Plastic and Human Health: alarming evidence

Ubiquity of Plastic

Plastic has reached the deepest point in our oceans, the Marianna Trench; it has been found on the peaks of the Himalayas, at both poles, and everywhere in-between. The intake of microplastics has been found in more than 100 species of marine biota, from zooplankton to mussels to seabirds and whales[1]. There is no place on earth that is completely free of plastic; animals and people alike are exposed to plastics every day.

Despite this, plastic production will grow from c. 360 billion kilos/year in 2018 to 500 billion kilos/year in 2025 if we don't change our consumption behavior significantly. This growth in production will result in more plastic leakage into the environment, where plastic degrades into ever smaller pieces. These small particles spread rapidly throughout organisms, moving up the food chain, through the air, and through the water. Ultimately, there is little that we know about how the plastic that surrounds us affects our bodies. More than anything, we have one question: what are the health consequences of all this plastic?

Chemical Additives to Plastic

Plastics contain chemical additives which give them various characteristics such as durability, plasticity, and stability in heat. Among these chemicals are endocrine disrupting chemicals (EDCs). According to the World Health Organization, EDCs are associated with imbalances in sex ratios, disruption in fertility cycles and delayed or

[1] Gallo, F., Fossi, C., Weber, R., Santillo, D., Sousa, J., Ingram, I., ... & Romano, D. (2018). Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. *Environmental Sciences Europe*, *30*, 1-14. P.4

accelerated puberty in females, delayed neurodevelopment in children, immune disorders, and hormone-related cancers[2].

Even low levels of exposure to endocrine disrupting chemicals are of concern to living organisms; experimental research on animals shows that at low levels of exposure, "[…] low birth rates […], thyroid function, and metabolism, and increased incidence and progression of hormone-sensitive cancers"[3] were observed. The period during which test subjects were most susceptible to the effects of endocrine disrupting chemicals were during embryonic and early development stages.

The same was found in a study of estrogen response in female mice after in-utero exposure to BPA[4]. Female offspring exposed to BPA during gestation were found to have permanently altered gene expression profiles, the results of which become apparent after sexual maturation. These changes may contribute to the development of estrogen-sensitive cancers in mice.

Though public awareness of the dangers BPA poses for hormone activity has been on the rise in recent years, "BPA Free" products are not as safe as they are purported to be. Studies have found that virtually all plastic items tested, even those advertised as BPA Free, contained chemical alternatives which similarly affected estrogenic activity[5].

Phthalates**,** another form of EDCs, are used in plastics to increase flexibility and are often referred to as plasticizers. They are also used as solvents and can be found in various products, ranging from vinyl on floors, to cosmetics and toys. Human exposure

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[2] Bergman, Å., Heindel, J. J., Jobling, S., Kidd, K., Zoeller, T. R., & World Health Organization. (2013). State of the science of endocrine disrupting chemicals 2012: summary for decision-makers

[3] Gallo et al., 2018

[4] Jorgensen, E. M., Alderman, M. H., & Taylor, H. S. (2016). Preferential epigenetic programming of estrogen response after in utero xenoestrogen (bisphenol-A) exposure. The FASEB Journal, 30(9), 3194-3201.

[5] Yang, C. Z., Yaniger, S. I., Jordan, V. C., Klein, D. J., & Bittner, G. D. (2011). Most plastic products release estrogenic chemicals: a potential health problem that can be solved. *Environmental Health Perspectives*, *119*(7), 989.

occurs mainly through diet, as phthalates can be released from packaging material into products. Phthalates are metabolized by the body and the metabolites usually pass out of the body through urine; phthalates are not known to bioaccumulate[6]. Despite this, some studies have observed associations with health effects, and therefore also these chemicals are considered to be of concern.

Routes of exposure and human effects

Chronic exposure to plastic in humans is expected to be of great concern; we consume microplastics and their chemical additives, but we also breathe and touch them — from nanoplastics in cosmetics to synthetic fibers in clothing, to plastic particles in both tap and bottled water, and microfibers in air pollution[7]. Evidence for dietary exposure exists in seafood, shellfish (the most important dietary source), and other, non-marine foods such as sugar, honey, meat, and salt. Orb Media recently showed the presence of microplastics in otherwise safe tap water and bottled water around the world[8]. Another major and oft-overlooked source of plastic in the environment are fibers released during the washing of synthetic clothing; an estimated 9 million plastic microfibers are shed per cycle, many of which pass through wastewater treatment plants due to their small size[9].

