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# Health and Environmental Impact of Xenobiotics in Water Quality Evaluation: A Review

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*Abstract*

***Xenobiotics are compounds or chemicals to which an organism is exposed, usually in large concentrations that are inessential to the regular pattern of metabolism of that organism. This review emphasised the categorization and impact of xenobiotics on people, animals, and the environment. It also gave a general overview of the process of discharging and detecting xenobiotics and their potential environmental fates. A chart of xenobiotic categories was also provided, including industrial products, insecticides, pharmaceuticals, personal care items, and radioactive waste. Microplastics and pesticides were discussed as xenobiotic chemicals commonly found in freshwater bodies; similarly, the impact of creating substances such as personal care products, medicinal chemicals, and insecticides through technology was discussed as the source of xenobiotics. Additionally, a thorough description of how pesticide pollution affects common environmental compartments such as soils, streambed sediment, groundwater, and surface water is provided since surface runoff accounts for more than 10% of pesticide residue in surface rivers. Effective techniques, including Fourier Transform Infrared (FTIR), High-Performance Liquid Chromatography (HPLC), Ultra-Performance Liquid Chromatography (UPLC), Gas Chromatography-Mass Spectrometry GC/MS, and Atomic Absorption Spectroscopy (AAS) along with diverse chromatographic techniques were also discussed as techniques for the analysis of xenobiotics. These techniques are often paired with state-of-the-art detection techniques like high-resolution mass spectrometry (HRMS). Highlighted as well were techniques for the removal of xenobiotics using membrane processes, improved oxidation processes, engineered wetlands, photocatalytic degradation, biotransformation, bioremediation, photo-remediation, adsorption, and bioremediation to decrease the side effects.***

***Keywords:** Contamination, Drinking water, Environment, Pollution, Xenobiotics*

## INTRODUCTION

Water bodies offer vital functions, including agriculture, recreation, aesthetics, and drinking water. Water that is available in adequate amounts and of good quality leads to good health (Bharti & Gajananda, 2013). Meanwhile, contamination from modern activity deteriorates their quality and makes their fundamental use impossible (Chukwu *et al*., 2008). Humanity's greatest challenge in the twenty-first century involves both water supply and quality issues. The water problem affects industrialized and developing countries; it is not localized to any nation or region (Karthigadevi *et al*., 2021). Water bodies and aquifers around the world are thought to be seriously threatened by point and non-point sources (Wang *et al*., 2012). Xenobiotics seep into public drains, enter the food chain, and directly harm humans and the micro-pollutant pollution of aquatic bodies (Roccaro *et al*., 2013). According to Ebele *et al*. (2017), new substances are introduced into the environment through technological advancement, greater medication accessibility (for both people and animals), and consistent usage of insecticides and personal hygiene goods. These composites, either separately or in a mixture, can potentially be hazardous, considering the short- and long-term impacts on humans, animals, and the ecosystem (soil, water, and air) (Embrandiri *et al*., 2016).

The rate of plastic recycling is often low, and some waste plastics end up in landfills or soils. Plastic product output has surged in recent years, reaching 359 million tons in 2018, with China accounting for 30% of the total(Yu *et al*., 2021). Microplastics have been divulged in air samples, food, and drinking water (Koelmans *et al*., 2019). The effects of microplastics on human health have been observed recently

(Wright & Kelly, 2017). Microplastics may aggregate and produce toxic particles by evoking an immunological reaction if inhaled or swallowed (Koelmans *et al.*, 2019). Microplastics can be categorized into two types: primary and secondary. Primary microplastics are composed of small plastic particles, whereas secondary microplastics are produced when larger plastics break down in the environment (Firdaus *et al.*, 2019). Because of wastewater discharge, these microplastics (MP) are commonly discovered in personal and healthcare commodities and can potentially harm the ecosystem (Duis & Coors, 2016). According to a growing body of research, microplastics are being integrated into frequently consumed food items by animals consuming microplastics in the environment, contamination during manufacture, and/or contamination by plastic packaging (Jambeck *et al.*, 2015).

