EYES ON PLASTIC - a multi-sensor solution to detect plastic litter in aquatic environments

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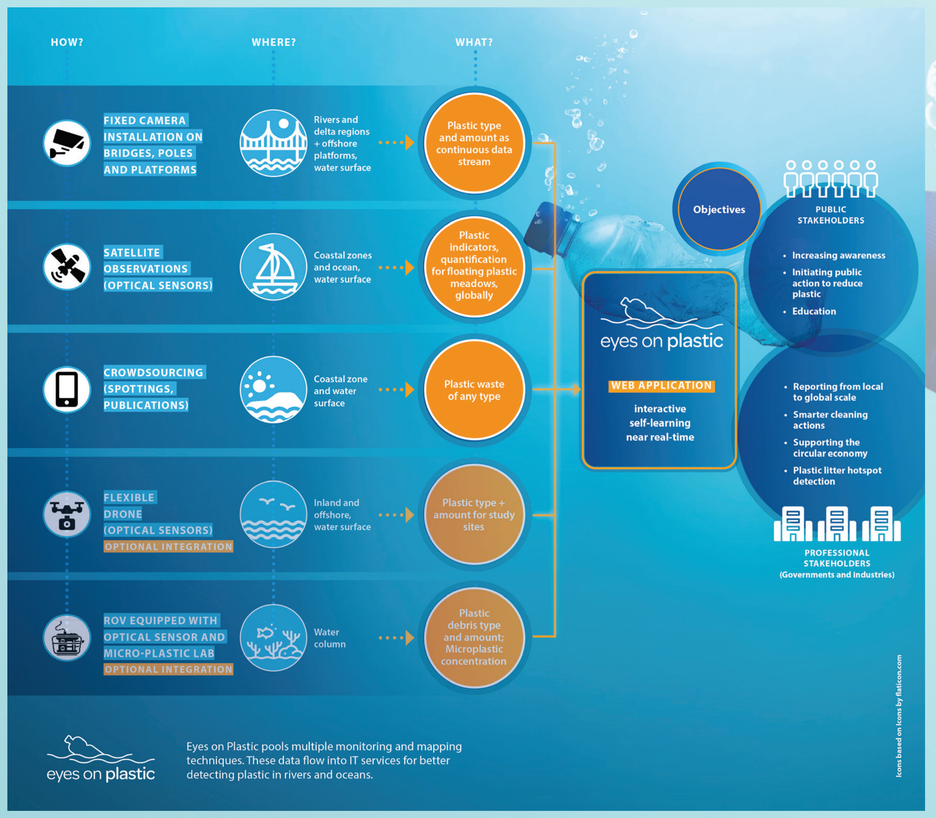
Introduction

Rivers are the **main contributors of aquatic plastic litter** in the marine environment, as the key plastic source is on land. In this context Eyes on Plastic has been developed as a **multi-sensor solution** to detect and track floating aquatic plastic litter in coastal and river environments. It combines **Copernicus satellite data, on-site sensors** such as streams from mobile or fixed cameras above and optionally below the water surface, and **crowdsourcing data** in a geographic web-application. This multi-sensor approach allows mapping plastic litter in different aquatic environments at a varying level of detail and frequency. The solution is supported by ESA Business Applications (BASS).



Methods

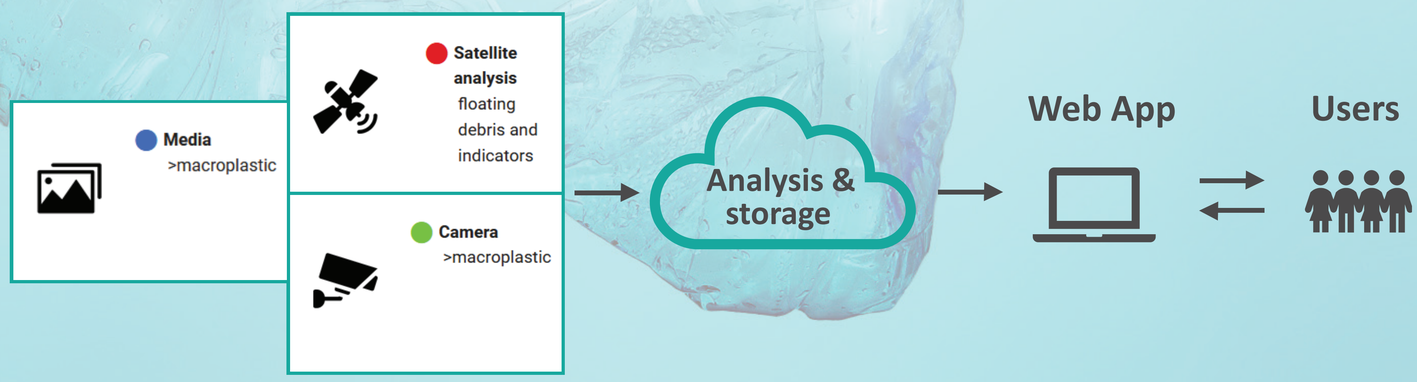
The holistic mapping approach is currently being developed and tested at four pilot sites in Jakarta (Indonesia - Bekasi and Cileungsi rivers), Genoa (Italy) and the Guanabara Bay (Brazil). Initial results are shown on the web-application.

