Determination of microplastic pollutants in tap water

Cite as: AIP Conference Proceedings **2454**, 050031 (2022); https://doi.org/10.1063/5.0078695
Published Online: 09 June 2022

Nurain Saipolbahri, Noor Syuhadah Subki, Sabiqah Tuan Anuar, et al.

Determination of Microplastic Pollutants in Tap Water

Nurain Saipolbahri[1, a)], Noor Syuhadah Subki[1, b)], Sabiqah Tuan Anuar[2, c)] and Yusof Shuaib Ibrahim[2, d)]

[1]*Faculty of Earth Science, Universiti Malaysia Kelantan, Jeli Campus, 17600 Jeli, Kelantan, Malaysia*
[2]*Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia*

[a)]Corresponding author: nurainsaipolbahri@gmail.com
[b)]syuhadah@umk.edu.my
[c)]sabiqahanuar@umt.edu.my
[d)]yusofshuaib@umt.edu.my

Abstract. Microplastic debris (<5 mm) is a prolific pollutant present in freshwater, marine and terrestrial habitats worldwide. Persistent pollutants of growing concern are emerging microplastics. Their presence in tap water, however, remains largely unexplored. This research concentrated on assessing the abundance of microplastics in tap water with their physical characteristics of colour and type. Tap water samples from one district in Terengganu were filtered through cellulose nitrate membrane filters (Whatman, 0.45 µm, 47 mm Ø). In addition, their physical characteristics were determined and categorised by sorting performed under a dissecting microscope. The total number of microplastics observed in all samples were 536 particulate microplastics varied in all categories. Eight colours of microplastics were recorded and two types of microplastics were categorised. Therefore, this study offers an insight into the colour and types of microplastics present in tap water thus, further research is needed to fully resolve the fate and ecological risks of microplastics in water.

INTRODUCTION

Plastics are synthetic organic polymers, which are derived from the polymerisation of monomers extracted from oil or gas [1, 2, 3]. Plastics have evolved into a lucrative commodity and an essential element of daily life with worldwide plastic manufacturing increasing from 1.5 million tonnes in the 1950s to 322 million tonnes in 2015. When introduced into the marine environment, most plastics are materials that endure for many years possibly hundreds [3]. Plastics in the environment can break down over time into smaller pieces of microscopic plastic particles known as microplastics when they are less than 5 mm in size. The presence of these polymers has been discovered in the environment. Regarding aquatic environments, much effort has been put into investigating microplastic pollution in seas, oceans, rivers and lakes globally [4, 5], even in remote areas [6, 7]. These microscopic microplastics can be swallowed by a variety of species, posing a threat to them. Microplastics can also provide a long-term stable habitat for a number of diseases and dangerous bacteria [8, 9]. Wright et al. (2013) have recently revealed that microplastics themselves can cause internal blockage or abrasions of animal gastrointestinal systems [9]. The transfer and (bio)accumulation of POPs adsorbed on microplastics in species may be possible [9, 10]. Some intermittent study has also examined microplastic interactions with human cells [5, 11, 12].

Microplastics abundance in Malaysia have been recorded in marine waters [13], biota (bivalve, fish, zooplankton) [14, 15, 16, 17] and even river sediments [18] but no scientific documents have been reported on the abundance of microplastics in tap water in Malaysia. In this study, the abundances and physical characteristics specificity of microplastics in tap water samples from one district in Terengganu, Malaysia were being investigated. The focal points of this study are to determine and characterise microplastics by colour and type using dissecting microscope.

International Conference on Bioengineering and Technology (IConBET2021)
AIP Conf. Proc. 2454, 050031-1–050031-7; https://doi.org/10.1063/5.0078695
Published by AIP Publishing. 978-0-7354-4193-4/$30.00

MATERIALS AND METHODS

Sampling

Tap water samples were collected from three sampling points of conventional water tap system in one of the district in Terengganu. Each sampling points were marked as Tap water 1 (T1), Tap water 2 (T2) and Tap water 3 (T3). The water tap was opened and being allowed to run for a minute before each sample was collected. Then, the water filled in 1L of laboratory glass bottles to the overflowing point. Each of the glass bottles were cleaned carefully with deionised water to prevent cross-contamination The samples of tap water were collected with three replications from each points. In order to prevent the airborne contamination of microplastics, the glass bottles were sealed with aluminium foil before closing with their lids. Then, the samples being kept in the laboratory and stored at 4ºC in a chiller before being analysed the presence of microplastics in each samples.