Unfortunately, due to a variety of human activities over the past few years, the water quality of these significant resources has changed, and the negative effects of water contamination have progressively come to light (Pourkhabbaz *et al.*, 2018). Heavy metal pollution of surface and groundwater is mostly caused by natural processes as well as human activity. Regardless of the source, the increase in heavy metal content in water poses a serious risk to aquatic ecosystems and human health (Banzi *et al.*, 2008). Arsenic, cadmium, chromium, lead, nickel, and zinc are some of the prevalent heavy metals that pose health risks to people (TBS, 2005; WHO, 2008). When heavy metal concentrations in the water exceed environmental tolerance limits, aquatic ecosystems, and humans through the food chain may be at risk. Consequently, these aspects must be taken into account when creating the baseline data that will be used as a reference for successful verification of compliance with recommended mining methods based on gradually increasing heavy metal concentrations and tolerance thresholds for heavy metal absorption (Pourkhabbaz *et al.*, 2018 & Huang *et al.*, 2020).

In developed as well as developing nations, pesticide use is crucial to modern agricultural practices (Vinas *et al.*, 2022). On this note, over the past few years, legislative, regulatory, and public criticism of the use of pesticides in agriculture to control a variety of pests, including insects, weeds, and plant diseases, has been strong (Syafrudin *et al.*, 2021). The dangers of pesticides include their direct effects on people, food products, the environment, beneficial soil microbes and soil fertility, air pollution, soil, surface water, and non-target vegetation (Beheary *et al.*, 2018). As a result, people are always at risk of losing their lives or paying a high price to protect themselves from the emergence of different water-borne diseases (Elfikrie *et al.*, 2020). In many parts of the world, water pollution brought on by pathogenic organisms, chemicals, heavy metals, pesticides, and industrial and agricultural operations is now a health risk to Humans (Manoj & Avinash, 2012).

## XENOBIOTICS

Exogenous substances, whether natural or artificial (such as pharmaceutical products and chemicals), that affect animals' cells, tissues, or organs physiologically or biologically are referred to as xenobiotics. Numerous xenobiotics can potentially be dangerous to organisms exposed to them in the environment (de Oliveira *et al.*, 2020). However, the qualities of the organisms, chemicals, and environment all affect how bioavailable these compounds are (Bonjoko, 2014). It's also conceivable to group xenobiotics as the unusual presence of whatever content in high concentrations, like the presence of antibiotic medications in the human body, something the body does not typically produce or consume, but perhaps a naturally occurring material might be classified as a xenobiotic if it gets into people or other animals (Mathew *et al.*, 2017). Numerous substances (antibiotics, insecticides, colors, personal care products, additives, etc.) that are used to make life better do not inevitably transpire naturally in the environment, or naturally occurring concentrations differ noticeably from those brought about by human action and were created as a result of 20th-century technological advancements (Kumar & Chopra, 2020). The fundamental issue is their physicochemical composition, and this causes them challenging to recognise, quantify, and discard due to factors like diminutive size of molecules, ionizability, Variability, polarity, lipophilicity, and solubility in water (de Oliveira *et al.*, 2020). According to Soucek (2011), in situations where they are excessively prevalent, A few naturally occurring substances, known as endobiotics, can become xenobiotics. According to Kumar and Chopra (2020), Pesticides, pharmaceutical compounds, personal care products, illicit drugs, industrial goods, and radioactive wastes are all considered xenobiotics. As seen in Figure 1, xenobiotics are also found in the air, soil, water, plants, animals, and humans. Among the numerous anthropogenic activities that can release xenobiotics into the environment are human consumption and excretion, wastewater and sewage treatment facilities, livestock treatment and excretion, industries and manufacturing facilities, and agricultural operations. Pesticides are applied directly to the soil, then swept into rivers in the area and groundwater (Pourkhabbaz *et al.*, 2018). Humans consume Pharmaceuticals and Personal Care Products, which indirectly penetrate the environment through some of their metabolites, some of which are excessively dangerous than the parent molecule cannot be fully digested (Ebele *et al.*, 2017).

