Help from above, satellite technology to track marine litter

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The issue of Marine Plastic Littter has been in the media spotlight for over a decade (Wilcox et al., 2015) and ongoing research continue to highlight the detrimental impact plastic can have on the environment as a whole and more specifically on human health once it enters the food chain in the form of very small particles (Vriend et al, 2021, UNEP, 2021). It is now well understood that a large portion of these micros and nano plastic particles come from the breakup of larger plastic pieces (Andrady, 2017, Wayman & Niemann, 2021) and that, as there is no viable large-scale solution to collect these small particles, the focus should be on larger sizes, preferably on land or as close as possible to the source to reduce collection costs. Nowadays, all over the world, in response to the UN Development Goals and objectives set out in 2015 (United Nations General Assembly 2015), governments and developing agencies are teaming up to find solution to contain and reduce the amount of plastic that ends up in the marine environment (Schneider et al, 2018). Many collection systems have been developed, including barriers and autonomous collection vehicle and a lot of effort has been invested in tracking and monitoring plastic pollution along coastlines and in shelf seas, using remote sensing platforms such as drones and satellite and automatic counting software. In addition to these often-expensive solution, plastic tracking using dedicated tags provides an important and affordable alternative solution (Maximenko et al., 2012; van Sebille et al., 2012). that can help not only identify areas of accumulation but also gain greater understanding of the mechanisms that drive the movement of plastic particles from river systems all the way to the open ocean. In this paper, we present the results of a study funded by the WBG in Indonesia and discuss the wider opportunities offered by satellite tracking in support of reducing Marine litter.

Material and Method

The study area chosen for this investigation was the Indonesian Archipelago, one of the highest marine plastic contributors in the world (Vriend et al, 2021) The intention was to provide the KPP with a greater understanding of the fate of plastics litter. The focus was then given to the 3 most polluted rivers, namely the Cisadane River which runs through Jarkarta,,Musi that runs through Palembang on the Island of Sulawesi and Bengawan Solo a river to the East of Java that ruins through the city of Bojonegoro. In order to follow the movement of plastic litter, the MAR-GE/T tracker was chosen for its robustness, relatively low cost, and ease of operation. This tracker uses the low power ARGOS telemetry system which confers exceptional autonomy to reduced size tracking systems.

Throughout the year 2020, a total of 23 drifting buoys were deployed in the mouth of the 3 rivers: 2 trackers have been released as a trial in Cisadane in March, then pools of 5 trackers were released in each of the 3 rivers in July and finally, a last pool of 6 MAR-GE/T was released in Cisadane in October.

A Lagrangian modelling tool called MOBIDRIFT was used to simulate plastic debris dispersion and grounding around Indonesia. It is driven by wind, surface currents and tide as external forcing data and can then calculates the trajectories of multiple particles with varying wind and current sensitivity. Several coefficients of wind have been used to represent a diversity of plastic debris depending on their buoyancy: 0%, 1.5% or 3% of wind coefficient was applied on the particle advection. This enables the user to investigate the behavior of a wide range of plastic types.

By using a probabilistic approach in the simulations, a larger field of possibilities have been investigated increasing the accuracy by including uncertainties. All in all, more than 60 000 particules were simulated, numerically released in the river mouths of Cisadane, Musi and Bengawan Solo from July 2018 to March 2020.

Results :

By the end of 2020, most of the trackers got rapidly grounded: 11 devices got grounded within 10 days, 7 grounded within a month. But others drifted for several months and eventually crossed the Indian Ocean since 5 devices were still drifting in December 2020.

This is in keeping with the simulations results where about 99% of simulated particles grounded, most of the time in a close to the river mouth where they were released

Particles and trackers released in Cisadane river mouth were highly dependent on the season, but most of the particles rapidly grounded in the first kilometers of the coast West from Jakarta. In specific conditions of winds and currents, particles eventually drifted for several months towards the East to Papua Province or through the Sunda Strait into the Indian Ocean.

Results from Musi river mouth indicate a high consistency with particles and trackers grounded within the first days after release in a very close radius from the Musi delta. The tide seems to have a major impact causing back and forth movements and even trackers brought back upstream the river.

Regarding the results from Bengawan Solo, the dispersion of the particles discharged was extremely high, as was the proportion of particles still drifting after 3 months. An accumulation zone was identified on Pangkah Cape (East Java), but most of the particles and trackers drifted away towards the East to Sumatra Island and the Indian Ocean as well as to the West reaching Papua and the Timor Sea.

