ESMIC

Estimation, monitoring and reduction of plastic pollutants in Latvian-Lithuanian coastal area via innovative tools and awareness raising

Implementation guideline of plastic litter monitoring and management related to algal wracks/scums

(D.T.1.3.1)

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Content

Introduction

One of the goals of the ESMIC project has been provision of practically applicable guidelines and recommendations on treatment of plastic pollution in the coastal areas of Latvia and Lithuania. The project has tested two hypotheses on concentration of plastic in the locations of dense beach wrack accumulations and at the sites with cyanobacterial blooms. Both hypotheses have been proven to be true/or not, check the project presentations, emphasising the need to pay specific attention to the algal accumulations. Methodological approaches are extensively described in the project's "Report on methodology development results, uncertainty identification, improvement or solutions" (D.T.1.1.2) and therefore are not repeated here. This report, on its turn, has an intention to suggest the most beneficial and feasible methods from those described. Besides, a description of beach wrack management practices in the coastal municipalities is added together with analysis on impact of plastic pollution. Conclusions are drawn on suggested further steps and future actions.

1. Guidelines for implementation of plastic litter monitoring

1.1. Overview of methods used

1.1.1. Remote observations

Two types of remote observations have been tested in the project in order to find beach wrack and cyanobacterial accumulations (thoroughly described in Chapter 3.1.1., D.T.1.1.2). Analysis of satellite images has shown that detection of the beach wrack is possible and the obtained data can also serve as a basis for a warning system. Still, the level of satellite image resolution is helpful in case of large scale accumulations, it will not indicate the appearance of beach wrack smaller than 10x10 m. So the use of other method - visual data collection with drones - is mandatory in order to get more precise results. It has been clarified that multispectral camera shows good classification results of area coverage. It is also possible to calculate the volume of beach wrack with the help of an adjusted model. However, "drone method" is not fully remote as it requires a trip to the coast to collect visual data anyway.

The benefits of both methods are that they do not require substantial investments for infrastructure - satellite images are available on the web and drones are not so expensive, so the costs mostly include software for image analysis. Additional costs are needed for training of personnel to run these methods. Also a user-friendly interface is necessary to present the results and help to decide on further actions, e.g., beach cleaning.

Thus, remote sensing data can support and optimise expensive manual monitoring, especially in more remote areas with low population density, if the aim of the monitoring is to locate and/or sample all accumulations of beach wrack.

In any case, for the next step - assessment of plastic pollution related to beach wrack - the accumulations should be checked by *in situ* sampling.

1.1.2. *In situ* sample collection and analysis

Methods of *in situ* beach wrack and related plastic litter sampling have a detailed description in Chapters 3.1.1. and 3.1.2. of D.T.1.1.2. The sampling methods are not very complicated and do not require use of advanced equipment or devices. Metal frames, buckets, zip lock bags and containers of various sizes are not resource demanding investments. Human resources for carrying out timely sampling here are the most important. We would assume that similar to campaigns "My Sea" this kind of sampling could be a topic for citizen involvement and also a theme of longer-term citizen science projects or citizen-performed monitoring. Certain resources will be needed to organise promotion of campaigns, educate leaders for campaigns and also to support a reciprocal link with citizens involved. Here a cooperation of municipality, local communities and academic institutions could be successfully developed.

Analysis of samples and interpretation of obtained results require trained personnel, though. During the project it has been decided to use the simplest and cost-effective method for sample treatment with hydrogen peroxide to eliminate organic matter. Still, the assessment of microplastic abundance should be treated carefully and all possible sources of errors should be checked. We observed that at Latvian and Lithuanian coastal sites the abundance of microplastic particles differed by an order and the reason for the phenomena has not been found yet (Table 1).

Table 1

Concentration of microplastic (MP) particles in the samples of beach wrack in the coastal areas of Latvia and Lithuania, particles per m3

Location of sampling	**Total abundance of MP particles**
Akmeņrags	53542
Bernāti	32708
Liepāja	13687
Pape	54375
Tūja	34083
Palanga	454345 (mean value, n=2)
Karkle	748130 (mean value, n=2)
Sventoji	518052 (mean value, n=5)
Melnrage	366744 (mean value, n=7)

Collection of phytoplankton (cyanobacteria) samples and sampling of microplastic litter with Manta net have also been considered in the project and are described in Chapters 4 and 5 of the D.T.1.1.2. However, these methods either still need practical testing (in case of cyanobacteria) or more complicated equipment and logistics. Sampling with Manta net requires use of a research vessel and therefore is more appropriate for national marine monitoring programmes. The sampling of cyanobacterial accumulations can also differ substantially due to the characteristics of the water body. In the case of the project ESMIC cyanobacteria could be sampled with a bucket from the coast or small boat in the Curonian lagoon, while in Latvian waters the sampling will require larger boats or even vessels and different sampling equipment.

