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Impacts of Microplastic Pollution in Freshwater System in Kampung Jambu Lapan, Negeri Sembilan

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Abstract

The prevalence of microplastic pollution in freshwater environmetal poses a severe ecological issue because of the persistence and possible bioaccumulation nature of the material. This study investigates the presence, morphological characteristics, and polymer composition of microplastic in the freshwater system of Kampung Jambu Lapan in Negeri Sembilan. The primary objective was to suggest the effective and eco-friendly solution for reduce the microplastic pollution impacts. Five liters water sample were collected in dry and rainy seasons using the grab sampling method whereby microplastics were separated using density separation and filtration. Stereomicroscopy was used to make morphological identification and Fourier Transform Infrared (FTIR) was used to identify the type of polymer with certainty.The number of microplastic was between 3 and 4 particles per sample during the dry and rainy seasons. However, the sample sizes of rainy-day samples (S4 to S6) were always bigger and the FTIR spectra were clear, which allowed the positive identification of the polymers, in contrast to dry-day samples, where the moisture interfered with the analysis.This implies that the first cause of plastic influx into the riverine system is storm-driven surface runoff. The most common morphology consisted of fibres and fragments with a majority of the particles less than 1 mm. FTIR was used to identify polydimethylsiloxane (PDMS) as the dominant polymer, which is a major contributor of domestic and urban wastewater. The results are a valuable baseline information in the area and they demonstrate the importance of hydrological cycles in the microplastic cycle. In order to reduce these effects, integrated source control plans and long-term monitoring plans are essential towards the health of freshwater ecosystems.

1. Introduction

Small plastic particles less than 5 mm are known as microplastics, and they have become common pollutants in water bodies due to large-scale manufacturing and inadequate disposal methods for plastic materials (Andrady, 2011). Although marine microplastic contamination has become a major topic of discussion, freshwater bodies such as rivers and lakes are now recognised as important pathways and accumulation points for microplastics (Wagner et al., 2014).

Microplastic pollution in rivers originates from various sources, including urban runoff, effluents from wastewater treatment plants, industrial discharges, agricultural activities, and the fragmentation of larger plastic debris (Browne et al., 2011; Eerkes-Medrano et al., 2015). Weather variability, especially rainfall, plays a significant role in mobilising and redistributing microplastics through surface runoff and increased river discharge (Hurley et al., 2018).

Research on microplastic pollution in freshwater systems is limited and fragmented in Malaysia, particularly in tropical river systems, where hydrological properties differ greatly from those in temperate regions. Rivers such as the Muar River are major water sources for domestic, agricultural, and ecological purposes, highlighting the importance of evaluating microplastic contamination in these systems.

Consequently, the objectives research is expected to explore the occurrence, distribution, and nature of microplastics in a freshwater river system under varying weather patterns. The results can serve as a baseline for tropical river systems and help to understand the environmental consequences of microplastic pollution in Malaysia.

2. Methodology

The study employed a combination of field and laboratory research to determine the occurrence and distribution of microplastics in surface water at the confluence of the Muar and Jempol Rivers. To assess the effects of weather variability on microplastic prevalence, surface water samples were collected during both dry and rainy seasons and analysed using conventional extraction, microscopic identification, and polymer characterisation methods, including Fourier Transform Infrared (FTIR) spectroscopy.

2.1 Study Area and Sample Collection

The study employed a combination of field and laboratory research to determine the occurrence and distribution of microplastics in surface water at the confluence of the Muar and Jempol Rivers. To assess the effects of weather variability on microplastic prevalence, surface water samples were collected during both dry and rainy seasons and analysed using conventional extraction, microscopic identification, and polymer characterisation methods, including Fourier Transform Infrared (FTIR) spectroscopy.

The research was conducted at the meeting point of the Muar and Jempol Rivers in Kampung Jambu Lapan, Negeri Sembilan, Malaysia. This site, a tropical river habitat surrounded by residential areas and human activities, was considered suitable for evaluating microplastic pollution in a freshwater system. The confluence area was selected as it represents a mixing zone likely to contain pollutants.

