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Observation of Floating Inorganic Macro-debris in The Downstream Citarum River using Manual Counting

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Abstract. Inorganic Macro-debris (IMD) such as plastics can negatively affect aquatic life and human wellbeing. Information about IMD transport in river systems is required to optimize prevention, mitigation, and reduction strategies. However, this data is currently lacking. Manual counting technique can be used to quantify and characterize macro-debris contamination and its transport in rivers. We demonstrate how this method can provide a rapid and cost-effective tool for characterization and quantification of floating macro-debris. This study aims to quantify the abundance of IMD, explore the spatio-temporal trends, and identify the composition of floating IMD in the downstream section of the Citarum River, West Java, Indonesia. Data collection was carried out in March and May 2021. Observations were performed between 8 AM and 5 PM across the whole river width across several days. Results showed that IMD transport varies between days, ranging from 60 to 350 pieces in March and 40 to 4700 IMD pieces per day in May. The magnitude of macro-debris is correlated with precipitation ($r=0.793$ and 0.622 for March and May, respectively). Spatially, concentration of macro-debris fluxes was observed close to river shores across the channel widths. The most frequent IMD category observed in March and May 2021 was Polystyrene (60% to 70%).

1. Introduction

Macro-debris refers to litter measuring >2.5 cm that is present in the environment. Negative impacts of macro-debris include entanglement with organisms, degradation of aesthetic value of the environment, and the potential risks posed by their breakdown products [1]. One common form of macro-debris which has received a lot of attention is macroplastics: pieces of plastic that are larger than 2.5 cm. Over time and depending on environmental exposure, this plastic litter may decompose at various rates depending on the polymer materials, density, type of functional group, hydrophobicity, and crystallinity [2]. In river systems, macro-plastics may break down into micro- and nano-plastics and can leak toxin additives [3] that may have negative impacts on the aquatic ecosystem including mangrove forests. Recent global estimates of riverine plastic emissions into the oceans vary between 0.4–2.75 million tons plastic per year [4, 5, 6]. Indonesia is estimated to be one of the largest plastic emitting countries in the world [4] mainly as a result of densely populated areas with high amounts of mismanaged plastic waste [7]. Additionally, many of the plastic items in the oceans originate from land and Indonesia is suggested as the second-largest producer of marine plastic debris after China, i.e., 0.48-1.29 million Mt/year [8]. Hence, as a preventive measure against marine plastic pollution, the



macro-plastics in rivers must be efficiently captured before they can degrade and fragment or be released to the oceans.

Observation of the transport of riverine macro-debris, which are major sources of marine debris, is crucial to optimize measures in formulating prevention, mitigation and reduction strategies. River plastic data are required to identify sources and to estimate plastic mass transport and also to investigate the variable mechanisms that determine its spatio-temporal variation. In previous research, riverine debris data were mainly obtained by net sampling from boats or bridges [9, 10, 11]. Even if such methods may give valuable insights into macro-debris composition, they require more field personnel and additional equipment. An alternative methodology to quantify macro-debris transport in rivers is visual observation. This method is a simple and cost-effective river macro-debris monitoring method which has now been applied in many rivers globally. Previous research conducted on the Saigon River using visual counting revealed that hydrometeorological factors such as wind, water level, and flow velocity are strongly influence to seasonal plastic transport [13, 14]. Other studies, such as the pan-European RIMMEL project carried out observations using visual methods in more than 40 rivers [15]. Visual counting of macro-debris is based on the approach first presented by González-Fernández and Hanke [12]. This method represents a straightforward approach to determine macro-debris flows at various sections across the river width. Manual counting is one such visual observation technique to quantify and characterize macro-debris. For this method, observers stand on bridges and count the amount of visible floating and superficially submerged debris for a certain duration. The observed macro-debris transport is expressed as total macro-debris items per unit of time or discharge and provided the magnitude information on floating macro-debris transport. Visual counting can be made by either trained volunteers or professionals and does not require any additional equipment or infrastructure. This method allows for (1) quantification of riverine macro-debris transport and its distribution over the river width, (2) study of spatio-temporal variation, and (3) also to determine macro-debris composition of each observed item.