On-site sensors: Data streams from fixed cameras observing rivers or coastlines (e.g. CCTV) are downloaded every 15 minutes into a cloud environment and analysed for floating plastic litter. Each plastic object/ patch is counted and added to an accumulative statistic, which is continuously updated and displayed in the web-application.
For the plastic object detection, we use the Convolutional Neural Network (CNN) YOLOv5. We apply the SORT model on the output of YOLOv5 ensuring that each object, which occurs in multiple frames of a 15 minute data stream, is only counted once. The SORT model also ensures objects that submerge and emerge on the water surface again are only counted once.

Satellite imagery: We apply the EOMAP atmospheric correction on Sentinel-2 imagery. On these data we tested three methods to automatically find floating plastic, namely the Support Vector Machines (SVM), the Floating Debris Index (FDI) and the Random Forest approach. The mentioned algorithms predicted plastic with a probability of around 70%. The results contained too many false positives or were unable to discriminate plastic from other floating objects for use in a commercial application. Currently, the UNet++ deep segmentation model is undergoing testing and is expected to yield better results.

Water quality data: Turbidity information is derived from Sentinel-2 imagery using a physics-based approach developed by EOMAP. The hypothesis whether turbidity values are a proxy for floating plastic debris will be tested within the project scope.

Crowd-sourcing data: Everybody is invited to actively engage in finding plastic litter by uploading relevant images or publications with a specified geolocation. This approach helps to increase awareness of the plastic litter problem and initiate public action to reduce plastic from the environment by showing tangible examples and images of plastic pollution.



Results

The Eyes on Plastic solution provides information on aquatic plastic occurrences and statistical data derived from multiple sensors. Eyes on Plastic can monitor and quantify plastic in different aquatic environments supporting plastic policy management and on-site cleaning actvities. It enables users to continuously track plastic pollution over time, identify trends, assess the impacts of local policies, and increase the efficiency of local cleaning activities. Technically the solution can be easily scaled up, as the low-cost CCTV installations can be applied to - or make use of existing - key rivers worldwide.

Figure 1: The data from the installed camera is downloaded and analysed in 15 minutes intervals. For the detection of floating plastic objects the CNN YOLOv5 is applied. In the figure, each detection is highlighted by an orange box.

Figure 2: The YOLOv5 model counts objects multiple times, e.g. when occurring in several frames of the data stream. Therefore, we apply the SORT model on the output of YOLOv5 ensuring one count per single object. Each colour in the figure presents an individual object.

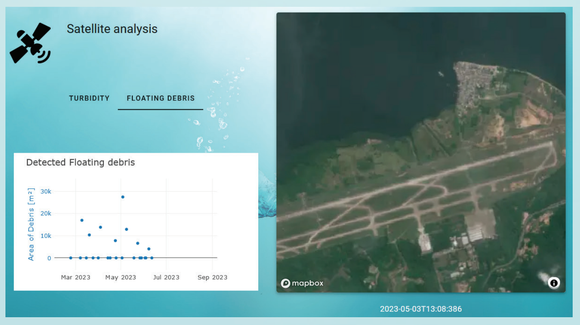


Figure 3: Sentinel-2 images are used for the detection of plastic on a large scale. The presented example shows floating debris found by visual interpretation. The identified objects are added to the statistics on the web-application.