1.2. Practical implications

The project experiences indicate that additional steps are required for:

1) development of practical use of the project findings;
2) harmonisation of methods in sampling and sample analysis;
3) education of personnel for wide use of elaborated methods.

It is also obvious that these steps initially should be taken by academic/research institutions, as the knowledge and infrastructure is there. At the same time, close cooperation with stakeholders should be maintained to understand the needs and demands.

For the time being, involvement of citizens into observations of beach wrack accumulations could be increased - both in order to supplement remote data and support *in situ* observations. The initiative for involvement most probably should come from academic institutions but can be transferred later to the municipality (on the basis of mutual agreement). Existing nature observation apps and portals can be used for reporting on beach wrack accumulations, additional online promotion would be helpful then, though. Dabasdati.lv is the most popular portal and app for observations in Latvia, but also international ones like inaturalist.org could be an option.

Monitoring of plastic litter is required by EU Marine Strategy Framework Directive (2008/56/EC) and respective national regulations. While monitoring of macroplastic litter has already obtained a component of citizen science (e.g., campaign “My Sea”), then due to relative simplicity of sampling the same approach could be exploited also for microplastic litter surveys. Wider involvement of citizens has several benefits like increase of environmental responsibility, sense of ownership, closer relation to nature and better understanding of the need for research activities (Garcia-Soto et al. 2017).

2. Guidelines for implementation of algal wrack management

Beach wrack is known as a material that can be found all over the world in the swash zone, in lines along the foreshore and sometimes at the back of the beach, especially after storms. Same features are observed also in the ESMIC project countries, the amount and composition varies depending on the season, coastal landform, offshore substrates (determining algae/ seagrass growth), currents, tidal forces, wind and wave action (Woelfel et al. 2021). It has been observed that the amount of beach wrack on German beaches has increased by a factor of 3.4 in a course of 35 years (1977-2013) and species composition has changed towards annual opportunistic species like *Ceramium tenuicorne*. In addition, beach wrack composed of nutrient opportunistic algal species has a relatively higher nuisance potential than beach wrack composed of late successional macrophytes, e.g., *Fucus vesiculosus* (Weinberger et al., 2021).

The intention of the project was to map and analyse the practices of the municipalities in collection and further management of the beach cast, and have a look at the related costs in a three year period (2018-2021). However, data for 2021 were mostly available therefore we have concentrated on those. On the other hand, regarding the costs one should admit that data of 2021 reflects the actual situation with higher similarity than the previous years.

2.1. Known practices and costs

The moment beach wrack is collected it is effectively considered waste and that creates administrative and legislative pressures for municipalities in the EU (Chubarenko et al 2021). Costs associated with beach clean-ups involve use of technical appliances for collection and refining, labour expenses as well as costs associated with transportation of the collected material. Beach wrack collection from rocky beaches is especially challenging and there have not yet been developed ways of accomplishing this (Chubarenko et al 2021).

Composition of sea wrack is location-specific as there are different dominant algae species present. Depending on composition, beach wrack can be used in agriculture as fertiliser /soil improvement products, compost material or landfill biocovers (Denmark), for biocoal or biogas production, deposited for dune protection (Kaliningrad, Russia) or processed for creating new products (e.g. EstAGAR example) (Chubarenko et al 2021).

Project CONTRA has estimated both the abundance of the beach wrack and the related costs for the beach clean up. Thus, in the southern Baltic Sea region potential beach wrack harvest is estimated to be between 20 and 6000 tons per km of coast per year (Chubarenko et al 2021). So high variation depends both on each year's meteorological conditions (wind strength and direction) and location of the beach, i.e., level of eutrophication in the respective area. For instance, Køge Municipality collected 1.400–1.800 tons of beach wrack per year in the years 2017 and 2018. However, the amounts varied each year and had reached up to 14.000 tons a year.

The municipality of the Island of Poel in Germany is treating on average 3000m3 of beach wrack per year, costing 200 000 € per year (pers. comm.). Similar costs have been reported by Glowe,Germany amounting 268 000 € for 2017 (pers. comm.).

In general, associated costs of beach wrack clean up are scarcely available (Robbe et al 2021). According to a recent beach wrack study by Hofmann and Banovec (2021), municipalities and private beach operators invest between 20€ and 40€ per m of beach length annually in beach cleaning efforts. Costs sum up to annually 38€ per m managed beach (Mossbauer et al. 2012), showing annual costs from 7.6–253€/m^3, with the highest values in Scharbeutz of up to 140,000€ (Jensen 2017).