In this paper, we aim to quantify the magnitude of floating inorganic macro-debris (IMD) in the surface flow in the river, explore the IMD distribution over the river width, and identify composition of IMD type. We used a case study on floating debris in the downstream Citarum River in West Java, Indonesia.

2. Material and Methods

2.1. Study Site and General Framework

This study focuses on the downstream Citarum River located in Muara Gembong, Bekasi District, Indonesia ($5^{\circ} 59' 4.27''\text{S}$, $107^{\circ} 2' 37.63''\text{E}$). The Citarum River flows from the district of Bandung with a watershed area of 6614 km^2 and a total river length of 297 km. The river predominantly flows through farmlands and the city of Bandung which is largely composed of industrial and residential areas. Due to mismanaged waste, the Citarum River is highly polluted with plastics and other types of waste [16].

The floating debris transport measurement technique is based on the visual counting method of González-Fernández and Hanke [12] and the adaptation by van Emmerik et al. [13], with site specific modifications. The adaptation includes a focus on macro-debris (vs. all anthropogenic litter without organic debris), and multiple measurement points along the river width (vs. only one location). Inorganic macro-debris counting was done at 6 locations across the Muara Gembong bridge (also called the Jokowi bridge) which is 65 m wide from the river bank and 10 m high from the river surface, during several observation periods in March and May 2021. Figure 1 indicates the measurement locations of macro-debris counting, which are further described in Section 2.2. Precipitation data were obtained from meteorological station of the Meteorological, Climatological, and Geophysical Agency (BMKG) in Bandung. Surface flow velocity was estimated using the 'Pooh sticks' method utilizing selected pieces of drift floating with the current across a known distance.

2.2. Inorganic macro-debris transport observation

The visual observation approach employed for the measurement of IMD flows in this study allows for the quantification and characterization of the visible floating fraction of total IMD transport. This may include some partially or fully submerged items, depending on the degree of turbidity influencing the depth of visibility. Counting was performed using human analysts who observed the visible floating material and categorized it by type. To facilitate the accurate detection of IMD across the full river width at this site (65 m), the river was divided into six segments with a width of 10-15 m each. This allowed for reasonable identification of IMD, including its composition, at the flow rate and IMD density at this site. The segments are depicted in figure 1.

Observations were undertaken from the bridge present at the sampling location, for a total of 10 minutes per segment. Each segment was observed sequentially, from the left to the right bank, so that the full river width was observed within one hour. All IMD passing through this section was counted and classified according to the categories detailed in Section 2.3. The lower size limit for accurate detection of IMD was judged to be 1 cm based on the observation height of 7 m and the defined segment widths. All sites were observed sequentially starting at section 1, so that the complete river width was covered in one hour at most. The number of items per hour per segment provides the spatial variation over the river width and the sum of the segments provide the total number of floating debris per hour over the whole river width.



Figure 1. Measurement location in the downstream Citarum River in Bekasi, West Java (Map: Google map 2021 modified by Siti Aisyah).

2.3. Inorganic macro-debris composition

The observed IMD were divided into two primary categories: (1) plastic, and (2) other materials. All plastic items were visually subdivided into Polyethylene Terephthalate (PET), Polystyrene (PS), High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Polyvinyl Chloride (PVC), Polypropylene (PP) based upon the product types that were observed. Each item was counted and assigned to a polymer category based on their common use:

- PET: transparent plastic bottles; usually used as packaging for drinks, cooking oil, and chili sauce
- PS: foam objects, such as lunch boxes and food trays;
- HDPE: milk and juice container, shampoo bottles, and medicine bottle.
- LDPE: grocery bag, plastic wraps; container lids, and coatings for paper milk cartons
- PVC: toys, water pipe, and electricity cable
- Other: all other inorganic objects that do not belong to one of the mentioned categories, e.g. rubber, wood, glass, textile).

3. Results and Discussion

3.1. Magnitude of riverine plastic debris transport

An overview of total floating inorganic debris transport of the downstream Citarum River, expressed as the number of inorganic macro-debris items over the full river width per day is shown in figure 2. IMD transport varies between days, ranging from 60 to 350 items/day in March and 40 to 4700 items/day in May. The magnitude of flux in May is higher than that of March. This may be explained by the higher precipitation that occurred in May compared to March, which may have mobilized IMD stored in the catchment.