Discussion :

Combining in situ tracking data with drift model simulations provides a better understanding of the behavior of plastic throughout the year and in varying wind and current conditions, most notably in Indonesia in the dry and wet seasons. Beside trajectories of specific plastic types, the tag data provides critical ground truth information that enables the validation of the model, increasing the confidence in the accumulation zone identified. These are important as they indicate the areas that need to be monitored to assess the effectiveness of policies and measures put in place to combat the Marine Litter issue. The trajectories are also key in providing information on where the litter could be intercepted before it reaches a sensitive area such as a marine reserve or an area of touristic value.

Ideally, the tagging of plastic litter should be performed from the source all the way its final accumulation zone. This would enable a better understanding of the dynamics of plastic litter within rivers and estuaries and shed light on key events that lead to the grounding and remobilization of waste. Furthermore, in the case of marine plastic litter, known contributors to the problem such as fishing equipment could be tagged before they are put into the water. This would facilitate their recovery if they are lost as the tag would transmit their position in near real time.

Conclusion:

In this study, the fate of plastic released into the Indonesian archipelago was investigated using a combination of in situ data provided by satellite trackers and a drift modelling tool. This result show that depending on the time of year, the accumulation zone changes in location for the Cisadane and Solo River. For the Musi river, there is little variability in the location of the accumulation area. This combined approach can be easily replicated elsewhere and can help authorities identify the area that need to monitor to assess the effectiveness of measures implemented t combat marine plastic pollution.

References:

Andrady, A.L., 2017. The plastic in microplastics: A review. Mar. Pollut. Bull. 119,12–22 .https://doi.org/ 10.1016 /j.marpolbul. 2017.01.082.

Maximenko, N., Hafner, J., and Niiler, P. (2012). Pathways of marine debris derived from trajectories of Lagrangian drifters. Mar. Pollut. Bull. 65, 51–62. doi: 10.1016/j.marpolbul.2011.04.016

Meijer, L. J. J., van Emmerik, T., van der Ent, R., Schmidt, C., and Lebreton, L. (2021). More Than 1000 Rivers Account for 80% of Global Riverine Plastic Emissions into the Ocean. *Sci. Adv.* 7 (18). eaaz5803. doi:10.1126/sciadv.aaz5803

Sari D.A.A , Suryanto, A S Sudarwanto , S Nugraha, R Utomowati, 2021, Reduce marine debris policy in Indonesia IOP Conf. Ser.: Earth Environ. Sci. 724 012118

Schneider, F., Parsons, S., Clift, S., Stolte, A., McManus, M.C., 2018. Collected marine litter – A growing waste challenge. Mar. Pollut. Bull. 128, 162–174. https://doi.

org/10.1016/j.marpolbul.2018.01.011.

United Nations General Assembly (2015). Resolution 70/1. Transforming our world: The 2030 Agenda for 696Sustainable Development. October 21. A/RES/70/1.

United Nations Environment Programme (2021). From Pollution to Solution:A global assessment of marine litter and plastic pollution. Synthesis. Nairobi

van Sebille, E., England, M. H., and Froyland, G. (2012). Origin, dynamics and evolution of ocean garbage patches from observed surface drifters. Environ. Res. Lett. 7, 1–6. doi: 10.1088/1748-9326/7/4/044040

Vriend P., Hidayat H., van Leeuwen J., Cordova M. R., Purba N. P., Löhr A. J., Faizal I., Ningsih N. S., Agustina K., Husrin S., Suryono D. D., Hantoro I., Widianarko B., Lestari P., Vermeulen B., van Emmerik Tim, 202, Plastic Pollution Research in Indonesia: State of Science and Future Research Directions to Reduce Impacts ,Frontiers in Environmental Science , 9 DOI=10.3389/fenvs.2021.692907

Waymann C. & H. Niemann, 2021, The fate of plastic in the ocean environment –a minireview,Environ. Sci.: Processes, Impacts, 2021, 23, 198

Wilcox, C., Van Sebille, E., and Hardesty, B. D. (2015). Threat of plastic pollution to seabirds is global, pervasive, and increasing. Proc. Natl. Acad. Sci. 112, 11899–11904. doi: 10.1073/pnas.1502108112