



## Green Solutions for a Plastic-Free World-Counteracting Bisphenol-Induced Endocrine and Metabolic Disruption

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**Received:** July 08, 2026

**Published:** October 09, 2026

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The extensive use of plastics in human life has silently reshaped human health [1]. Among the most concerning components of plastic are bisphenols- mainly bisphenol A and its analogues [2]. They are widely used in plastic bottles, food packaging, thermal receipts, etc., because of their water resistance, excellent plasticity and affordable manufacturing cost [3]. These compounds are now recognised as endocrine-disrupting chemicals because they cause hormonal imbalances and interfere with glucose metabolism and lipid homeostasis [4]. As research continues on the adverse effects of bisphenols, it is increasingly clear that bisphenol exposure is causing not only environmental issues but also health issues [5]. Not only adults, but early-life exposure to bisphenols also contributes to the development of paediatric liver disorders [6].

Bisphenols are rapidly absorbed upon ingestion, undergo hepatic metabolism, and form conjugated metabolites that are excreted primarily in urine [7]. The continuous low-dose exposure to bisphenol, however, can impose a chronic burden that further exacerbates insulin resistance and disrupts glucose homeostasis [8]. Not only does this bisphenol act as an endocrine-disrupting agent, but it also further promotes metabolic dysfunction [9]. The growing awareness has led to mitigation efforts to reduce plastic use and limit exposure. However, such strategies are insufficient

[10]. Because of the ubiquity of plastic in daily life, complete avoidance is impractical [11].

SDG Target 3.9, which aims to drastically reduce diseases induced by toxic chemicals and environmental pollutants, and Sustainable Development Goal 3 (Good Health and Well-Being) are increasingly threatened by the widespread exposure to bisphenols through plastic-based consumer products [12]. This also underscores the necessity of a One Health approach, acknowledging the interconnections among human, animal, and environmental health [13].

Therefore, it has become essential to focus towards complementary strategies that not only prevent exposure but also reduce the residence time of bisphenol within the body or increase its excretion.

Using dietary fibres is a viable approach. According to recent studies, some fibres can bind to environmental pollutants, such as bisphenol, in the digestive system, thereby decreasing absorption and increasing elimination [14]. In animal studies, chitosan, a naturally occurring carbohydrate, has been shown to facilitate the excretion of BPA. These dietary fibres may act as physical adsorbents, drawing in bisphenols and facilitating their removal [15].

However, there is currently insufficient direct human research on the fibre-mediated binding of BPA and its equivalents, making this theory tenable but not yet supported by experiments [16].

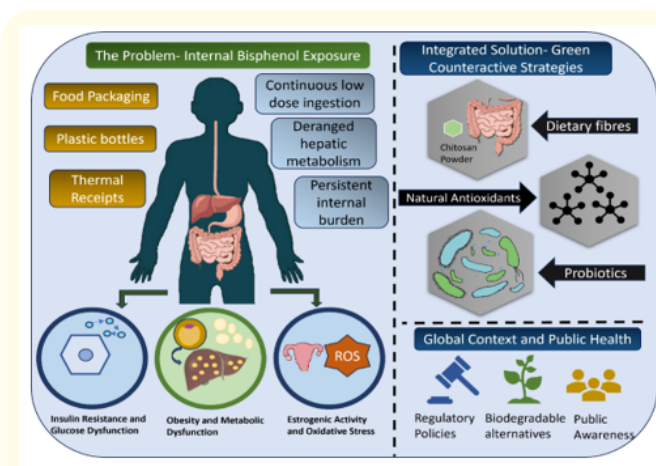
Another possible intervention tactic is the use of natural antioxidants. Exposure to bisphenols results in oxidative stress, which damages cells and slows metabolism by generating reactive oxygen species [17]. Antioxidants that may help prevent oxidative damage and restore redox balance include polyphenols, flavonoids, and vitamins C and E [18]. Numerous studies have demonstrated the potential of antioxidant-rich diets as supportive treatments for bisphenol poisoning by reducing toxin-induced metabolic abnormalities [19].