Sample Analysis

The tap water samples with volume of 1L each were filtered with cellulose nitrate membrane filters (Whatman, 0.45 µm, 47 mm Ø). Then, each of the membrane filter paper was transferred to a clean glass dish. The membrane filter papers were dried in desiccator for 24 hours before future analysing under microscope. After 24 hours of drying at ambient temperature, the membrane filter papers were observed under a dissecting microscope to determine and categorise the abundance of colour and type of microplastics in the tap water samples. The revolving turret was turned to the 100x magnification. The image was looked through the eyepiece. The condenser was adjusted until the image of filter paper was observed under dissecting microscope.

Prevention of Contamination

In this research area, control and reduction of potentially airborne cross-contamination are essential. During storage, processing and analysis, the samples should be handled in an air-closed cleanroom. Both filter kits and laboratory surfaces used for sample processing should be thoroughly washed with deionized water or distilled water. Then, all materials need to be stored under clean air facilities and covered with aluminium foils. One blank was analysed to prevent contamination in water samples during sample preparation and filtration. The blank sample was filled with 1L of ultrapure water in a glass container. To examine the interference of airborne particles, samples of blank were prepared and observed. In addition, the color of the fabric worn under the lab coat must be registered to prevent fiber contamination from the lab coat.

RESULTS AND DISCUSSION

Abundance of Microplastic Pollutants in Tap Water

The abundance of microplastics were found in the tap water samples after being analysed with dissecting microscope. The recorded number of microplastics varied among the tap water samples. In this analysis, the abundance of microplastics in tap water samples ranged 0 to 200 particles. The presence of particles size ranged from 3 µm to 5000 µm. Much studies shown the abundance of microplastics in freshwater and marine environments, few studies have reported microplastics pollution in tap water [19, 20, 21, 22]. Based on the previous study, 0 to 57 plastic particles were found in the samples that collected from treated water at the outflow to the treated water [23, 24]. However, the tap water samples from the previous study relied on the plant outlet and the consumer household in the drinking water treatment plant delivery system [24]. The findings from each study differ considerably. This is understandable because many variables include sample sizes, the methodologies used, the environmental climate, drinking water delivery systems pipe materials and current weather patterns [25].

In this study, the colours and type of microplastics from three different tap water points are being determined and characterised. As result, the microplastics present in Tap water 1 (T1) recorded the highest number which are about 206 plastic particles found. Next, about 167 plastic particles found in Tap water 2 (T2) meanwhile, 163 plastic particles found in sample of Tap water 3 (T3). Hence, the results in Figure 1 shown the microplastic abundance in the tap water samples.

