The Review of Remote Sensing Technology for Plastic Waste Monitoring

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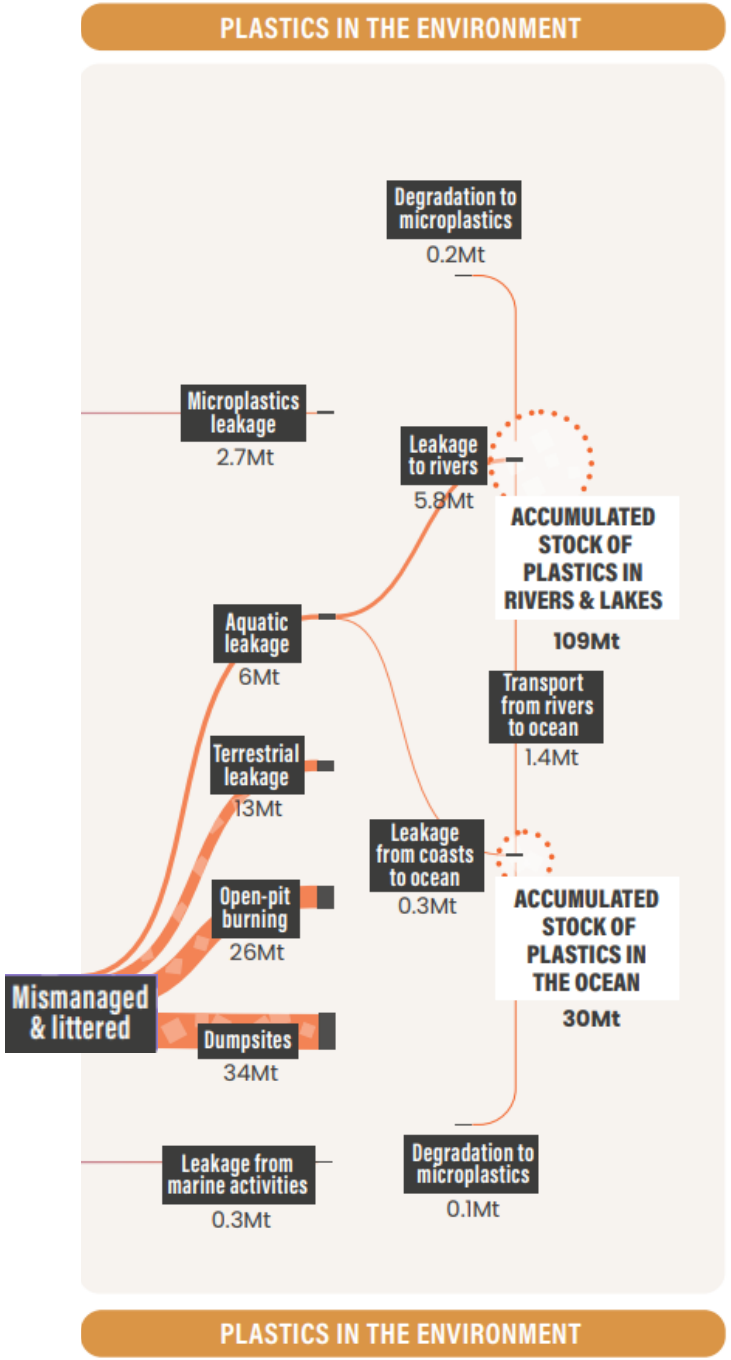


Source: OECD Plastics Outlook Database

Introduction: Plastics Waste Plastic Monitoring

Plastics Waste

- In 2019, 22 Mt of plastic materials leaked into the environment. **88%** of plastics leakage is **macroplastics** (OECD, 2022).
- **109** Mt of plastics accumulated in **rivers**, and 30 Mt in the ocean (OECD, 2022).
- **5** of the most **countries** that release plastic into the ocean are in **Southeast Asia** (https://worldpopulationreview.com/, 2021).