Probiotics also show promise as a tactic [20]. Changes in microbial composition can impact the biotransformation and removal of ambient chemicals, and the gut microbiota is essential for xenobiotic metabolism [21]. Some probiotic strains may improve the integrity of the gut barrier, control inflammation, and maybe aid in the breakdown or sequestration of harmful substances [22]. The nexus between toxicity and microbial science offers a rich environment for creative solutions, even though research in this field remains in its early stages [23].

The concept of “green plastic” has been around for some time [24]. Even though the use of biodegradable plastics has been promoted, gaps remain in our understanding of their environmental safety [25]. Green plastics are made from a variety of plant-based materials, whereas traditional plastics are made from non-renewable resources like fossil fuels. Biodegradable and environmentally friendly polymers are referred to as “green plastics” [26]. All natural or organic sources are sources of bio- or biodegradable polymers. On the other hand, their production also uses a substantial amount of energy derived from fossil fuels [27].

These tactics have potential, but they need to be used with scientific rigour. The absence of direct human data emphasises the necessity of carefully planned clinical and translational research to support these theories [28]. There is an urgent need to investigate the effectiveness of antioxidant therapies, the function of gut microbiota in regulating exposure, and the binding affinity of various fibre types for bisphenols [29]. In addition to expanding our knowledge, this kind of research will open the door to evidence-based dietary and treatment recommendations.

The need for a world free of plastic must remain at the centre of this conversation on a larger scale [30]. It is crucial to implement regulations that reduce plastic production, encourage biodegradable substitutes, and remove bisphenol-containing compounds from food packaging [31]. Campaigns for public awareness and changes in consumer behaviour toward sustainable consumption can hasten this shift [32]. From the above discussion, it appears that we should conduct research in multiple directions to develop a green solution to plastic-induced health issues (Figure 1).



**Figure 1:** Counteracting Bisphenol- Induced Endocrine and Metabolic Disruption: A Green Interactive Approach.

In conclusion, bisphenol-induced endocrine and metabolic disturbances are complex issues that call for equally complex solutions. Reducing plastic use is important for prevention, but it's also important to look for ways to reduce internal exposure. Dietary fibre, probiotics, and natural antioxidants all offer intriguing possibilities that warrant further investigation. The scientific community needs to start actively developing solutions rather than just diagnosing the problem. Through such integrative efforts, we can only expect to lessen the silent but pervasive harm posed by bisphenols and get closer to a truly green, plastic-free future.

### Acknowledgement

SC acknowledges CSIR for financial assistance (File no. 09/0141(20690)/2024-EMR-I).