The IMD flux seems to follow the flow velocity and precipitation data, although the scaling factor between them changes over time. The IMD flux follows the flow velocity from May 19 to May 23 but shows a different pattern on May 24. On the 3rd and 4th days (May 20 and May 21, 2021), the number of IMD was much less than other days. This pattern follows the pattern of precipitation and velocity at the same time.

In general, the IMD flux also follows the magnitude of precipitation in May. Based on statistical analysis, the correlation value (r) of IMD number and precipitation value in March and May were 0.793 and 0.622, respectively. We have not enough velocity data on March but depend to precipitation rate; generally the IMD follows with the magnitude of precipitation. These patterns suggest that macro-debris transport is not only related to flow velocity and precipitation, but also strongly depends on the temporal variation of input of land-waste inorganic waste in river systems [14].

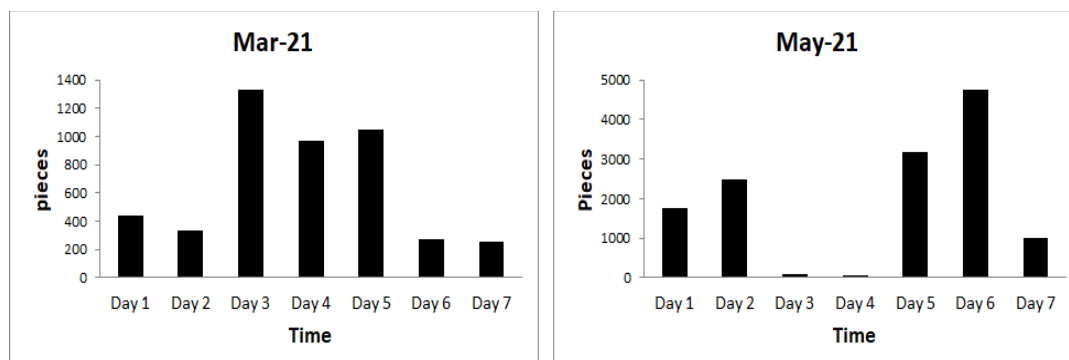


Figure 2. The daily amount of Inorganic macro-debris items transported in downstream Citarum River.