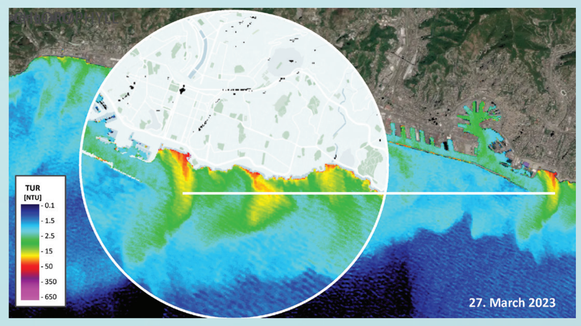


Figure 4: Turbidity maps based on Sentinel-2 satellite imagery are also integrated into the solution. The hypothesis of whether turbidity values are a proxy for floating plastic debris still needs to be tested.

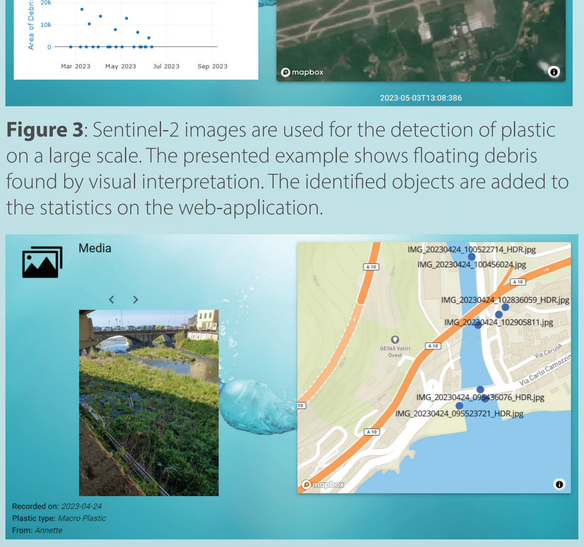
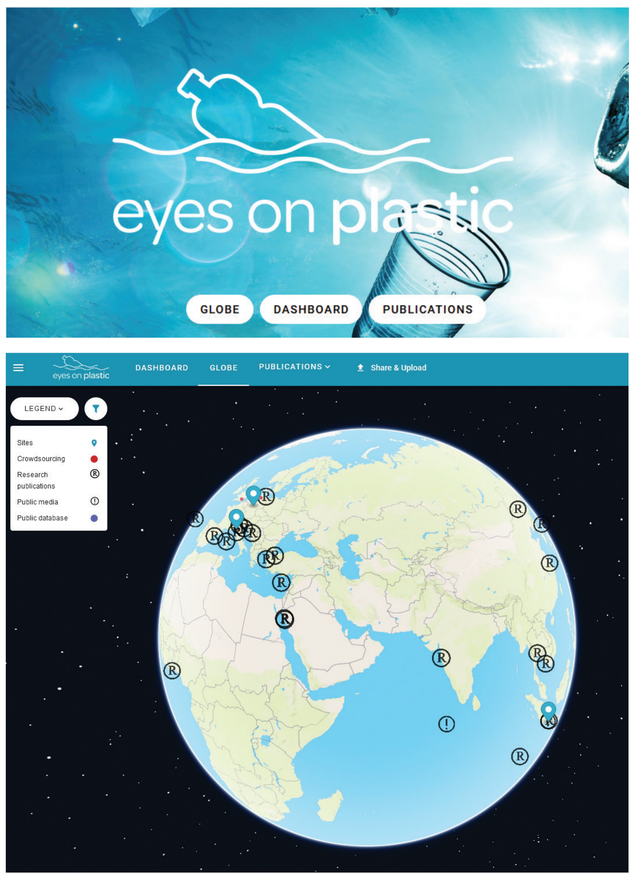


Figure 5: The crowdsourcing option allows uploading images that show plastic pollution and specifying a geolocation. Each uploaded image is shown on its geolocation in the Globe view and on the Sites overview. The web-application can be used on smartphones or tablets.



Outlook

In the upcoming 1.5 years Eyes on Plastic will be developed from a prototype to a mature solution.
Two political initiatives will shape the global plastic economy in close future:
1. The recently adopted United Nations resolution UNEA 5/14 aims to draft a legally binding framework until the end of 2024. It will hold member nations accountable for their contributions to the global plastic pollution crisis.

2. The EU Strategy for Plastics in a Circular Economy supports investment in research, innovation, and infrastructure for waste management and recycling. It will establish committees and terms that will cover all phases of the plastic life cycle from design and production to waste management.

With both frameworks underway, Eyes on Plastic has a huge potential to disseminate accross international markets, in principle all countries with a coastline and where river systems enter the sea.

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