Fig. 1 *Sampling activity conducted on site*

Sampling was done at some of the points of the river confluence. At each of the sampling points, about 5 L of surface water was sampled with the help of a sampling rod and put into clean high-density polyethylene (HDPE) containers. Sampling and storage were of the normal procedures as suggested by APHA (2012). All the sampling equipment was rinsed with distilled water in order to minimise the risk of contamination. The samples were collected and then taken to the laboratory to analyze.

2.2 Sample Preparation and Laboratory Analysis

All laboratory tests were conducted according to standard procedures to extract, identify, and characterise microplastic particles in surface water samples. Care was taken throughout the process to minimise contamination, including the use of non-plastic equipment where necessary and performing the analysis in a controlled laboratory environment.

2.2.1 Filtration and Density Separation

Surface water samples collected from the study area were initially filtered to remove gross debris and other non-plastic particles. Density separation was performed using a saturated sodium chloride (NaCl) solution with an approximate density of 1.20 g/cm^3 to isolate low-density microplastic particles. The samples were thoroughly mixed to ensure uniformity and then allowed sufficient time to settle, enabling effective separation. After sedimentation, the supernatant containing buoyant particles was carefully decanted and set aside for further use.

2.2.2 Digestion of Organic Matter

Chemical digestion was applied to the separated samples to remove organic matter that could interfere with microplastic identification. The digestion process was conducted at a controlled temperature to optimise the removal of organic matter and minimise potential degradation of plastic particles. This step was necessary to improve sample clarity and enhance the accuracy of subsequent microscopic and spectroscopic analyses.

2.2.3 Microscopic Observtion

The remaining particles after digestion were examined under a stereomicroscope to preliminarily identify possible microplastics. Physical characteristics such as shape, size, colour, and surface texture were used for visual identification. To facilitate further analysis and comparison of samples collected under different weather conditions, identified particles were classified into morphological groups, with fragments and fibres being the most common.

Fig. 2 *Stereo microscope model SZX16-S4-GEO*

2.2.4 FTIR Analysis

Fourier Transform Infrared (FTIR) spectroscopy was used to analyse selected suspected microplastic particles to determine their polymer composition. The infrared spectra obtained were compared with reference spectra from available spectral libraries. Polymer types were identified by the characteristic absorption peaks, particularly in the fingerprint region, which verifies the presence of plastic materials in the samples.fter digestion, the remaining particles were examined under a stereomicroscope. Suspected microplastics were visually identified and categorised based on their physical properties, such as shape, size, and colour. The particles were classified into groups such as fibres and fragments for further analysis.

Fig. 3 *Agilent Cary 630 FTIR*

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3. Result and Dicussion

This section presents the findings of microplastic analysis conducted on surface water samples from the intersection of the Muar and Jempol Rivers. Six samples were analysed. The results include the presence of microplastics, their morphological features under the microscope, and the identification of polymers by Fourier Transform Infrared (FTIR) spectroscopy. The effect of weather variability on the presence of microplastics and the detectability of polymers is also compared under dry and rainy conditions.

3.1 Microplastics Occurance and Abundance

Microplastics were identified in all six samples, confirming their presence in the freshwater system during both dry and rainy seasons. This finding supports previous studies that have reported the widespread occurrence of microplastics in riverine environments, regardless of seasonal variation (Andrady, 2011; Eerkes-Medrano et al., 2015). Each sample contained between three and four particles, indicating that the overall microplastic abundance at the sampling site was relatively low.

Samples collected during rainy conditions showed slightly greater uniformity in microplastic identification compared to those collected on dry days. This pattern suggests that rainfall events can enhance the mobilisation and transport of microplastics into river systems through surface runoff, stormwater discharge, and soil erosion. Similar observations have been reported in previous freshwater studies, where increased runoff during rainfall contributed to the redistribution of microplastics from surrounding catchments into rivers.

The relatively low abundance observed in this study is consistent with findings from semi-urban or less industrialised catchments, where microplastic concentrations are generally lower than those reported in highly urbanised or industrial river systems. This may be attributed to limited industrial discharge, lower population density, and reduced plastic input sources in the surrounding area. Local land-use characteristics therefore play an important role in determining microplastic abundance in freshwater environment.