At the Lithuanian main sea resort Palanga (CONTRA, 2021), since 2019 daily mechanical beach cleaning takes place during the tourism season from 15th of May to 15th of September (~40 moto-hours/month), while done before only manually or semi-manually. In 2019, a total of 1.49 t per 35 ha beach wrack and litter were collected. This resulted in an estimated cost of 32 €/m2 for beach wrack and litter removal.

Then, considering a less used aspect, Söderqvist et al. 2022 looks at cost-benefit analysis incorporating CO2 emission calculations and shows an example of beach clean up costs in Gotland, Sweden that reach a total cost of USD 0.24 million.

2.2. Practices and costs of beach wrack management in the project area

To clarify the activities performed by the municipalities in the project area towards beach wrack management, a questionnaire was prepared and a survey carried out. The questionnaire of the survey is attached as Annex. We also checked the descriptions and requirements of municipal tenders for beach cleaning to potential subcontractors at the site of Latvian electronic procurement system www. eis.gov.lv Following observations, conclusions and recommendations are based on the results of the survey and supported by findings at the tender documents.

All together, nine municipalities have been surveyed - five in Latvia and four in Lithuania. In the Lithuanian case only one municipality - Palanga - reported the occurrence of the algal material on the beach, while it was present at all questioned municipalities of Latvia. Municipalities from the coast of the Gulf of Riga were also included in the survey due to the large amount of algal material present on their beaches (Jurmala).

The approach towards beach wrack in the project areas differ little between the coastal municipalities. As almost everywhere around the Baltic Sea, the main issue is to have a clean beach for recreational purposes. Therefore, municipalities mostly use machinery of various sizes to collect beach wrack or other litter. Efforts of municipalities in collection of beach based material is related to the size of respective settlements, i.e., the largest towns and cities are paying much attention to beach cleanliness while smaller settlements simply do not have resources for it. Cooperation between municipalities on beach wrack management does not exist, except for random exchange of experience. Lack of cooperation is mostly due to the fact that municipalities announce tenders for beach cleaning according to their needs and subcontractors - either municipal enterprises or private companies - are performing the actual cleaning and consequently counting on their share of profit.

There are no specific procedures on removal of plastic litter while collecting beach wrack. The largest visible items, irrespective of the origin, are hand-picked from the algal material and sorted afterwards at landfill. If the concentration of littering objects is too high and hand-picking on the site is not efficient, the beach wrack is regarded as “dirty” and transferred directly to the landfill (Liepaja, Riga). Otherwise the collected beach wrack is either partially buried closer to the dunes if no other waste is present. The burial in the pre-dune zone serves as a natural tool against erosion. Other approaches are to compost it (Ventspils) or allow local inhabitants to take it - most often used as a soil fertiliser (Liepaja, Riga). No collection occurs, if the amount of beach wrack is small (Saulkrasti). In these cases there is also no budget allocated to beach wrack management.

The abundance of beach wrack varied considerably between the municipalities (Fig.1), although it was no surprise. Resort city Jūrmala is located on the coast of the most eutrophied part of the Gulf of Riga and receives high loads of beach wrack annually. Liepāja is located north to the richest underwater vegetation area in Latvian waters and therefore detached macroalgae accumulates besides coastal structures against erosion and on the beach.