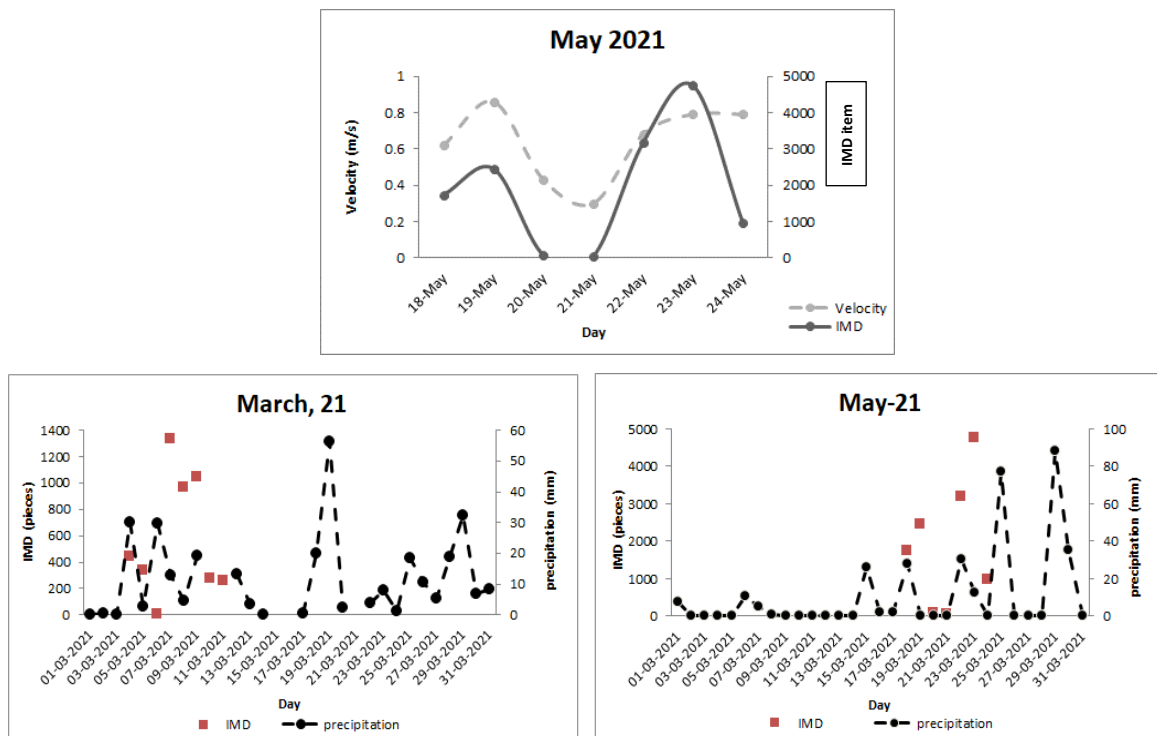


Figure 3. Inorganic macro-debris items per hour and measured daily mean flow velocity and daily precipitation rate.

3.2. Distribution of plastic debris over the river width

Figure 4 presents the cross-sectional profiles of the inorganic macro-debris (IMD) flux for March and May 2021. These results demonstrate the variation of IMD transport across the river width at different observation times during the sampling days. At this site, the macro-debris transport was always in a downstream direction especially in the morning until afternoon. During periods of positive flux, macro-debris is concentrated on the south side around 20 m (March 4, 5, 7) and the north side around 30 m (March 8, 9, 10). While in May, macro-debris flux was concentrated on the south side around 10 m to 30 m.

During the negative flux, that occur in the afternoon make the water stagnation and macro-debris was not moving (see 18th-22nd May). In the Citarum River, when the wind from the sea towards the land is strong, the debris floating in the river is almost non-existent. This condition shows that wind is also a significant factor.

Figure 5 shows the variation in IMD counts across different variables: the sampling day, the river width and the measurement time. As previously mentioned, more IMD was detected in May than March, which is likely connected to the higher precipitation and flow velocities. The variability in daily IMD counts can be linked to antecedent conditions, with precipitation events typically preceding high IMD counts (figure 3). During the 4th and 5th March and between 18th-22nd May, IMD flows were most significant in segments 1 and 2, close to the south-hand bank. In March, this trend flipped to favour transport closer to the north bank during the last sampling days. On May 23rd and 24th, more significant variability is observed across the river width. Higher IMD counts were typically observed during the morning hours across most sampling days, with peaks between 08:00 and 09:00. In many cases, zero measurements were observed during later hours in the day. There are some exceptions to this trend; for example there is a mid-afternoon peak observed around 16:00 during the 7th-10th March.

3.3. The composition of floating inorganic macro-debris

The most frequent plastic category observed in March and May were PS (60% to 70%) followed by PET and others were < 30% (figure 5). These results are similar to the observations in Saigon River [13]. Very little PP was found (<1% of the count). Most of the identified pieces were related to consumables (food and beverages) which is represented by PET, with a clear peak for PS foam food containers and fragments.

