In vitro gut models reveal how microplastics affect the GI tract

By Dr. Priyom Bose, Ph.D.

Reviewed by Benedette Cuffari, M.Sc.

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Plastics were discovered in 1950 and, since then, have remained some of the most widely used materials in the world. Increased demand for plastics has led to the accumulation of these materials in landfills and oceans, thus causing plastic pollution to become a significant environmental threat that affects all ecosystems.

Study: Microplastics: what happens in the human digestive tract? First evidences in adults using in vitro gut models. Image Credit: lucio pepe / Shutterstock.com

Background

Plastics undergo natural weathering in the environment, during which they are converted into small particles.

Microplastics (MPs) are small polymeric matrices that are within the size range of one micrometer (µm) and five millimeters (mm) in diameter. MPs are regular or irregularly shaped, insoluble substances that are sometimes manufactured voluntarily or released due to plastic weathering and fragmentation.

MPs enter the food chain due to their presence in many foods and drinking water. Several studies have confirmed the presence of MPs in human blood, stool, and colonic tissues. However, despite these observations, very few studies have assessed the fate of MPs in the human gastrointestinal (GI) tract.

After ingestion, MPs encounter the GI barrier, which is composed of intestinal epithelium and mucus. In addition, MPs interact with gut microbiota, constituting a complex and diverse community of microbes, including bacteria, fungi, archaea, protozoa, and viruses. A viscoelastic gel of the mucus layer is the first line of chemical, physical, and biological defense that protects the intestinal epithelium.

Gut microbiota also has an essential role in regulating host immunity and the metabolism of toxins, drugs, and xenobiotics. In addition, these microorganisms are also associated with breaking down undigested foods and producing secondary metabolites, such as short-chain fatty acids (SCFAs), aryl hydrocarbon receptor (AhR) ligands, volatile organic compounds (VOCs), and gas.

AhR ligands and SCFAs are responsible for maintaining the integrity of intercellular tight junctions in the intestinal epithelium. A strong link between gut microbial activity and effective preservation of intestinal barrier function has been established.

Several *in* vivo models have highlighted various effects of MPs that depend upon their size, shape, type of the polymer matrix, duration of exposure, surface charge, and mode of administration. Some of these effects include changes in mucus secretion patterns and microbial dysbiosis.

About the study

In a recent *Journal of Hazardous Materials* study, researchers hypothesize that exposure to polyethylene (PE) MPs could affect the human adult GI system *in*

vitro under realistic conditions. The researchers were particularly interested in determining the interactions that arise between the gut microbiome and PE MPs.

The impact of PE MPs exposure on human metabolic activity and gut microbiota composition was analyzed after participants were exposed daily for two weeks to a 21 mg/day dose.

A total of four healthy adult volunteers participated in the current study. The *in vitro* Mucosal Artificial Colon model (M-ARCOL) was also used.

The M-ARCOL model is a one-stage fermentation system that simulates the human colon's mean microbial and physicochemical parameters. This model comprises both luminal and mucosal microbiota through an external mucin-alginate beads compartment.

Both human Caco-2 and mucus-secreting HT29-MTX intestinal cells were incubated with M-ARCOL luminal supernatants that were obtained following two weeks of exposure.

Taken together, the current analysis provided a deeper understanding of the effects of MPs, such as permeability, cytotoxicity, and inflammation, on the intestinal epithelium and mucus.

Study findings

The initial fecal microbiota used for M-ARCOL inoculation exhibited significant inter-individual variabilities. Furthermore, these variabilities were maintained throughout the course of the *in vitro* experiment.

All participants exposed to PE MPs observed a significant change in microbial diversity. An increasing trend associated with α-diversity for the luminal microbiota was found. In addition to inter-individual variability, similar effects linked to the lumen and mucus-associated microbiota were reported.

Following exposure to PE MPs, increased levels of *Desulfovibrionaceae*, *Dethiosulfovibrionaceae*, and *Enterobacteriaceae* were observed, along with reduced *Christensenellaceae* and *Akkermansiaceae*. The latter two groups are associated with an individual's healthy state.

Some of the variations in the microbial structures were analogous to microbial diversity in individuals experiencing irritable bowel syndrome (IBS) or inflammatory diseases of the GI tract. Polyethylene terephthalate (PET) MPs exposure also decreased Bacteroidota in the colonic compartments of three donors. In one participant, an increase in *Desulfobacterota* was observed.

The effect of PE MPs on the production of gas, SCFAs, and VOCs revealed no significant difference between the control and treated groups. However, an increase in indole, 3-methyl-, and skatole levels following PE MPs exposure suggested the possibility of microbiota-mediated GI dysregulation, which requires further investigation.

Reduced AhR activity associated with PE-MP exposed gut microbiota was observed. Similar results have also been reported in individuals with IBD and celiac disease. The present study highlights that intestinal cells exposed to two sizes of PE did not significantly reduce cell viability; however, they induced oxidative stress.

Conclusions

The current study investigated the impact of daily exposure to PE MPs on the adult human GI system. To this end, the effect of PE MPs on mucosal gut microbiota and the intestinal lining was found to be dependent on individual characteristics.

In the future, more research is needed to characterize specific "gut plastisphere" in terms of composition and metabolism.

Journal reference:

- Fournier, E., Leveque, M., Ruiz, P., *et al.* (2022). Microplastics: what happens in the human digestive tract? First evidences in adults using *in vitro* gut models. *Journal of Hazardous Materials.* doi:10.1016/j.jhazmat.2022.130010

Written by

Dr. Priyom Bose

Priyom holds a Ph.D. in Plant Biology and Biotechnology from the University of Madras, India. She is an active researcher and an experienced science writer. Priyom has also co-authored several original research articles that have been published in reputed peer-reviewed journals. She is also an avid reader and an amateur photographer.