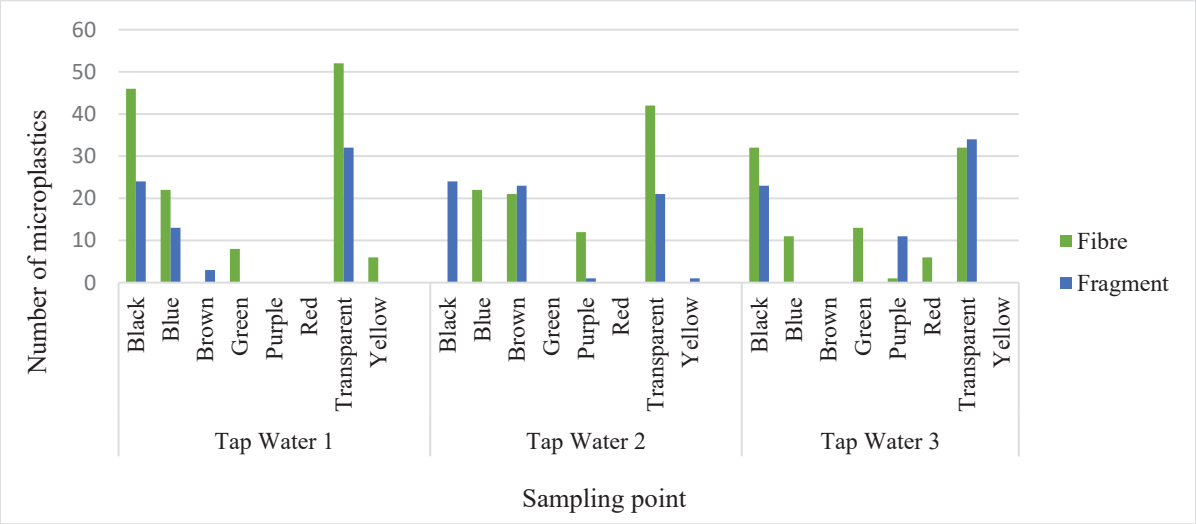

FIGURE 1. Microplastic abundance in the tap water samples

The results indicate that the microplastics present were slightly different in three tap water points. There were eight colours of microplastics presented in the tap water samples. Meanwhile, plastic fragments and plastic fibers were recorded as the abundance type of microplastics in the tap water samples. Plastic fibres in transparent recorded the highest number in T1 and T2. There were 52 plastic fibers presented in T1 while 42 plastic fibers were presented in T2. However, T3 recorded that plastic fragments were the most abundance microplastics present there. About 34 plastic fragments in transparent present in T3.

Although the sampling points have the same water sources but the amount of microplastics varied among the points. In this study, the type of microplastics present were only fragments and fibers. This was differing with a study in China by Tong et.al. (2020), they found microplastics in fragments, fibers and sphere in tap water samples [22]. In fact, China and Malaysia's household pipes in tap water distribution systems are mainly from plastic pipes which is Polyvinyl chloride (PVC) [24]. PVC is a synthetic resin produced by the vinyl chloride polymerisation process, which derives its name from Poly-Vinyl-Chloride. The usage of PVC pipe in globally is higher compare to Polyethylene (PE) in plastics consumption. Most PVC plastic is used for the production of plumbing and piping pipes used in industrial and municipal applications [26]. Because of the solid, light and low-reactive PVC properties, they are well suited for sanitary, underground cabling and water delivery applications [27].

This may cause microplastic pollution and increase the abundance of microplastics in tap water samples due to the higher use of plastic pipes in delivery systems. Faster and more detailed methods for the detection of plastics need to be explored in the future. Although the quantity could be overestimated, the presence of microplastics in tap water was shown by our findings, which cannot be ignored. However, given the projected daily intake, it was not possible to disregard tap water in microplastic sources for humans. Therefore, much attention needs to be given to studying the number of changes in microplastics in tap water especially in different seasons.

Physical Characteristics: Colour

The results indicated that the microplastics present were variety in colour. Figure 2 shown the abundance of coloured microplastics present in the tap water samples.