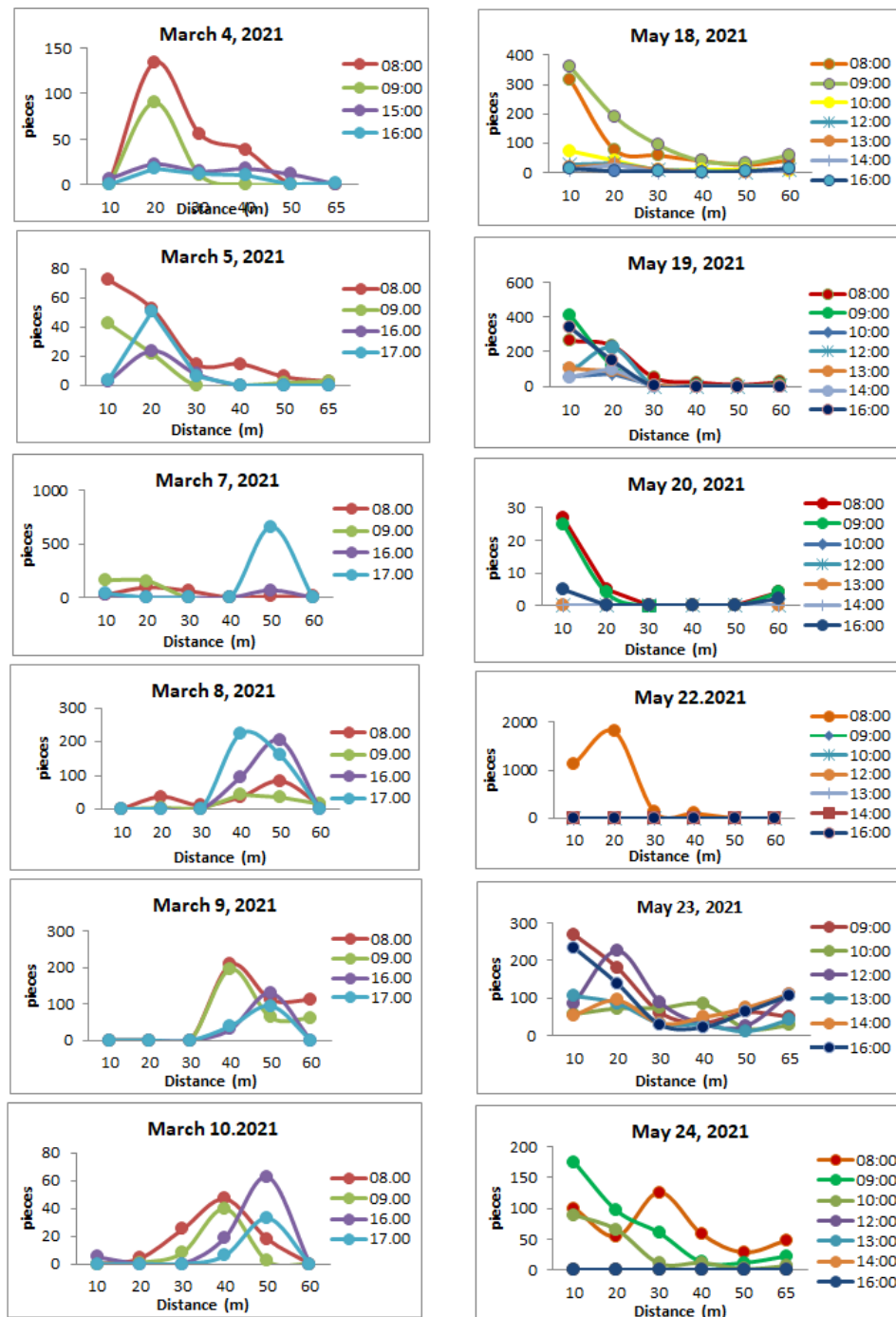


Figure 4. Cross-sectional profiles of observed plastic pieces per hour over the river width for March and May 2021.

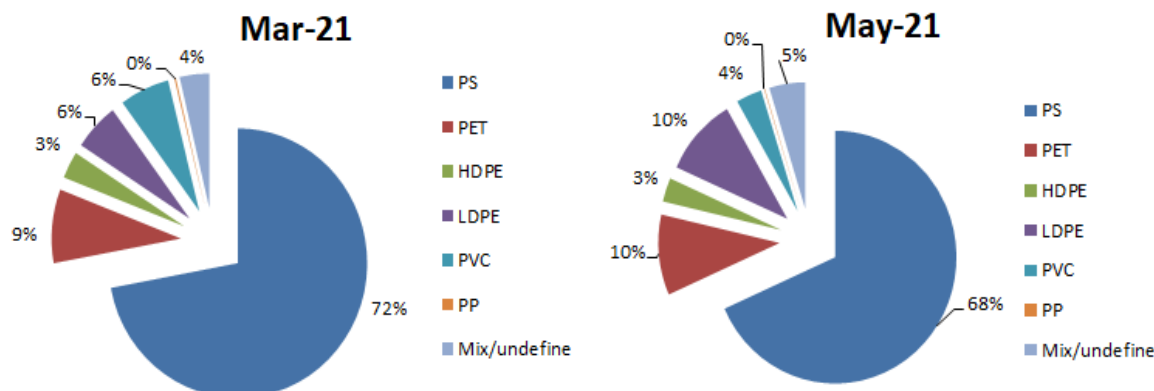


Figure 5. Plastic piece identification including plastic composition.

