spectrophotometric analysis using and ammonium vanadate-molybdate solution. The Potassium (K) was analysed by flame spectrophotometric analyses. Total nitrogen (N) was analysed in air dry samples by 3 steps Kjeldahl method using Büchi Digest System K – 437, Büchi Distillation Unit K – 355 and TitroLine Easy for titrating with 0.1M HCl. Total carbon (C) and sulphur (S) content was determined by oxygen stream and subsequent measurement of the combustion gases by using ELTRA CS-500.

For heavy metal analyses three subsamples from dried grounded beach cast algae samples were taken sifted through a 500 µm metal sieve. Then samples were digested with nitric acid and hydrogen peroxide in a microwave according to US EPA method 3052. The measurements of Cadmium (Cd); Lead (Pb) and Nickel (Ni) in beach-cast algae digestate were performed using a atomic absorption spectrometer Varian SpectrAA – 880Z with Zeeman background corrector, GTA-100 graphite atomizer and PSD-100 programmable sample dispenser. The measurements of Mercury in seaweed samples were made by Thermal Decomposition, Amalgamation and Cold Vapour Atomic Absorption, USEPA method 7473. For measurement quality control were used Certified Reference Material for trace metals in seaweed ERM CD200 (*Fucus Vesiculosus*) and LIS IA 1.125- Laboratory Internal standard, beach-cast algae mix from previous project.