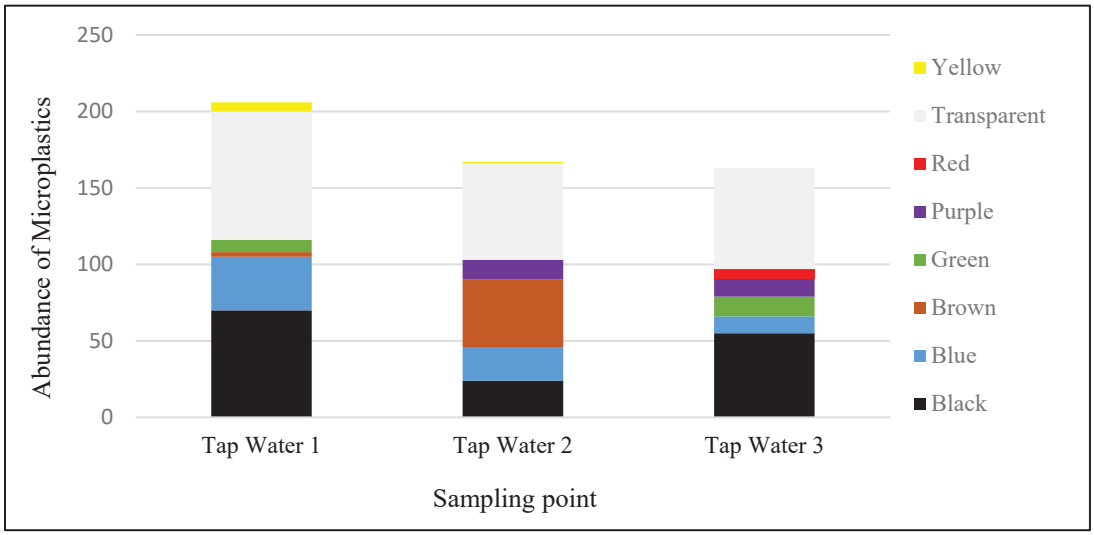

FIGURE 2. Abundance of coloured microplastics in the tap water samples

Each of the tap water samples was being analysed using dissecting microscope to see the coloured microplastics presented. As resulted, microplastics present in tap water samples were varied in colour. T1 recorded that plastic particle with purple and red colour was absent while, T2 recorded as green and red plastic particle was absent. Plastic particle in brown and yellow colour was not present in T3. Furthermore, the highest number of coloured microplastics in all tap water points was transparent plastic particles which recorded about 84 transparent microplastics in T1, 63 transparent microplastics in T2 and about 66 transparent microplastics in T3. The second higher of coloured microplastics present in this study was black which recorded that 70 black microplastics in T1, 24 black microplastics in T2 and 55 black microplastics in T3. It was followed by blue colour of microplastics which being the third higher number of microplastics presented. There were about 35 microplastics in T1, 22 blue microplastics in T2 and 11 blue microplastics in T3.

Physical Characteristics: Types

Two types of plastic particles were found in these tap water samples. Fragments and fibers were found in this study. Figure 3 shown the comparison on type of microplastics present in the tap water samples according to their colour. As resulted, fiber has the higher abundancy in the vicinity compared to fragment. Fibers were the most abundant type of microplastics in the tap water samples. This was because most of the coloured particles were found as plastic fibers. Meanwhile, fragment particles were absent in green and red coloured particle in this study. Moreover, the plastic fiber and plastic fragment in yellow colour recorded as the least number of microplastics present in this study. Plastic fiber in yellow colour was about 6 microplastics present but, only 2 plastic fragment in yellow colour presented in this study. The higher abundance of plastic fragment and plastic fiber present in the tap water samples were in transparent or colourless. About 126 plastic fiber recorded in transparent meanwhile 87 plastic fragment in transparent presented in this study.

This study was slightly different with other studies from [17] and [22] which observed the predominant type of the tap water samples from their studies were plastic fragment. Some factors need to be focused to discuss about the differences results obtained. One of the most frequently mentioned and inconsistently managed issues is contamination with fibres produced from airborne pollution or compounds utilised during the manufacturing process [23, 24]. Therefore, the test was carried out on a laminar flow table in order to reduce the background contamination in the laboratory with only pure cotton experimental clothing and Nitrile-Butadiene gloves being used during the lab work [24]. Decomposition of many plastic items can result in plastic fragments in water. Thus, the removal efficiency of different microplastics present in tap water may need further study in order to obtain the better accuracy of the abundancy of microplastics present in a sample.