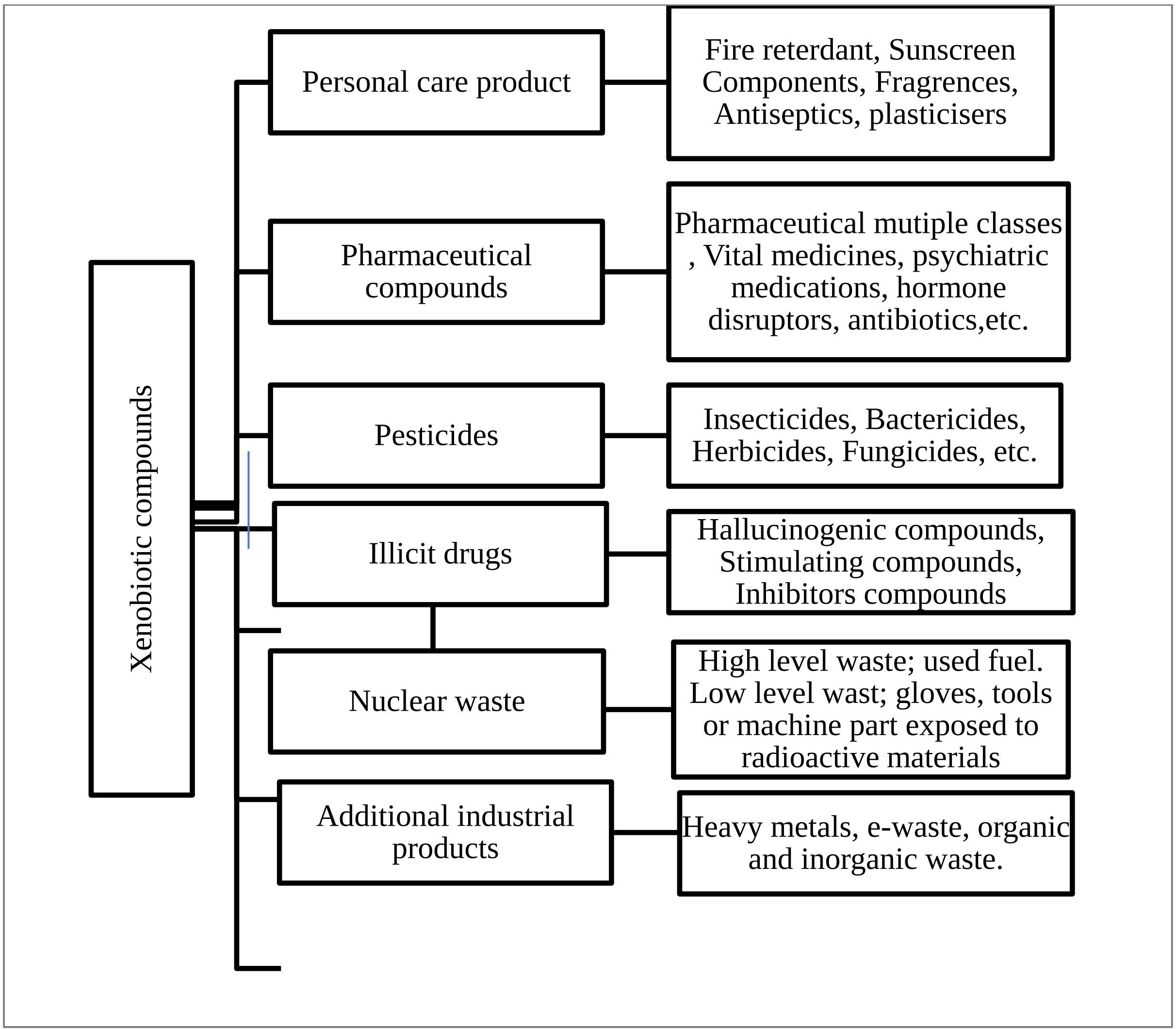


Figure 1: Types of Xenobiotic Compounds (Modified from Kumar & Chopra, 2020).

