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PERSPECTIVE

Collaboration and infrastructure is needed to develop an African perspective on micro(nano)plastic pollution

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Abstract

Our current understanding of environmental micro(nano)plastic (MNP) pollution is driven by field and lab-based studies performed predominantly by and in wealthier countries. However, mismanaged waste and its consequences affect low- and middle-income countries over-proportionately. Evidence suggests that studies on MNP pollution in Africa are critically limited by the scientific infrastructure available, restricting research activities to opportunities for external collaboration with established research laboratories in the Global North. The development of Pan-African research networks and analytical nodes, is required to support intra-African research exchange and training, and drive evidence-based policy relevant to an African context. This can facilitate more inclusive conversations around the harmonization and standardization of methods currently mainly available to the Global North.

1. Introduction

While the global rise in plastic pollution represents one of the most pressing environmental challenges of our lifetime, some of the poorest countries in the world, many of them located on the African continent, are affected over-proportionally by the consequences of plastic waste mismanagement. Despite our current efforts, Borrelle *et al* (2020) suggests that by 2030, global plastic emissions may reach 53 million metric tons per year, an increase from 8 million metric tons in 2010. The state of plastic pollution in parts of Africa is dramatic, as a result of weak policies and indiscriminate dumping of solid waste (Bundhoo 2018). Five African countries (i.e. Algeria, Egypt, Morocco, Nigeria and South Africa) are listed among the top 20 countries estimated to contribute the most to marine plastic pollution (Jambeck *et al* 2015). Africa's contribution to plastic pollution is expected to increase due to predicted population growth, rapid urbanization and the shift to a more plastic dominated consumer market (Jambeck *et al* 2018). The environmental impacts of plastic pollution in Africa will likely be accelerated, especially if plans to flood 'poorer' countries with plastic waste are to go ahead (Tabuchi *et al* 2020). This perceptive will focus on the smaller size fractions, namely microplastic ($\leqslant$5 mm) and nanoplastic ($\leqslant$1 μm) particles (MNP). Although these particles may contribute only a small fraction, by weight, to the total global plastic pollution crisis (Ryan *et al* 2020), their overall abundance and potential toxicity, to humans, animals and plants, increase as sizes decrease (see for example Choi *et al* (2020)). Research looking at the full size range of plastic pollution is needed (see for example Ryan *et al* (2020)), however, specific hurdles faced when investigating MNP are discussed here especially as the availability, accessibility and affordability of technologies required for accurate quantification decreases as we shift from ‘larger’ to ‘smaller’ debris. In consequence, quantitative MNP research faces specific challenges and limitations that are different to investigations of macroplastics for instance.

While globally, MNP research has increased exponentially in the last few decades, with over 3800 articles published between 2005 and 2020. Many studies come from specific geographical regions, with the top contributors being the People’s Republic of China (22%), USA (13%), Germany (10%), England (9%) and Italy (8%). In contrast, South Africa, Nigeria, Tunisia, Egypt, Kenya, and other African countries, cumulatively contributed a mere 3% (ISI Web of Knowledge, accessed in 2020). Given the sheer magnitude of the environmental plastic pollution problem in Africa, and the fact that microplastic research on the continent began in the 1980s (Alimi *et al* 2021), one should expect a higher contribution.

2. Challenges MNP research in Africa is currently facing

Most knowledge on MNPs in the environment have been based on studies performed outside of Africa, in areas that are likely to differ in their sources, concentrations, and types of MNP pollution. Associated surface contaminants may also differ, as well as degradation, fouling, and aggregation rates of MNPs, due to different environmental and anthropogenic factors (Shahul Hamid *et al* 2018). As these factors influence exposure mechanisms, one can also expect ecological toxicity to vary (Krause *et al* 2021). To advance MNP research in Africa we need to provide analytical capacity that enables investigation of the specific geographical context of MNP sources, pathways, and mechanisms. For example, indiscriminate dumping of solid waste often occurs along rivers in low- and middle-income countries (Bundhoo 2018). However, the role these sites play in the contribution of MNPs to the aquatic environment is under-studied. The burning of plastic items may also be a major MNP source rather than a termination point of plastic pollution (Yang *et al* 2021). The African blind spot of MNP research causes a critical information gap that urgently needs to be closed, as scientists call for the generation of accurate and comparable datasets that are regionally relevant and simultaneously contribute to our global understanding of MNP transport and fate through environmental compartments.

Compared to other environmental contaminants, the investigation of MNP pollution is still in its infancy, with scientific standards for analysis, reporting, and interpretation only now being developed. In many respects, the current formative phase of defining and agreeing on guidelines, standards, and protocols will shape the way MNP research is conducted in the future. It is hence paramount to ensure that widespread access to agreed protocols and standards will be available to enable and even foster inclusivity of the most affected regions.