Furthermore, evidence for human exposure to plastic particles through inhalation exists. It includes the presence of microplastics in atmospheric fallout, sludge byproducts used for agricultural purposes, and pollution caused by the wear of rubber tires[10]. Fibrous microplastics have been found in lung tissue, meaning that it is possible for them to

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[6] CDC. National Biomonitoring Program - Factsheet Phthalates. http://www.cdc.gov/biomonitoring/Phthalates_FactSheet.html. (Last accessed on 03-09, 2013).

[7] Wright, S. L., & Kelly, F. J. (2017). Plastic and human health: a micro issue?. Environmental science & technology, 51(12), 6634-6647.

[8] Tyree, C. and Morrison, D. (2018). *Plus Plastic - Microplastics Found in Global Bottled Water*. [online] Orbmedia.org. Available at: https://orbmedia.org/stories/plus-plastic/multimedia [Accessed 1 May 2018].

[9] De Falco, F., Gullo, M. P., Gentile, G., Di Pace, E., Cocca, M., Gelabert, L., ... & Mossotti, R. (2017). Evaluation of microplastic release caused by textile washing processes of synthetic fabrics. *Environmental Pollution*.

[10] Wright and Kelly (2017)

enter the body despite mucociliary clearance channels[11,12]. These inhaled plastic fibers are extremely durable in physiological fluid, meaning the plastic fibers are likely to persist in the lung and build up over time. Studies among nylon fiber workers suggest that increased exposure to fibrous microplastics in the air is associated with respiratory irritation, interstitial lung disease, breathlessness, and reduced lung capacity.

As for plastic exposure through skin absorption, there is much that we don't know. What we do know is that most cosmetics, depending on the brand, contain some form of plastic – if not abrasive microbeads, then other forms of micro and nanoplastics – everything from lipstick to sunscreen to body wash, mascara, and nail polish is suspect. The abundance of synthetic fibers in clothing also raises questions about the extent to which these substances are absorbed into the skin and consequently the bloodstream. This field requires more research and is not to be overlooked.

Concluding

With the increasing ubiquity of plastic in life and in nature, our lack of knowledge is a matter of concern. Medical costs related to repeated exposure to EDCs in pesticides and everyday items amounted was estimated at €157 billion in the EU and $340 billion in the US annually — this is a similar price tag to the health costs of smoking-related illnesses. Most jarring, perhaps, is that the largest cost comes from the effects of EDCs on children. This is a problem that can't be ignored.

The dangers plastic pose to marine life are slowly coming to the attention of the public, but there is a missing link; if plastic affects life in the ocean so drastically, it may also impact human health. The presence of plastic nanoparticles was found to cause brain damage and behavioural abnormalities in fish in a 2017 study[13], which marked the first

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[11] Gasperi, J., Dris, R., Mirande-Bret, C., Mandin, C., Langlois, V., & Tassin, B. (2015, September). First overview of microplastics in indoor and outdoor air. In *15th EuCheMS International Conference on Chemistry and the Environment*.

[12] Prata, J. C. (2018). Airborne microplastics: Consequences to human health?. *Environmental Pollution*, *234*, 115-126.

[13] Mattsson, K., Johnson, E. V., Malmendal, A., Linse, S., Hansson, L. A., & Cedervall, T. (2017). Brain damage and behavioural disorders in fish induced by plastic nanoparticles delivered through the food chain. *Scientific Reports*, *7*(1), 11452.

observed cases of direct interactions between plastic nanoparticles and brain tissue. Plastic nanoparticles are transferred through the food chain, and eventually enter the brain of the top marine consumer, leading to potential changes in behaviour and disrupting the function of natural ecosystems, as displayed in the study.

Although this study was carried out on fish, the repercussions of human exposure to plastic particles must be better understood. Along with the growth in production of toxic chemicals, an increase in the prevalence of neurodevelopmental disorders such as Autism Spectrum Disorders (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) has been observed in humans over the past decades. Increased awareness and a shift in diagnosis procedures may have contributed to higher rates, but this does not offer a complete explanation for these findings. It is hypothesized that exposure to chemicals with endocrine disrupting properties increases the risk for neurodevelopmental disorders such as ASD and ADHD in humans[14].

Knowledge gaps that exist must be explored. An understanding of plastics, their additives, and the interaction they have with our bodies is critical.

[14] Hertz-Picciotto I, Delwiche L 2009 The rise in autism and the role of age at diagnosis. Epidemiology 20:84-90.