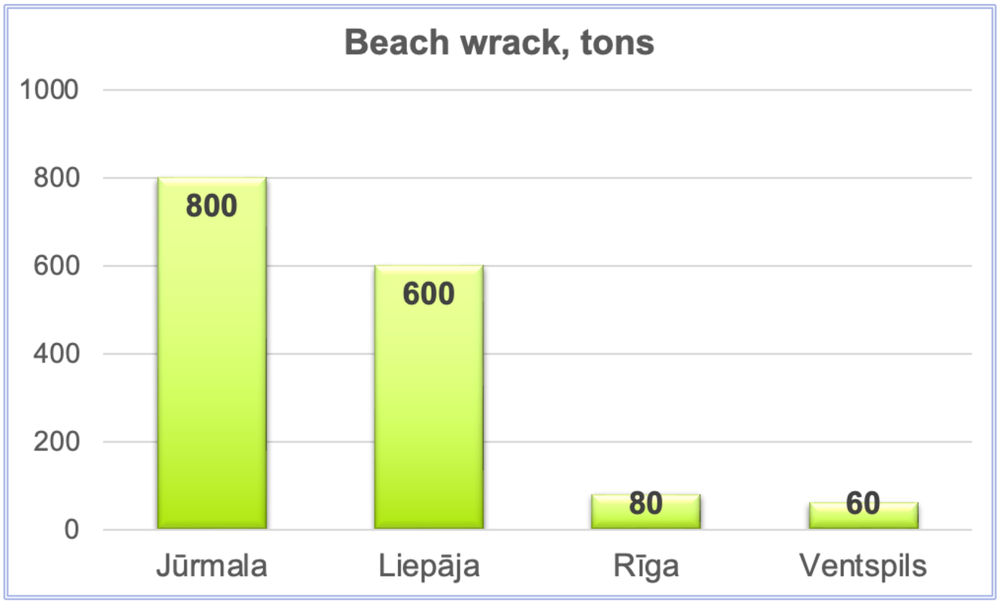

Fig.1. Approximate abundance of beach wrack at the coastal areas of Latvian seashore. No data were available for Lithuania (Palanga).

The costs of management were reflecting the amount of beach wrack quite directly (Fig.2).

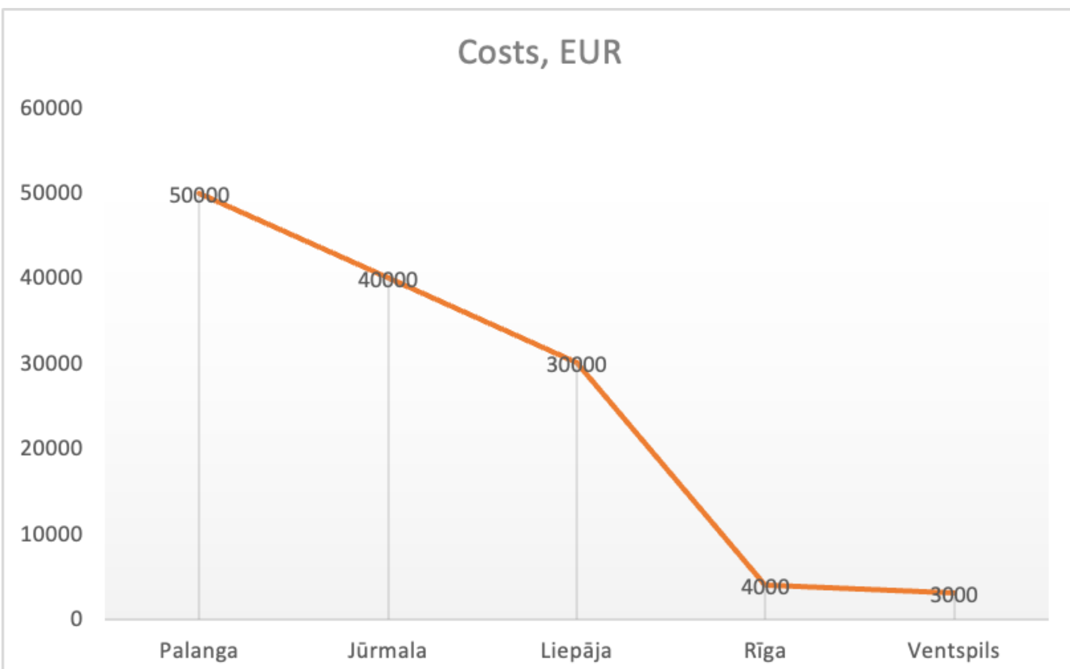

Fig.2. Beach wrack management costs at the coastal municipalities, 2021.

All municipalities have indicated that they do not plan to change anything in beach wrack collection practices in the nearest future. It is possible that presently growing costs of transportation and power can lead to somewhat reduced beach cleaning procedures. Taking into account that information on beach wrack presence so far is collected by manual observations, then remote reporting options could be a contribution for cost reduction at least in this aspect.

Considering the findings of the project - a significance of beach wrack in trapping microplastic litter, the practices of the municipalities now raise a question whether it is safe to dump the beach wrack in the dunes, turn it into compost or allow distribution of it for local inhabitants? Example from Akmeņrags (Fig.3) indicates that number of particles per cubic metre are several tens of thousands.