Because pesticides are widely used for agricultural and non-agricultural purposes, there are residues of pesticides in surface and groundwater resources (Székács *et al.*, 2015). As substances for protecting crops from deadly infestations and diseases that impact humans, pesticides are well known, and the good benefits of pesticides make them vital instruments for safeguarding and enhancing the living conditions of the overall world's population (Kumar *et al.*, 2013). Herbicides and insecticides are the most frequently utilized pesticides, making about 47.5% and 29.5% of total pesticide consumption, respectively (Syafrudin *et al.*, 2021).

## SURFACE WATER PESTICIDE CONTAMINATION

Water supplies for drinking (both raw and tap) and irrigation for ecological agriculture are both at risk from pesticide contamination, which is present in the water because of runoff from agricultural fields and industrial wastes, which makes it more difficult to practice pesticide-free agriculture (Yadav *et al.*, 2015). Though agrochemicals have a strong affinity for soil, the soil matrix functions as a pesticide storage compartment. Because soil and water bodies are closely related, pesticide contamination can affect groundwater and "surface" water supplies, including streams, estuaries, and lakes (Syafrudin *et al.*, 2021). Low concentrations of pesticides accumulated in water can be multiplied by entering the food chain and aquatic life, eventually harming humans (Sharma *et al.*, 2019). Both point sources and nonpoint sources allow pesticides to enter water bodies. Discharge of chemicals during improper preservation, loading, Waste disposal, and even improper pesticide application to aquatic areas are point sources originating from a permanent site (Alamgir *et al.*, 2015). Exposure to pesticides and improper discharge of pesticides results in the Pesticides seeping directly into groundwater, an example of point source pollution (Lushchak *et al.*, 2018). Despite the extensive utilization of pesticides in the agricultural sector, indoor gardening and other urban pest management practices are a significant origin of the water pollution caused by pesticides, and in comparison to other pesticides like herbicides, fungicides, and insecticides are more strongly detected in urban areas (Zubrod *et al.*, 2019).

## CLASSIFICATION OF PESTICIDE POLLUTANTS IN WATER

Herbicides, fungicides, and insecticides have been the most often used pesticides in metropolitan and agricultural settings based on their capacity to eradicate particular species (Alamgir & Chowdhury, 2015). Herbicides destroy weeds and are typically present in plant growth regulators. Garden insects, stored food facilities, and farmlands are controlled using insecticides. Whereas fungicides are sometimes sprayed before or after a fungus infects a plant, preventing the growth of fungi in seeds or plants (Wolfram *et al.*, 2019). Organophosphorus pesticides are less frequent in aquifers because of their rapid environmental degradation, even though they are still quite toxic to humans. Carbamate insecticides are also being introduced to replace chlorinated hydrocarbons. The active components of carbamate insecticides may end up in surface waterways since they are uncertain to be bonded to soil particles(Sabin *et al.*, 2009).

## PESTICIDE INCIDENCES AND HEALTH EFFECTS

It is a common problem to find pesticides within particular sections of the environment, including surface water, groundwater, and the silt in streambeds (McKnight *et al.*, 2015). According to the standard of the National Water-Quality Assessment NWQA, (2021), 25 pesticides were discovered, out of which more than 10% of them are in surface waterways, and 2% are in groundwater in a variety of land-use settings, including agricultural, metropolitan, and mixed land use, which demonstrates that pesticides are frequently found in surface waterways due to their direct and quick transportation over land via surface runoff. The sluggish pace of water infiltration into the aquifer through the soil may be the cause why pesticide contamination of groundwater is less likely. Groundwater contamination is more challenging to reverse once it has occurred due to pesticides' morphological flexibility, distribution, and sorption during the prolonged transit time (Sharma *et al.*, 2019).