3.2 Morphological Characteristics of Microplastics

Microscopic analysis of the six surface water samples revealed that irregular fragments comprised the majority of microplastics during both dry and rainy conditions. In some samples, particularly S2 and S6, fibres and rod-like particles were also observed. The predominance of fragments indicates the breakdown and fragmentation of larger plastic debris, an occurrence frequently reported in freshwater and riverine microplastic research. Fragment-type microplastics are typically associated with secondary microplastics that result from physical, chemical, and biological weathering.

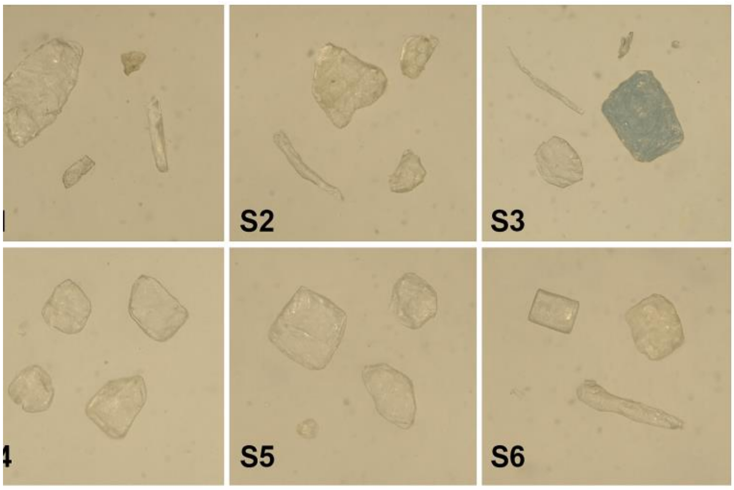

Fig. 4 *Microscopic observation of microplastic*

The size distribution of microplastics varied between rainy and dry conditions. Samples collected during the rainy season tended to contain more large particles, indicating that rainfall may contribute to the transport of larger and less fragmented plastics into the river system via surface run-off. Smaller particles, on the other hand, were more common in dry-day samples, likely due to prolonged environmental exposure, mechanical abrasion, and fragmentation occurring within the river channel itself. The results of previous studies regarding the effect of hydrological conditions on microplastic transport showed similar seasonal changes in size.

The majority of the microplastics observed were white or transparent, indicating high levels of weathering and photodegradation. Excessive exposure to ultraviolet radiation and oxidative processes can cause plastics to lose their colour over time, resulting in light-coloured or colourless particles. Coloured microplastics (such as the blue fragment in sample S3) were occasional and may represent more recent additions to the plastic load. Surface texture analysis also revealed that microplastics collected under dry conditions were rougher and more angular, while those collected on rainy days were smoother. These differences suggest variations in environmental residence time and indicate that rainfall may introduce newer or less weathered particles into the river system.

Table 1 *Summary of morphological characteristics of microplastics*

Sample	Weather condition	Shape	Size range (mm)	Colour	Surface texture	Remarks
S1	Dry	Irregular fragments	0.1–1.0	Transparent / white	Rough, angular	Low microplastic abundance
S2	Dry	Fragments and rod-like particle	0.2–1.0	Transparent / white	Rough surfaces	Presence of elongated particle
S3	Dry	Fragments	0.2–1.5	Transparent / white, blue	Mixed textures	Highest morphological variety
S4	Rainy	Irregular fragments	0.3–1.0	Transparent / white	Smooth to semi-rough	Slight increase in abundance
S5	Rainy	Large irregular fragments	0.5–1.5	Transparent / white	Rough, chipped edges	More weathered particles
S6	Rainy	Fragments and rod-like particle	0.3–1.2	Transparent / white	Mixed smooth/rough	Consistent with rain wash-in

3.3 Polymer Indentification using FTIR

The composition of the polymer in the sampled microplastics was determined using Fourier Transform Infrared (FTIR) spectroscopy. The analysis focused on the fingerprint region (600–1500 cm^{-1}), which is essential for polymer identification. The samples collected during dry and rainy periods showed marked differences.