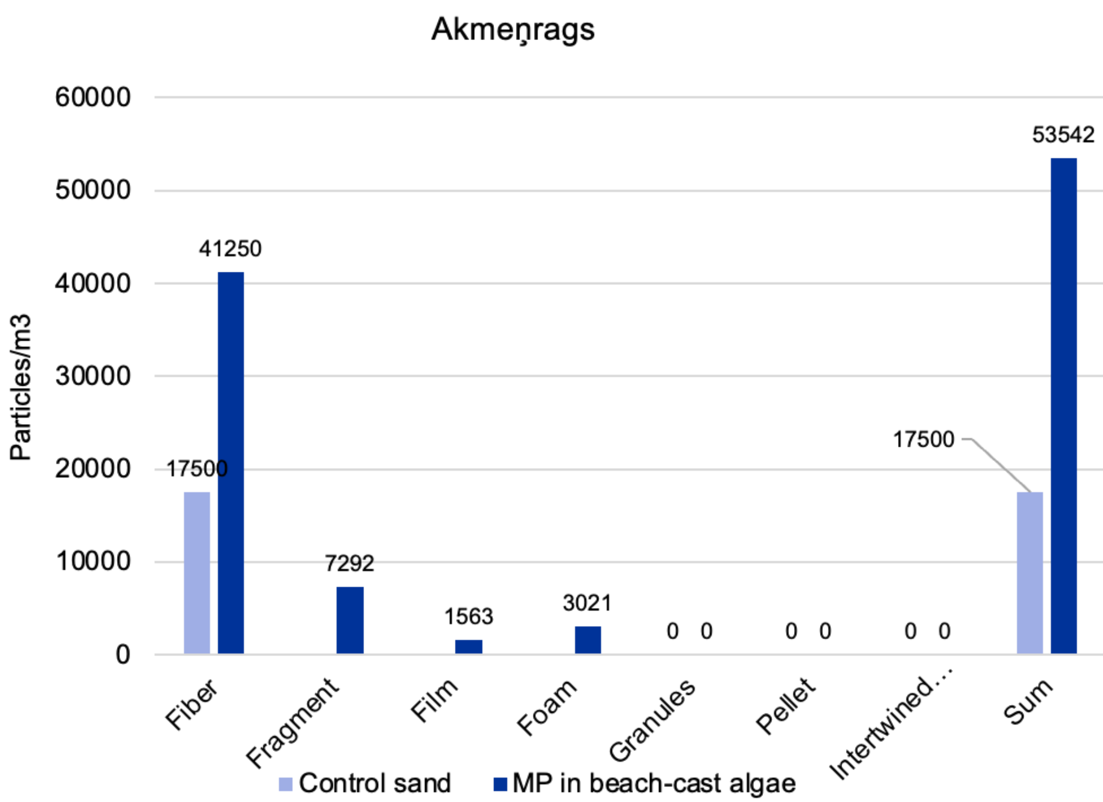

Fig.3 Types of microplastic particles and their abundance in the beach wrack (beach-cast algae) per m3 near Akmeņrags, Latvia in 2021.

Another aspect of beach wrack removal involves coastal ecosystem functioning. Robbe et al. (2021) argue that total removal of algal material from the beach reduces the number of ecosystem services like protection from coastal erosion and potential as a carbon sink. The authors suggest partial or "on-demand" removal of beach wrack and other alternative approaches.

However, it would take some time to change or alternate any practices by municipalities in beach wrack management. The beach wrack is considered a nuisance in areas where the number of visitors is high and therefore cleanliness of the beach is maintained by quite strict regularity. Tender descriptions indicate that beaches should be checked frequently, at least twice per week during tourism season and litter of any origin should be removed. We cannot neglect though that decomposing beach wrack can also become a substrate for pathogenic bacteria and its removal at least minimises risks of infection.

Cost calculation methods in the provided examples from the southeastern Baltic Sea have been different, as there the expenses for cleaning an area have been considered. In Latvian municipalities a price per ton of a beach wrack is the accounted unit. Therefore a comparison of costs between different regions of the Baltic Sea is not quite possible.

3. Conclusions

The results of the project activities have shown that for further proceeding on implementation of plastic litter monitoring improvements for methodological approaches are still necessary. Remote observation methods could be complemented by user-friendly interfaces, while *in situ* monitoring surveys of cyanobacteria need additional testing. A component of citizen science can be included at beach wrack observations and *in situ* sampling activities, and can become a basis for closer cooperation between academic institutions and various stakeholders.

The beach wrack management practices show the same pattern for most of the coastal municipalities - beaches should be clean and any litter should be removed. High number of microplastic particles leaves an open question whether the collected beach wrack should be used as a resource or should be treated only as a waste? Additional studies are needed to estimate whether removal of beach wrack creates significant reduction of ecosystem services or - contrarily - helps to reduce the risks of bacterial infections. The remote observation methods in future could help to estimate the need of beach cleaning by providing operational data on beach wrack accumulations also for municipalities.

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Annex

Questionnaire for municipalities on beach-wrack collection practices, T.1.3.1.