A report by Zaidon *et al.* (2018) revealed that pesticide exposure results in cancer, hormone disruption, reduced IQ, immunosuppression, and altered reproduction. The most frequent acute health consequences of pesticides include impaired vision, headaches, salivation, diarrhea, nausea, vomiting, wheezing, coma, and even death (Elfikrie *et al.*, 2020). Pesticide exposure can have both immediate and long-term negative consequences on human health. Neurological side effects, such as the onset of Parkinson's disease, attention deficit disorder, anomalies in memory, reproductive problems, changes in fetal development, cancer, and birth deformities, are examples of chronic health issues (Zaidon *et al.*, 2018). The degree of pesticide toxicity determines these consequences because even mild pesticide poisoning can resemble the symptoms of bronchitis, gastroenteritis, and asthma, according to a study evaluated by Samsuddin *et al.* (2015). According to a different source (Dalvie *et al.*, 2004), endosulfan caused the metalloproteinase protein stromelysins to be over-expressed, which in turn caused the degeneration of the proteins necessary for the advancement of atherosclerosis. Farmers who frequently used chlorinated pesticides had a significant risk of getting prostate cancer and allergy or non-allergic asthma (Hoppin *et al.*, 2009).

## MICROPLASTICS

Between the 1950s and 2015, the amount of plastic produced worldwide rose from 1.5 million tons to 322 million tons, while in 2022, plastic production reached 400.3 million metric tons, given that plastics are now both a profitable commodity and a necessary part of daily existence (Nurain *et al*., 2020). Microplastics are microscopic plastic particles smaller than 5 mm and can form from larger plastic particles in the environment over time. Other tiny man-made microplastic particles discovered in the water are classified as primary microplastics because they are generated and used in goods like cosmetics, industrial particles, or pellets used to make plastic polymers (Sarijan *et al*., 2018).

High levels of persistent pollutants accumulate in rivers and coastal areas due to anthropogenic pressures, which could negatively affect species and the environment (Zhang *et al*., 2019). Microplastics in economic fish species pose concerns regarding food security and human health (Barboza *et al*., 2018) Precise exposure measurement is also necessary for risk evaluation, which makes biota sampling necessary (Anbumani & Kakkar, 2018).

## MICROPLASTICS AND THEIR HEALTH IMPACT

According to a report by Gasperi *et al*. (2018), air, water, and food samples contain microplastics, and most recently, there are assessments of the microplastics' implications on human health. Whereas it is possible to be exposed to microplastics by ingesting or inhalation, the effects on human health are still unknown, and limited evidence from animal research indicates that microplastics may collect and create particle toxicity by stimulating the immune system when ingested or breathed (Deng *et al*., 2017). Leaching of plastic-related compounds may result in chemical toxicity. Although there is a dearth of information on exposure levels, these effects are probably dose-dependent (Koelmans *et al*., 2019). Moreover, microbial infections could originate from biofilms that are developing on microplastics (SAPEA, 2019). Therefore, existing consumption levels, particularly via drinking water, must be assessed before considering possible chemical particles, and microbiological concerns related to microplastics. Only a few studies have been conducted so far that deal with this issue have shown that Microplastics can be found in both packaged and tap water (Kosuth *et al*., 2018). The issue of human being exposed to microplastics through drinking water became a priority for public health organizations worldwide due to some of this research garnering significant media and scientific attention. Generally speaking, obtaining clean water is a top political concern; one of the Sustainable Development Goals (SDG 6) is to provide clean, accessible water (WHO and UNICEF, 2017).