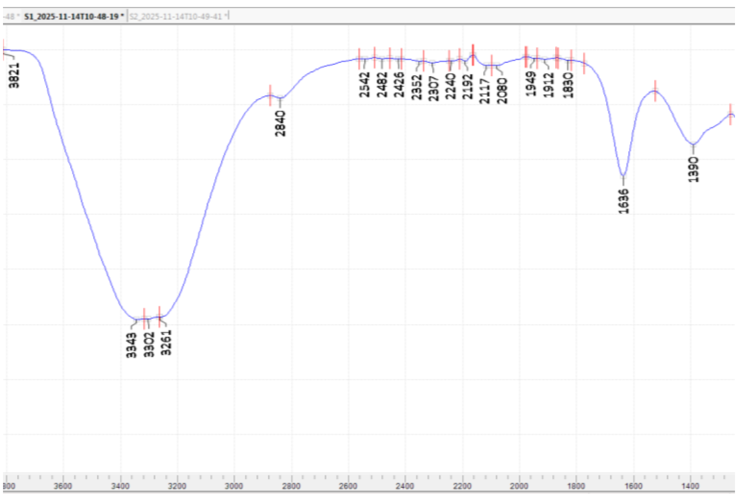

Fig. 5 *S1 FTIR Graph*

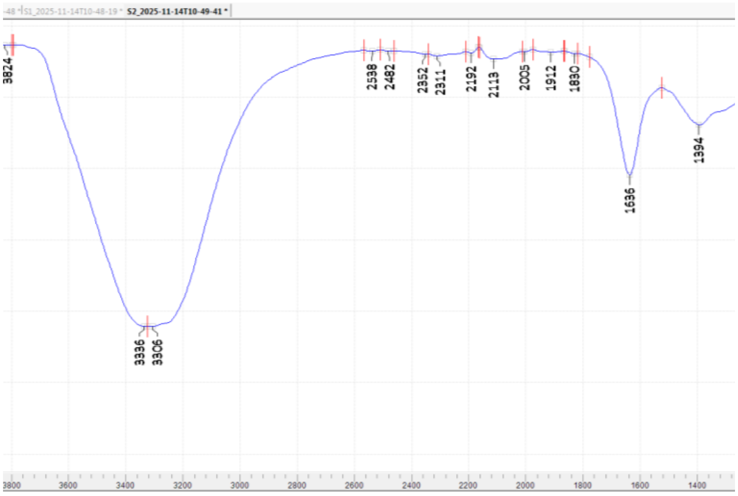

Fig. 6 *S2 FTIR graph*

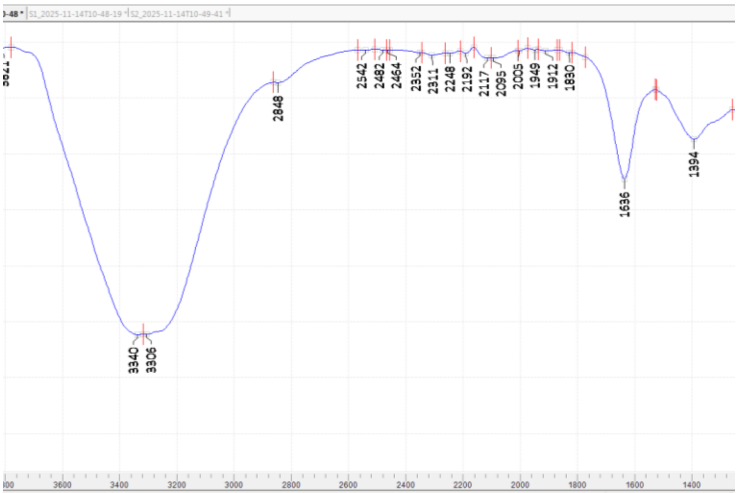

Fig. 7 *S3 FTIR graph*

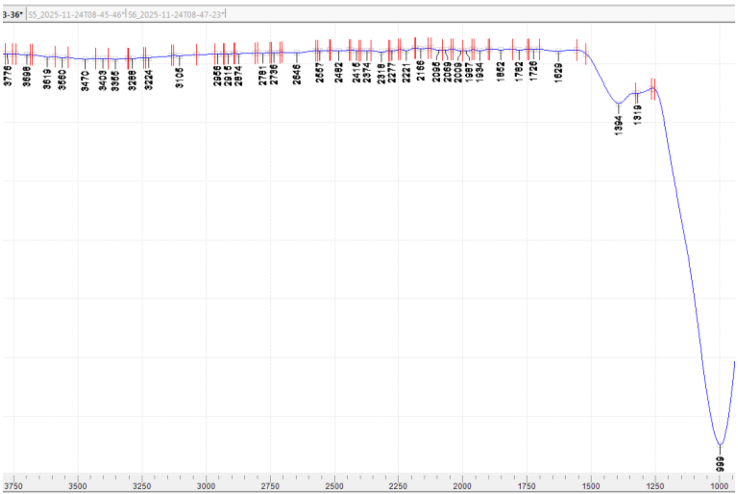

Fig. 8 *S4 FTIR graph*

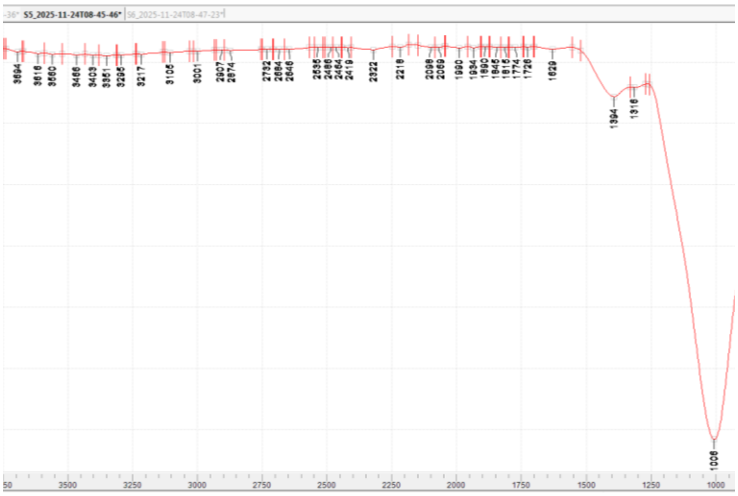

Fig. 9 *S5 FTIR graph*

Fig. 10 *S6 FTIR graph*

Samples S1, S2, and S3, considered dry-day samples, exhibited broad O–H and N–H absorption bands, indicating significant interference from moisture, which obscured the fingerprint region. Such interference is frequently observed in FTIR analysis of environmental microplastics, especially when particles contain moisture or organic residues. As a result, polymer identification failed for samples S1 and S2. Sample S3 showed only recognisable absorption peaks of silicone-based materials.

In contrast, FTIR provided clearer and more interpretable spectra for samples collected during rainy weather (S4–S6). Si–O–Si stretching vibrations at 1000–1100 cm^{-1} and $Si–CH_3$ bands between 780–1400 cm^{-1} enabled confident identification of polydimethylsiloxane (PDMS). The improved spectral quality can be attributed to lower contamination levels or more effective cleansing of particle surfaces due to rainfall, resulting in a stronger polymer signal. Similar enhancements in polymer detectability under specific environmental conditions have been reported in other FTIR-based microplastic studies.

Table 2 *Summary of FTIR polymer identification*

Sample	Weather condition	Key FTIR characteristics	Polymer identified
S1	Dry	Broad O–H and N–H bands; fingerprint region obscured	Not identifiable
S2	Dry	Moisture-dominated spectrum; weak polymer signals	Not identifiable
S3	Dry	Si–O–Si bands (1000–1100 cm^{-1}), CH_3 peaks	PDMS
S4	Rainy	Clear Si–O–Si stretching bands	PDMS
S5	Rainy	Strong silicone-based peaks	PDMS
S6	Rainy	Si–O–Si and $Si–CH_3$ bands (780–1400 cm^{-1})	PDMS

3.4 Comparison Between Dry and Rainy Conditions

There were clear differences between the microplastic samples collected in the dry and rainy seasons, particularly in the quality of FTIR spectra and the identification of polymers. The quantity of microplastic particles observed in both cases was similar, but weather variability had a strong impact on particle properties and analytical results.