Riverine macroplastic research is an emerging scientific field, and field assessments are still limited. A lot of data is needed to reveal the spatio-temporal variations of plastic transportation in the Citarum River. A follow-up study is crucial to increase data availability that contributes to improving our understanding of river plastic transport and to evaluate potential mitigation measures.

4. Conclusion

The two-month observation result, inorganic macro-debris magnitude in downstream Citarum River is estimated to be between 30 to 5000 pieces per day. Macro-debris flux in May was higher than that of March. There are correlations between precipitation and the magnitude of macro-debris, indicating that this is an important control of IMD flows. The primary flows of IMD occur close to the banks. Most of the identified pieces were related to consumables (food and beverages) which are represented by PET and EPS foam food containers and fragments.

Acknowledgement

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References

- [1] Gall S and Thompson R 2015 The impact of debris on marine life *Mar. Pollut. Bull.* **92** 170–179
- [2] Wilkes R A and Aristilde L 2017 Degradation and metabolism of synthetic plastics and associated products by *Pseudomonas* sp.: capabilities and challenges *J. Appl. Microbiol.* **582**–593
- [3] Weinstein J E, Crocker B K, Gray A D 2016 Macroplastic to microplastic: Degradation of high-density polyethylene, polypropylene, and polystyrene in a salt marsh habitat *Environ. Toxicol. Chem.* **35** 1632–1640
- [4] Ivar do Sul J A, Costa M F and Fillmann G 2014 Microplastics in the pelagic environment around oceanic islands of the Western Tropical Atlantic Ocean. *Water Air Soil Pollut.* **225** 2004
- [5] Lebreton L C, Van der Zwet J, Damsteeg JW, Slat B, Andrady A and Reisser J 2017 River plastic emissions to the world's oceans *Nat. Commun.* **8**
- [6] Schmidt C, Krauth T, and Wagner S 2017 Export of plastic debris by rivers into the sea *Environ. Sci. Technol.* **51** 12246–12253
- [7] Lebreton L and Andrady A 2019 Future scenarios of global plastic waste generation and disposal *Palgrave Commun.* **5**

- [8] Jambeck J R, Geyer R, Wilcox C, Siegler T R, Perryman M, Andrady A, Narayan R and Law KL 2015 Plastic waste inputs from land into the ocean *Science* **347** 768–71
- [9] Moore CJ, Lattin GL and Zellers AF 2011 Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California *J. Integr. Coast. Zone Manage* **11** 65–73
- [10] Lechner A, Keckeis H, Lumesberger-Loisl F, Zens B, Krusch R, Tritthart M, et al. 2014 The Danube so colourful: a potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. *Environ. Pollut.* **188** 177–181
- [11] Sadri S S, and Thompson R C 2014 On the quantity and composition of floating plastic debris entering and leaving the Tamar Estuary, Southwest England. *Mar. Pollut. Bull.* **81** 55–60
- [12] González-Fernández D, & Hanke G 2017 Toward a harmonized approach for monitoring of riverine floating macro litter inputs to the marine environment *Frontiers Marine Sci.* **4** 86
- [13] Emmerik T V, Kieu-Le T C, Loozen M, van Oeveren K, Strady E, Bui X T, ..., Schwarz A 2018 A methodology to characterize riverine macroplastic emission into the ocean *Frontiers Marine Sci.* **5** 372
- [14] Emmerik T V, Strady E, Kieu-Le T C, Nguyen L & Gratiot N 2019 Seasonality of riverine macroplastic transport *Scientific Reports* **9** 1–9
- [15] González-Fernández D, Hanke G, Marin J V, & Cabañas A C 2019 *Modelling floating macro litter loads from rivers to the marine environment based on visual observations* (Vienna: European Geosciences Union General Assembly)
- [16] Soeriaatmadja W 2018 Military Sent in to Clean Up Indonesia's Citarum River Available at: <https://www.straitstimes.com/asia/se-asia/military-sent-into-clean-up-indonesias-citarum-river> (accessed June 1, 2021)
- [17] Emmerik T V, and Schwarz A 2020 Plastic debris in rivers *WIREs Water* e1398:7. doi: 10.1002/wat2.1398