Our ability to study plastic pollution across wider size fractions, with higher precision, level of detail, and sample throughput, is driven by analytical advances over the last couple of years. It is, therefore, obvious that access to analytical facilities is instrumental for advancing MNP research, especially considering the range of scientific equipment and reagents needed to accurately quantify MNPs in various matrices. However, identifying particles <0.5 mm requires state-of-the-art technologies (Shim *et al* 2017) that at present do not appear to be available without external partnerships (figure 1 and table S1 (available online at stacks.iop.org/ERL/16/021002/mmedia)). There were only two publications without external partnerships that claimed to have local capacity to detect particles <0.5 mm, which could not be verified here as detection limits of the used analytical equipment were not reported (figure 1 and table S1).

As corroborated by Naidoo *et al* (2020a) MNP research in developing countries is often critically impeded by the lack of access to instrumentation. As a result of this, we see large fractions of scientific papers by African labs being published without polymer identification (Alimi *et al* 2021), with authors frequently citing the lack of access to relevant equipment as the main reason. Polymer identification has, however, become a reporting standard when investigating environmental MNP pollution and is increasingly seen as a requirement for publication. This is because polymer identification confirms visual accuracy and offers insight into possible pollution sources.

To overcome access restrictions, African researchers successfully collaborate with established research laboratories outside the continent. For instance, Akindele *et al* (2019) investigated microplastic contamination associated with gastropods in Nigeria, with polymer identification being supported through the German Academic Exchange Service (DAAD). Similarly, Naidoo *et al* (2020b) were supported by the Association of Commonwealth Universities, Blue Charter Fellowship to examine microplastics within juvenile fish associated with mangroves in South Africa. While these represent successful examples of initiatives to train the next generation of early career researchers, those African researchers are restricted in their ability to apply their newly gained knowledge when confronted with a lack of access to the required analytical facilities back home, locking them into a dependency to Northern hosts if they want to perform polymer identification. The inaccessibility of analytical techniques, frequently available to researchers from established Northern MNP laboratories, leaves African MNP scholars isolated, and reliant on gaining access to external facilities; a concept of scientific dependence that has relevance beyond the research of plastic pollution (Hountondji 1990).

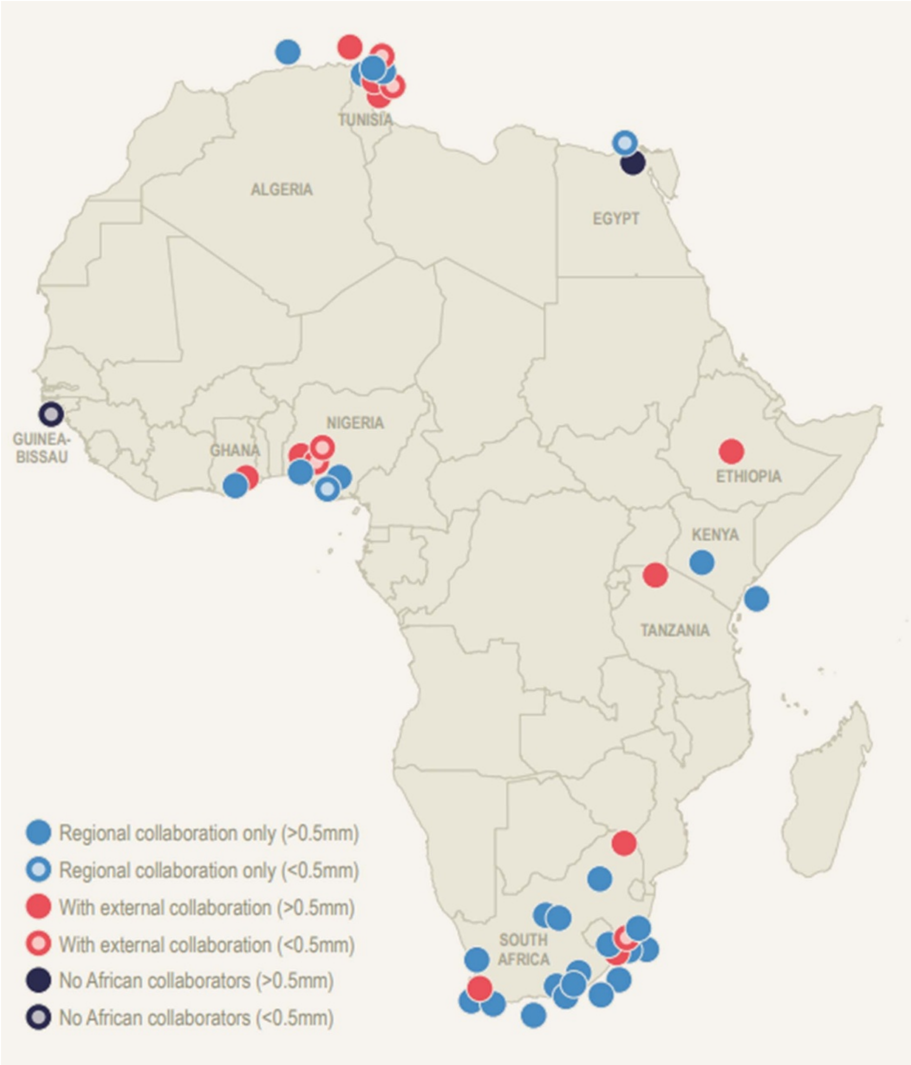

Figure 1. Micro(nano)plastic research studies conducted in Africa between 2005 and October 2020; showing where authorship indicates regional collaboration only, articles with external collaborators and those with no African collaborators included. Studies are also characterized according to the analytical techniques used to identify plastic particles with >0.5 mm and/or <0.5 mm included.