## Bibliography

1. Bora., *et al.* "Microplastics and human health: unveiling the gut microbiome disruption and chronic disease risks". *Frontiers in Cellular and Infection Microbiology* 14 (2024): 1492759.
2. Megan E Cull and Louise M Winn. "Bisphenol A and its potential mechanism of action for reproductive toxicity". *Toxicology* 511 (2025): 154040.
3. Wang H., *et al.* "Fighting microplastics: The role of dietary fibers in protecting health". *Food Frontiers* 5 (2024): 1984-1998.
4. Stanojević., *et al.* "Mechanisms of bisphenol A and its analogs as endocrine disruptors via nuclear receptors and related signaling pathways". *Archives of Toxicology* 99 (2025): 2397-2417.
5. Sangwan S., *et al.* "Plastic compounds and liver diseases: Whether bisphenol A is the only culprit". *Liver International* 44.5 (2024): 1093-1105.
6. Sangwan S., *et al.* "Plastic compounds and liver diseases in pediatrics: Navigating the hazards". *Journal of Clinical Pediatrics and Neonatology* 4.1 (2024): 25-27.
7. Genuis., *et al.* "Human excretion of bisphenol A: blood, urine, and sweat (BUS) study". *Journal of environmental and public health* (2012): 185731.
8. Levon Manukyanm., *et al.* "Developmental exposure to a very low dose of bisphenol A induces persistent islet insulin hypersecretion in Fischer 344 rat offspring." *Environmental Research* 172 (2019): 127-136.
9. Beverly S and Rubin. "Bisphenol A: An endocrine disruptor with widespread exposure and multiple effects". *The Journal of Steroid Biochemistry and Molecular Biology* 127.1-2 (2011): 27-34.
10. Salia S Sheriff., *et al.* "A comprehensive review on exposure to toxins and health risks from plastic waste: Challenges, mitigation measures, and policy interventions". *Waste Management Bulletin* 3.3 (2025): 100204.
11. Snehamayee., *et al.* "Microplastics and Human Health: A Comprehensive Review on Exposure Pathways, Toxicity, and Emerging Risks". *Microplastics* 5.1 (2026): 8.
12. World Health Organisation - "Targets of Sustainable Development Goal 3" (2015)
13. Danasekaran R. "One Health: A Holistic Approach to Tackling Global Health Issues". *Indian Journal of Community Medicine: Official Publication of Indian Association of Preventive and Social Medicine* 49.2 (2024): 260-263.
14. Wang., *et al.* "Fighting microplastics: The role of dietary fibers in protecting health". *Food Frontiers* 5 (2024): 1984-1998.
15. Noriyuki KOHDA., *et al.* "Effects of Chitosan Intake on Fecal Excretion of Bisphenol A and Di (2-ethyl) phthalate in Rats". *Bio-science, Biotechnology, and Biochemistry* 76.4 (2012): 732-736.
16. "Fiber's Role in Detox: How It Helps Remove BPA and Microplastic"s. *NutriScapeBeta*.
17. Amjad., *et al.* "Role of Antioxidants in Alleviating Bisphenol A Toxicity". *Biomolecules* 10.8 (2020): 1105.
18. Manful., *et al.* "Antioxidants and Reactive Oxygen Species: Shaping Human Health and Disease Outcomes". *International Journal of Molecular Sciences* 26.15 (2025): 7520.
19. Mączka., *et al.* "Can Antioxidants Reduce the Toxicity of Bisphenol?". *Antioxidants (Basel, Switzerland)* 11.2 (2022): 413.
20. Aleksandra Bykowska-Derda., *et al.* "The Effects of Probiotic Supplementation on Bisphenol A Toxicity: A Systematic Literature Review". *Nutrition Reviews* (2026): nuaf272.
21. Koppel., *et al.* "Chemical transformation of xenobiotics by the human gut microbiota". *Science (New York, N.Y.)* 356.6344 (2017): eaag2770.
22. Rao RK and Samak G. "Protection and Restitution of Gut Barrier by Probiotics: Nutritional and Clinical Implications". *Current Nutrition and Food Science* 9.2 (2013): 99-107.
23. Piccardi P., *et al.* "Toxicity drives facilitation between 4 bacterial species". *Proceedings of the National Academy of Sciences of the United States of America* 116.32 (2019): 15979-15984.
24. Frech and Cheryl. "Green Plastics: An Introduction to the New Science of Biodegradable Plastics (Stevens, E. S.)". *Journal of Chemical Education* 79 (2002): 1072.
25. Zhu., *et al.* "Can Biodegradable plastics: Green hope or green-washing?" *Marine Pollution Bulletin* 161 (2020): 111774.
26. Bukhari., *et al.* "Seaweed polysaccharide nanocomposite films: A review". *International Journal of Biological Macromolecules* 245 (2023): 125486.
27. Gerngross., *et al.* "How Green are Green Plastics?" *Scientific American* 283 (2000): 37-41.

28. Laura N., *et al.* "Human exposure to bisphenol A (BPA)". *Reproductive Toxicology* 24.2 (2007): 139-177.
29. Claus., *et al.* "The gut microbiota: a major player in the toxicity of environmental pollutants". *npj Biofilms Microbiomes* 2 (2016): 16003.
30. UNEP - UN Environment Programme- "Single-use plastics: A roadmap for sustainability".
31. Lambré C., *et al.* "Scientific Opinion on the re-evaluation of the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs". *EFSA Journal* 21.4 (2023): 392.
32. Raheel., *et al.* "Behavioral interventions related to plastic waste management in low-and middle-income countries: a systematic review using the behavior change wheel and the theoretical domains framework". *Environmental Research Letters* 21.5 (2026): 053003.