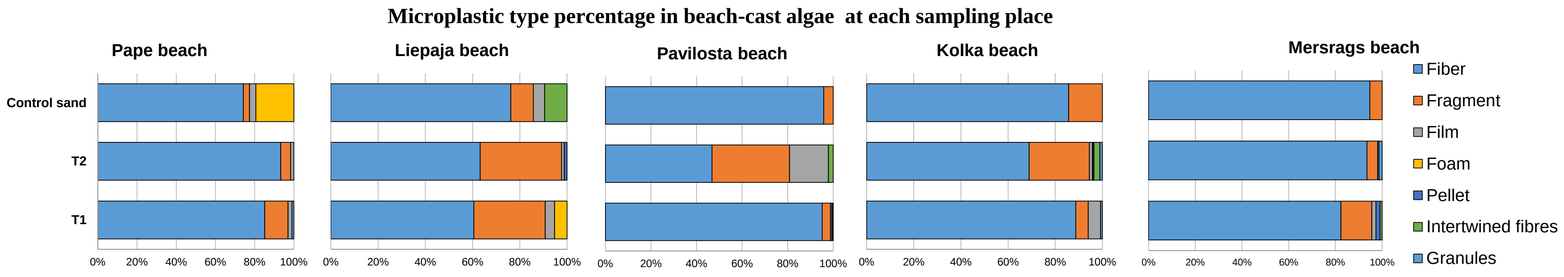
Results

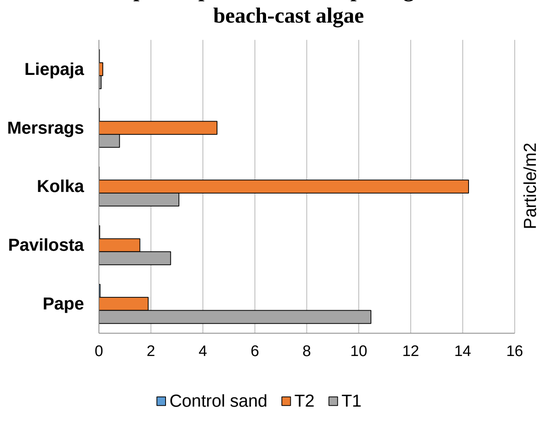
Chemical analysis

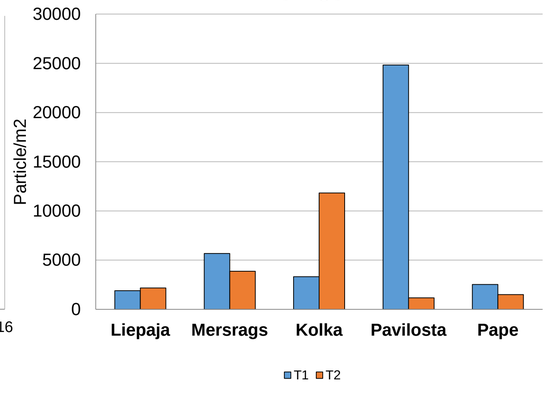


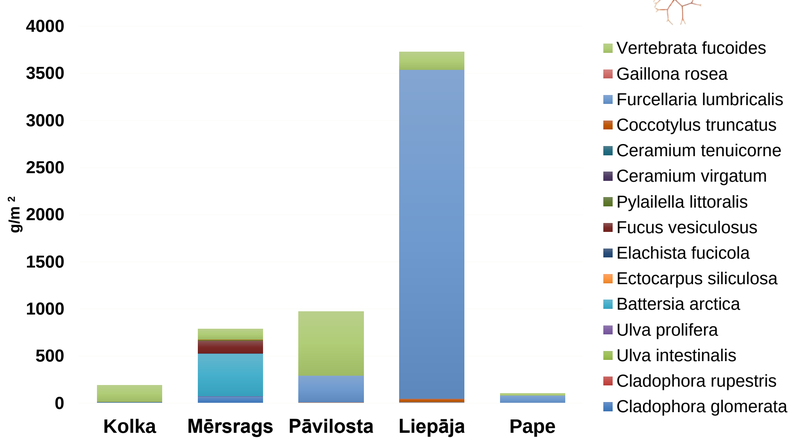


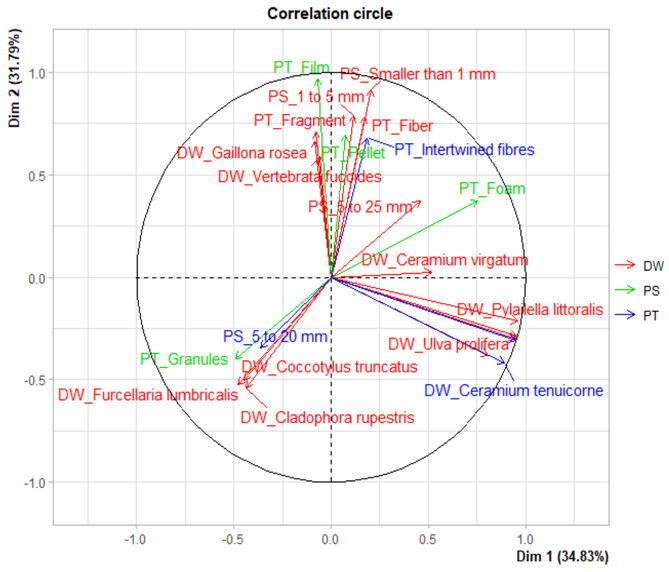
Microplastic amount and types

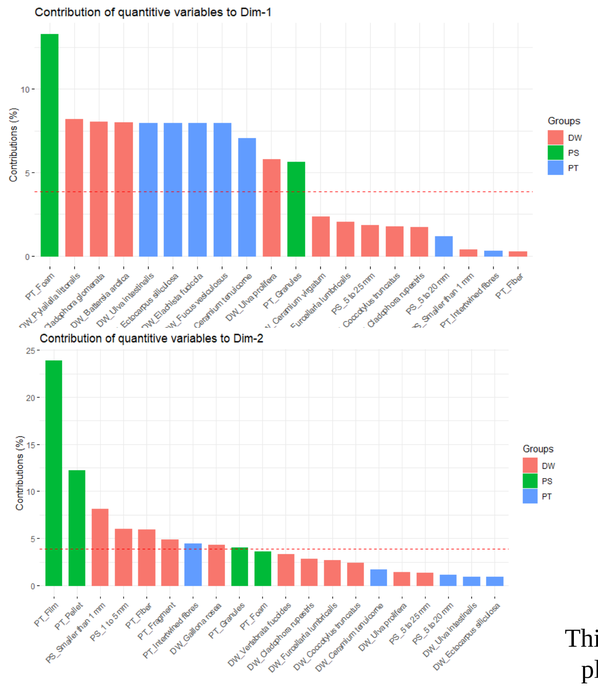












DW-dry weight, PS-particle size, PT-particle type

Conclusions:

- Microplastic particles were found in all analyzed beach-cast algae samples and their concentrations were higher comparing to control sand samples
- Chemical analysis of heavy metals show that Cd, Pb, Ni and Hg do not exceed limits mentioned in national rules and beach-cast algae can be applied on the fields as fertiliser
- **Higher** concentration of MP particles per m^2 was found **in Kolka and Pāvilosta, but higer** concentration of **MP per dry weight unit of algae – Pape and Kolka**
- Particle concentrations increase by decreasing their size range, except places where fibers are dominating
- **Based on multivariate data analysis** V*ertebrata fuccoides* positively correlates with microplastic pellets. And *Cladophora rupestris*, *Coccotylus truncatus*, *Furcellaria lumbricalis* positively correlates with microplastic granules in size 5 to 20 mm.
- **More research** is necessary to perform in order to clarify possible threats of beach-cast algae application on fields

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