3. Perspective on possible solutions

Advances in analytical techniques are key to progress, and scholars with the available resources should continue to evolve the field. However, given the complexity and geographical context of MNP pollution, the global research landscape would benefit from solutions that better include the perspectives and experiences of regions with limited infrastructural and resource capacity. Here we attempt to initiate this conversation, while outlining recommendations that may assist scholars outside of geographical MNP 'hubs' to accelerate internal research and method development. Our main goal is for governments and funding agencies to acknowledge the need to develop networks in Africa where Pan-African collaboration is fostered. While our secondary goal is to make the global MNP community aware that analytical advances and conversations surrounding harmonization need to include regions where data, expertise, and infrastructure is lacking, and where climatic conditions may adversely affect equipment developed in more temperate regions. Through inclusive and innovative conversations surrounding research and data requirements, scholars in low to middle-income countries can contribute towards a more holistic understanding of the problem within different climatic and socio-economic conditions.

To date, collaboration between scholars, working on MNP pollution, across African countries is minimal (figure 1). This is largely due to a lack of opportunity, since the need for access to scientific equipment for polymer identification currently requires collaborations with research laboratories outside Africa. While the results of these mainly bi-lateral collaborations provide initial insights into site-specific MNP pollution, the lack of lateral Pan-African integration and coordination limits a systematic analysis and interpretation of the Africa specific context (i.e. relating findings to respective pollution sources, transport and fate mechanisms, and associated impacts).

We advocate the development of a Pan-African network of research groups and facilities with dedicated plastic research programmes. Based on experiences from networks established in the UK (Microplastic Network, www.ukcpn.co.uk/uk-microplastics-network/) and Germany (Plastic Network—PLA-NET, www.plastic-network.org/), this Pan-African network should facilitate the sharing of facilities and expertise to foster research on MNP in the African context. Networking can facilitate interdisciplinary, cross-sectoral, and international collaboration, coordination of training and capacity building, and the development of multi-national, multi-institutional research strategies. A development of such magnitude will, however, require support by regional and global agents in the field (e.g. the African Union, African Development Bank, World Bank, and the United Nations Environment Programme) to initiate a development that can be sustained over the long-term.

A Pan-African network would not only require the establishment of adequate laboratories and research institutions, but also provide access to critical research infrastructure by supporting free movement of personnel between research groups and providing a long-term strategy ensuring facility maintenance (Oman *et al* 2006). Therefore, government and funding agencies should discuss innovative ways to encourage multi-national collaborations within Africa; while continuing partnerships with more established MNP laboratories globally. Lateral exchange programmes and training workshops are imperative, whereby visiting researchers are able to facilitate the development of African laboratories, while simultaneously obtaining a more inclusive understanding of site-specific drivers of plastic pollution. For example, in 2019 representatives from Centre for Environment, Fisheries and Aquaculture Science (Cefas), UK established a microplastic research facility, in South Africa, as part of the Commonwealth Litter Programme (CLiP) by providing infrastructure, training, and access to standard operating procedures (www.cefas.co.uk/clip/locations/africa/). This allowed scholars previously unable to visit established facilities the opportunity to develop the skills needed to set-up regional spaces for MNP research.

A first step towards establishing a Pan-African research network could be to collate an open-access database of expertise and equipment available nationally, regionally or across the continent, as well as a data sharing portal specific to Africa. Such information would provide critical evidence of core competences and interests, laying the foundation for where to establish collaborative research nodes. These collaborative research nodes will then become inclusive facilities whereby researchers can visit to perform various steps along the MNP analysis pipeline, access training workshops and discuss innovative pathways for future research with like-minded scholars. This will include training on requirements for contamination control in laboratories and the development of 'clean rooms' for analyses which follow international standards. Learning from TReND Africa (https://trendinafrica.org/about/) an NGO committed to creating a scientifically independent Africa, we need to increase access to infrastructure and training while encouraging do-it-yourself (DIY) method development through the ideology of open scientific hardware. To date, none of the equipment used for polymer identification or their replaceable parts are manufactured on the continent, making routine and mandatory maintenance of such facilities difficult and cost-intensive. Research nodes should therefore disseminate vital knowledge on the development and use of low-cost extraction tools (Nel *et al* 2019), screening techniques (Maes *et al* 2017, Nel *et al* 2021) and identification keys while also providing access to state-of-the-art analytical techniques either housed on-site or through external partnerships.

4. Conclusion

We, therefore, call for global investment into analytical research infrastructure and the establishment of a collaborative Pan-African research network that will enable the step change in African MNP research that gives justice to the critical and complex challenges caused by MNP pollution. To support the bottom-up development of such Pan-African networks we are instigating a series of international webinars on MNP research in Africa that will be held online in 2021.

Data availability statements

All data that support the findings of this study are included within the article (and any supplementary files).

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Author contribution

All co-authors contributed to the drafting of the manuscript, and all have approved the final version.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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