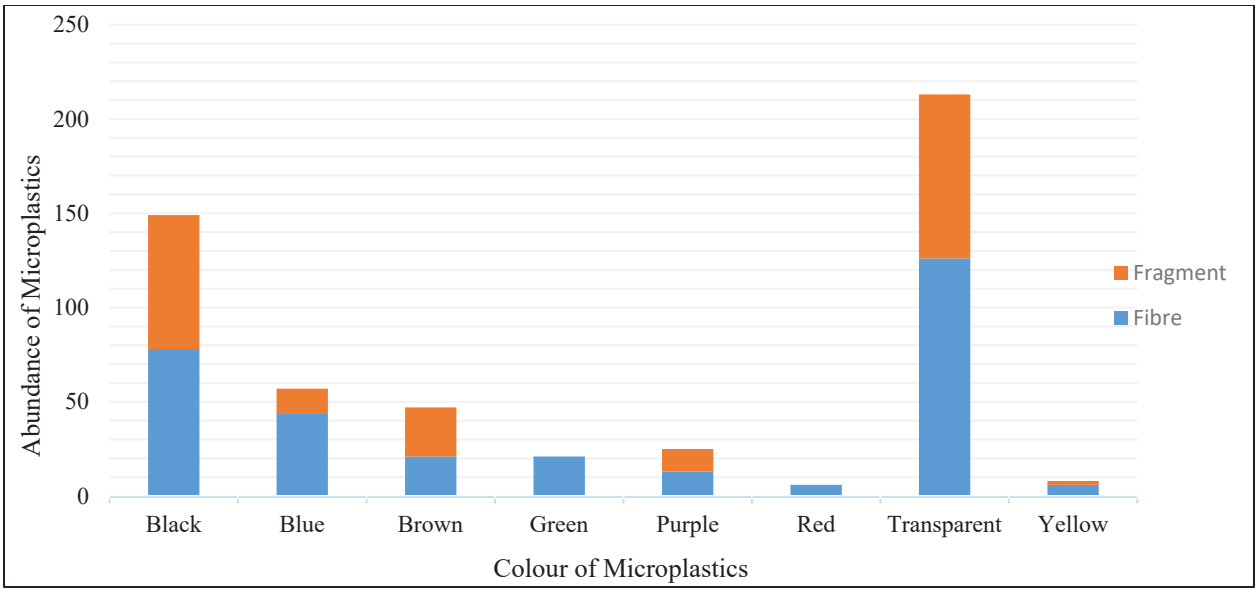

FIGURE 3. Comparison on type of microplastics present in the tap water samples according to their colour

Potential Health Risk of Microplastic Pollutants

The potential risk associated with microplastics come in three types that are part of biofilms which are physical particles, chemicals and microbial pathogens [27]. Particles may have effects on the body depending on a range of physicochemical features such as size, surface area and shape. Environmental hydrophobic chemicals, including persistent organic pollutants, may sorb the plastic particles as well [28]. Tap water biofilms are formed when microorganisms grow on the distribution systems of water and other surfaces [29]. The health risk of microplastics in tap water depends on the hazard (the potential for adverse effects) and the risk of exposure (dose). At different doses, the effects of the same medicine can vary depending on how much of the substance a person is exposed to, as well as the method of administration through which the exposure takes place such as ingestion, inhalation and injection [29].

All types of plastic contaminants identified are likely to affect human health, especially in the case of long term exposure to different substances or chemicals used in the manufacturing process [29]. A previous study by a researcher from the China Academy of Science (CAS) study, found that plastics containing organic contaminants can cause chronic effects and endocrine disorders [29, 30]. When absorbed into the body, an endocrine disruptor is a synthetic substance that either mimics or blocks hormones and disturbs the body's natural activities. Endocrine disruptors are referred to as environmental hormones or endocrine disrupting compounds (e-EDCs) since they have similar hormone effects, such as oestrogen [30]. In addition, related pollutants can harm and induce geno-toxicity, such as Polycyclic Aromatic Hydrocarbons (PAHs), whereas the plastic itself and its additives can have health implications, including carcinogenicity and mutagenicity [30].

CONCLUSION

This study's findings revealed the abundance of microplastics in variety of colour and type in samples of tap water. Microplastics were found in large quantities in tap water varying for 536 plastic particles. Although the number of microplastics in this study shown slightly differ with other studies, but the presence of microplastics in tap water should not be overlooked especially in Malaysia. In this study, the abundance of microplastics in tap water samples ranged 0 to 200 particles. The presence of particles size ranged from 3 µm to 5000 µm. Microplastics in transparent or colourless were the most coloured microplastics presented in the tap water. Besides, plastic fibers were dominating type of identified microplastics in this study compared to plastic fragments. In conclusion, the contamination of microplastics in tap water need more research in future in order to identify the risks towards water distribution systems. In order to properly evaluate the risk of microplastics in tap water, a targeted, well-designed and quality-controlled

investigative study should be carried out. This can aid in a better understanding of microplastics' presence across the water supply chain including their numbers, shapes, sizes, composition and origins.

ACKNOWLEDGEMENTS

The authors acknowledge the appreciation to all staffs from Faculty of Earth Science, UMK Jeli Campus for helping in completion of this research. A special gratitude goes to Faculty of Science and Marine Environment, UMT for giving ideas and information regarding to this research. This research was financially supported by Fundamental Research Grant Scheme (R/FRGS/A0800/01412A/003/2019/00706).