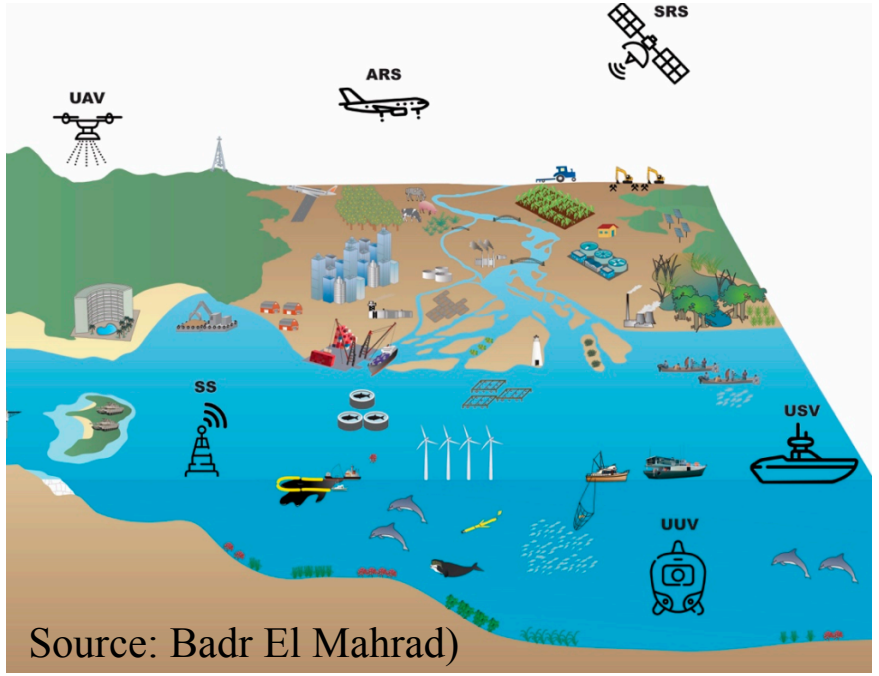
Plastic Monitoring

- **Tackle the marine plastic litter** issue is urgent action that has been proposed from the global governance, international bodies and initiatives (Winterstetter, A., et al.,2021)
- The **technologies and innovations** for **data collection** on the trajectory of plastic waste (e.g., via **earth observation**) in 2020 AHEG-4 meeting. (UNEA/UNEP, 2020)

Table 1: The main technologies and methods used by the marine litter innovative solutions in accordance with their function

Horizontal domain function	Surface
Prevention	Booms, traps, conveyor belt, filters
Monitoring	
Sampling	Grabs, filters, pumps, nets
Detection	Drones, aerial imagery, remote sensing, satellites, multispectral, image analyses, unmanned aerial vehicles
Modelling	2D Lagrangian particle tracking, Markov chain, GIS, beaching, generalized adversarials, source–pathway–receptor, variational analysis, observation simulations
Cleaning	Vessels (various types), nets, booms, water drones, aquarobots, beach robots, vacuum systems

Source: Bellou, N., Gambardella, C., Karantzalos, K. et al., 2021)



Source: Badr El Mahrad)

Figure 1. RS technology conceptual diagram summarizing the main activities in marine environment

Table 1 shows summary review of current RS technology for plastic litter monitoring

Technology types	Spectral types	Plastic detected band / model or method	Monitoring Area	Sample type	Sample size	Accuracy
1. Satellite Remote Sensing (SRS):						
LS-8, S-2, Planet[1]	multispectral	blue band, RS index/ neural network	Land, river	plastic, tyres, waste site	na	82-86%
Sentinel-2[2,3,4]		Red, NIR, SWIR, RS index/ matched filtering, ML	river, beach, ocean	PET, LDPE	1-10 m	58 – 90% 25% of pixels
PRISMA[5,6]	hyperspectral	un-supervised, RS index/ machine learning	beach, ocean	HDPE, PET, PS, HDPE + PET + PS	0.6-5.1 m	96%
Sentinel-1[7]	Synthetic Aperture Radar	VH polarization/ backscattering differences	river	plastic accumulation	na	85–95%
2. Aerial Remote Sensing (ARS):						
Pushbroom cameras[8]	hyperspectral	na/ deep learning (ZSL)	ocean	PE, LDPE, rope	2.5-10 m	98.71 %
3. Unmanned Aerial Vehicles (UAV):						
Multispectral camera[9,10,11]	multispectral	DSM, NDVI/ ML,deep learning	river	PET, LDPE, PU, PS	0.25-80 cm	65 - 86%
Pushbroom camera[12]	hyperspectral	NIR, SWIR/ linear discriminant	beach, ocean	PE, PET	na	na
4. Static Sensors:						
Radars antenna[13]	Radar signal	X-band/ Radar Cross Section	ocean	mix waste, PET, LDPE, PU, PS	0.3-1m	na

Conclusion: river plastic monitoring

- Unmanned Aerial Vehicles (UAV) is primarily RS platform for river plastic monitoring.
- Satellite Remote Sensing with temporal resolutions is suitable to monitor plastic accumulation in the river both optical and SAR sensors.
- PET (water bottle) and LDPE (plastic bags) are types of plastic waste that can be tracked with RS technology.

Sentinel-2[4] Sentinel-1[7]