The quality of FTIR spectra from dry-day samples was poor due to strong absorption bands in the spectrum caused by moisture, which obscured polymer-related signals. Conversely, rainy-day samples produced clear spectra, making it easy to identify PDMS in all rainy samples. These results suggest that weather conditions may affect not only the transport and characteristics of microplastics, but also the efficiency of polymer identification methods.

Additionally, rainy-day samples were more likely to contain larger and smoother particles, suggesting that rainfall events facilitate the mobilisation of less weathered microplastics into the river system. Overall, the findings show that weather conditions should be considered when evaluating microplastic pollution and interpreting FTIR-based polymer identification in freshwater settings.

4. Conclusion

This paper closely examined the presence, characteristics, and polymer structure of microplastics in the surface water at the confluence of the Muar and Jempol Rivers during both dry and rainy seasons. Microplastics were detected in all samples, indicating their presence in the freshwater system under study, even though the total number was relatively low.

Microscopic examination revealed that the most common type of microplastic was an irregular fragment, with particle sizes ranging from 0.1 mm to 1.5 mm. Older particles were more prevalent during rainy weather, suggesting that the movement of microplastics through surface runoff increases when it rains. The majority of the particles were white or transparent, signifying a high level of environmental weathering.

FTIR analysis showed that polymer identification was mostly ineffective in dry-day samples due to moisture interference, whereas in rainy-day samples, clearer spectra allowed confident identification of polydimethylsiloxane (PDMS). The results indicate that weather parameters greatly affect microplastic properties and the accuracy of polymer identification. Overall, the research provides baseline information on freshwater microplastic pollution in a tropical river system, as well as highlighting the significance of weather variability in the study of microplastics.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

All authors of this study have a complete contribution for data collection, data analysis and manuscript writing.

References

Journal

[i]. Andrady, A. L. (2011). Microplastics in the marine environment. Marine Pollution Bulletin, 62(8), 1596–1605. https://doi.org/https://doi.org/10.1016/j.marpolbul.2011.05.030

[ii]. American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF) (2012). Standard Methods for the Examination of Water and Wastewater. 21st Edition. Washing, DC.

[iii]. Browne, M. A., Crump, P., Niven, S. J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks. Environmental Science & Technology, 45(21), 9175–9179. https://pubs.acs.org/doi/10.1021/es201811s

[iv]. Eerkes-Medrano, D., Thompson, R. C., & Aldridge, D. C. (2015). Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. Water Research, 75(1), 63–82. https://doi.org/10.1016/j.watres.2015.02.012

[v]. Hassan, I., Sethupathi, S., Bashir, M. J. K., Ahmad, A. L., & Parthasarathy, P. (2025). Tracking microplastics at the source: a comparative study of fluorescent and FTIR microscopy at a drinking water intake in the Perak River, Malaysia. Environmental Monitoring and Assessment, 197(6), 702. https://doi.org/10.1007/s10661-025-14127-x

[vi]. Hurley, R., Woodward, J. & Rothwell, J.J. Microplastic contamination of river beds significantly reduced by catchment-wide flooding. Nature Geosci 11, 251–257 (2018). https://doi.org/10.1038/s41561-018-0080-1

[vii]. Li, J., Liu, H., & Paul Chen, J. (2018). Microplastics in freshwater systems: A review on occurrence, environmental effects, and methods for microplastics detection. Water Research, 137(137), 362–374. https://doi.org/10.1016/j.watres.2017.12.056

[viii]. Ministry of Environment and Water Malaysia. (2020). Solid Waste Management in Malaysia: Legal Framework and Policy.

[ix]. United Nations Environment Programme (UNEP). (2018). Combating marine plastic litter and microplastics: An overview of the actions taken by the United Nations Environment Programme. UNEP. https://wedocs.unep.org/handle/20.500.11822/25496

[x]. Wagner, M., Scherer, C., Alvarez-Muñoz, D., Brennholt, N., Bourrain, X., Buchinger, S., Fries, E., Grosbois, C., Klasmeier, J., Marti, T., Rodriguez-Mozaz, S., Urbatzka, R., Vethaak, A. D., Winther-Nielsen, M., & Reifferscheid, G. (2014). Microplastics in freshwater ecosystems: what we know and what we need to know. Environmental Sciences Europe, 26(1). https://doi.org/10.1186/s12302-014-0012-7