REFERENCES

1. J.G.B. Derraik, J. Mar. Pollut. Bull. **44**, 842-852 (2002).
2. L.M. Rios, C. Moore and P.R. Jones, J. Mar. Pollut. Bull. **54**, 1230–1237 (2007).
3. R.C. Thompson, C.J. Moore, F.S. Saal and S.H. Swan, J. Biol. Sci. **364**, 2153–2166 (2009).
4. Z. Pan, Q. Liu, X. Sun and H. Lin, J. Mar. Pollut. Bull. **146**, 215-224 (2019).
5. R. Triebskorn, T. Braunbeck, T. Grummt, L. Hanslik, S. Huppertsberg, M. Jekel, T.P. Knepper, S. Krais, Y. Muller, M. Pittroff, A.S. Ruhl, H. Schmieg, C. Schur, C. Strobel, M. Wagner, N. Zumbulte and H.R. Kohler, J. Trends Anal. Chem. **110**, 375-392 (2019).
6. C.L. Waller, H.J. Griffiths, C.M. Waluda, S.E. Thorpe, I. Loaiza, B. Moreno, C.O. Pacherres and K.A. Hughes, J. Sci. Total Environ. **598**, 220-227 (2017).
7. D.S. Green, L. Kregting, B. Boots, D.J. Blockey, P. Brickle and Q. Crowley, J. Mar. Pollut. Bull. **137**, 695-701 (2018).
8. K. Betts, J. Env. Sci. & Tech. **42**, 8995-8995 (2008).
9. A.L. Andrady, Mar. Pollut. Bull. **62**(8), 1596-1605 (2011).
10. D. Lobelle and M. Cunliffe, J. Mar. Pollut. Bull. **62**, 197-200 (2011).
11. Y. Mato, T. Isobe, H. Takada, H. Kanehiro, C. Ohtake and T. Kaminuma, J. Env. Sci. & Tech. **35**, 318-324 (2001).
12. E.L. Teuten, S.J. Rowland, T.S. Galloway and R.C. Thompson, J. Env. Sci. & Tech. **41**, 7759-7764 (2007).
13. W.M.A.W.M. Khalik, Y.S. Ibrahim, S.T. Anuar, S. Govindasamy and N.F. Baharuddin, J. Mar. Pollut. Bull. **135**, 451-457 (2018).
14. R.M. Amin, E.S. Sohaimi, S.T. Anuar and Z. Bachok, J. Mar. Pollut. Bull. **150**, 110616 (2020).
15. Y.S. Ibrahim, R. Rathnam, S.T. Anuar and W.M.A.W.M. Khalik, Malaysian J. of Anal. Sci. **21**(5), 1054-1064 (2017).
16. Y.S. Ibrahim, A.A. Azmi, S.A. Shukor, S.T. Anuar and S.A. Abdullah, J. of Sci. Research **24**(6), 2129-2136 (2016).
17. S. Karbalaei, A. Golieskardi, H.B. Hamzah, S. Abdulwahid, P. Hanachi, T.R. Walker and A. Karami, J. Mar. Pollut. Bull. **148**, 5-15 (2019).
18. S. Sarijan, S. Azman, M.I.M. Said, Y. Andu and N.F. Zon, MATEC Web of Conf. **250**, 06012 (2018).
19. M. Pivokonsky, L. Cerakova, K. Novotna, P. Peer, T. Cajthaml and V. Janda, J. Sci. Total Environ. **643**, 1644-1651 (2018).
20. D. Eerkes-Medrano, H.A. Leslie and B. Quinn, J. Curr. Opin. Environ. Sci. Health. **68**, 69-75 (2019).
21. A.A. Koelmans, N.N. Mohamed, E. Hermsen, M. Kooi, S.M. Mintenig and J.D. France, J. Water Res. **155**(4), 410-422 (2019).
22. S.M. Mintenig, M. Loder, S. Primpke and G. Gerdts, J. Sci. Total Environ. **648**(1), 631-635 (2019).
23. K. Novotna, L. Cermakova, L. Pivokonska, T. Cajthaml and M. Pivokonsky, J. Sci. Total Environ. **667**(3), 730-740 (2019).
24. H. Tong, Q. Jiang, X. Hu and X. Zhong, J. Inn. Sci, Eng. & Tech. **23**, (2020).
25. L.C. Woodall, C. Gwinnett, M. Packer, R.C. Thompson, L.F. Robinson and G.L. Patterson, J. Mar. Pollut. Bull. **95**, 40-46 (2015).
26. S.L. Wright and F.J. Kelly, J. Env. Sci. & Tech. **51**(4), 6634-6647 (2017).
27. C.E. Talsness, A.J.M. Andrade, S.N. Kuriyama, J.A. Taylor and F.S.V. Saal, J. Biol. Sci. **364**(4), 2079-2096 (2009).
28. G.Roland, J.R. Jambeck and L.L. Kara, J. Sci. Adv. **3**(7), (2010).

29. R.C. Thompson, Y. Olsen, R.P. Mitchell, A. Davis, S.J. Rowland, , A.W.G. John, , D. McGonigle and A.E. Russell, Sci. J. **54**, 838 (2004).
30. C.J. Moore, J. Env. Research. **108**(3), 131-139 (2001).