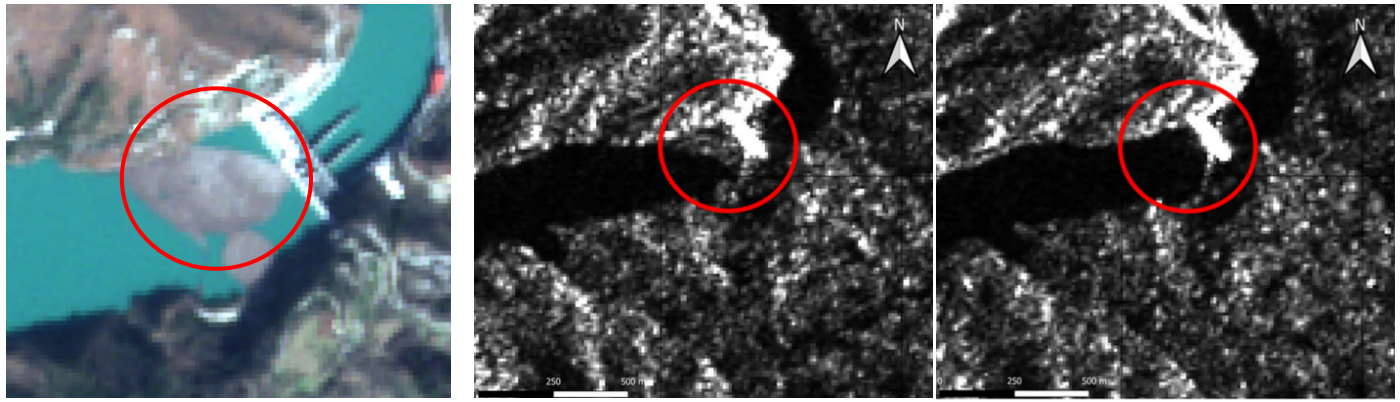


Figure 2. Samples images of accumulated plastic from optical and SAR sensors

Largest size[10] Largest size[11]

Figure 3. Samples of plastic waste from UAV images

Discussion and recommendation

- RS technologies should be integrated from various platform and tools with local addresses for more efficient tracking of plastic waste.
- Plastic waste monitoring in the marine environment with RS technologies are mostly pilot projects or research experiments which has not been fully implemented.
- RS Technologies for plastic monitoring requires data from on-site surveys or measurements and cleaning activities for validation process and planning
- Technologies and solutions can be used to raise awareness and set as local indicators for plastic waste management.

Thank you very much

Reference

1 Kikaki, A., Karantzalos, K., Power, C. A., & Raitsos, D. E. (2020). Remotely sensing the source and transport of marine plastic debris in Bay Islands of Honduras (Caribbean Sea). Remote Sensing, 12(11), 1727.

2 Topouzelis, K., Papageorgiou, D., Karagaitanakis, A., Papakonstantinou, A., & Arias Ballesteros, M. (2020). Remote sensing of sea surface artificial floating plastic targets with Sentinel-2 and unmanned aerial systems (plastic litter project 2019). Remote Sensing, 12(12), 2013.

3 Themistocleous, K., Papoutsa, C., Michaelides, S., & Hadjimitsis, D. (2020). Investigating detection of floating plastic litter from space using sentinel-2 imagery. Remote Sensing, 12(16), 2648.

4 Lavender, S. (2022). Detection of Waste Plastics in the Environment: Application of Copernicus Earth Observation Data. Remote Sensing, 14(19), 4772.

5 Kremezi, M., Kristollari, V., Karathanassi, V., Topouzelis, K., Kolokoussis, P., Taggio, N., ... & Corradi, P. (2021). Pansharpening PRISMA data for marine plastic litter detection using plastic indexes. IEEE Access, 9, 61955-61971.

6 Taggio, N., Aiello, A., Ceriola, G., Kremezi, M., Kristollari, V., Kolokoussis, P., ... & Barbone, E. (2022). A Combination of machine learning algorithms for marine plastic litter detection exploiting hyperspectral PRISMA data. Remote Sensing, 14(15), 3606.

7 Simpson, M. D., Marino, A., de Maagt, P., Gandini, E., Hunter, P., Spyrakos, E., ... & Telfer, T. (2022). Monitoring of Plastic Islands in River Environment Using Sentinel-1 SAR Data. Remote Sensing, 14(18), 4473.

8 Freitas, S., Silva, H., & Silva, E. (2022). Hyperspectral Imaging Zero-Shot Learning for Remote Marine Litter Detection and Classification. Remote Sensing, 14(21), 5516.

9 Luo, W., Han, W., Fu, P., Wang, H., Zhao, Y., Liu, K., ... & Wei, G. (2022). A water surface contaminants monitoring method based on airborne depth reasoning. Processes, 10(1), 131.

10 Taddia, Y., Corbau, C., Buoninsegni, J., Simeoni, U., & Pellegrinelli, A. (2021). UAV approach for detecting plastic marine debris on the beach: A case study in the Po River Delta (Italy). Drones, 5(4), 140.

11 Maharjan, N., Miyazaki, H., Pati, B. M., Dailey, M. N., Shrestha, S., & Nakamura, T. (2022). Detection of river plastic using UAV sensor data and deep learning. Remote Sensing, 14(13), 3049.

12 Balsi, M., Moroni, M., Chiarabini, V., & Tanda, G. (2021). High-resolution aerial detection of marine plastic litter by hyperspectral sensing. Remote Sensing, 13(8), 1557.

13 Serafino, F., & Bianco, A. (2021). Use of X-band radars to monitor small garbage islands. Remote Sensing, 13(18), 3558.