## TECHNIQUES FOR XENOBIOTIC IDENTIFICATION AND ELIMINATION

Using the right extraction and analytical techniques for separating and determining a blend of xenobiotics alternatives is crucial. Likewise, these techniques must be quick, precise, and affordable (Kumar & Chopra, 2020). The chemicals are frequently diverse in various sample types and are challenging to detect at low concentration rates, making it difficult to identify xenobiotics in environmental samples (de Oliveira *et al*., 2020). Among the extremely sensitive and analytical techniques used to examine xenobiotics are multifunctional chromatographic techniques, Gas Chromatography (GC), Ultra-high-Performance Liquid Chromatography (UPLC), and High-Performance Liquid Chromatography (HPLC) (Tuzimski& Sherma, 2019). In both human and veterinary medicine, chromatographic analysis of xenobiotics is employed to separate and identify compounds with similar chemical structures in the air, ground, surface water, sludge, soil matrices, food, and food items. Compounds like toluene, xylene, and acetaldehyde that are either highly volatile or somewhat volatile are necessary for GC techniques, while the detection of phenols, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons in water and soil, including fluoranthene, pyrene, chrysene, acenaphthene, and fluorene, HPLC is used (Oros *et al*., 2012). Functional groups related to the chemical characteristics of polymers are found using Fourier Transform Infrared (FTIR) spectroscopy. Samples of water extracted using solid phase extraction (SPE; 1000 x intensity factor), thenGC-MS, either with or without derivatization, is next, which is used to determine the selected analytes (Maloschik *et al*., 2010). While neonicotinoid pesticides are determined using HPLC, glyphosate is tested using ELISA (M¨ortl *et al*., 2013). Dried samples are generated by directly depositing big, visible particles onto the filter surface or by filtering the sample solution through an appropriate mesh filter with suspensions ranging in size from microliters to litres. A single filter can enable a one-step analysis of large volumes of suspected contaminated solutions (Schymanski *et al*., 2018).

Many techniques effectively remove xenobiotics, including depletion, adsorption, biosynthesis, improved oxidation processes, engineered marshes, and membrane mechanisms (Roccaro *et al.*, 2013). Techniques for degradation are categorized as photo-remediation and biological remediation (microbial remediation using bacteria, fungi, and algae). In photo-remediation, photon-adsorbing xenobiotic substances, including pesticides, heavy metals, and dyes, are broken down using radiation from the sun that is ultraviolet (UV) and infrared radiation. Introducing photodegradable polymers has made it possible to utilize photo-remediation to break down plastic. Photocatalytic degradation utilizing ZnO and UV-A is one advancement used in Congo red dye degradation (Kumar & Chopra, 2020). Utilizing microorganisms like *Aspergillus niger* and *Penicillium funiculosum* to decompose synthetic and natural polymers, biodegradation is assessed by photodegraded films (Varsha *et al.*, 2011).

## CONCLUSION

The examined literature indicates that different effective methods/techniques can be used in detecting and mitigating/eliminating the xenobiotic compounds in drinking water. More so, consumption of such compounds may result in carcinogenic or non-carcinogenic effects that may even result in death. There is a significant variation in the reports of microplastic concentrations in various types of water; however, this discrepancy can be explained by the fact that several studies have focused on different size classes. Research has indicated that drinking and freshwater commonly contain xenobiotics despite limitations on quality. It is, therefore, necessary to enhance the capacity to examine and distinguish minuscule xenobiotic compounds in diverse water samples.

## REFERENCES


Alamgir Z., Chowdhury M., Hossain, M. S., Pramanik, M. D., Rahman, M. A., Fakhruddin, A. N. M. & Alam, M. K. (2015). Determination of selected pesticides in water samples adjacent to agricultural fields and removal of organophosphorus insecticide chlorpyrifos using soil bacterial isolates, *Applied Water Science*, *5*(2), 171-179. **[Crossref]**

Anbumani, S. & Kakkar, P. (2018). Ecotoxicological effects of microplasticss in biota: a re- view. *Environmental Science Pollution Res.Int.25*(15), 14373-14396. **[Crossref]**

Banzi, F. P., Msaki, P. K. & Mohammed, N. K. (2008). Assessment of heavy metal concentration In Water around the Proposed Mkuju River uranium project in Tanzania. *Tanzania. Journal of Science*, *41*(1), 8-18.

Barboza, L.G.A., Vethaak, A.D., Lavorante, B.R.B.O., Lundebye, A.-K. & Guilhermino, L., (2018). Marine microplastics debris: an emerging issue for food security, food safety and human health. *Marine Pollution Bulletin,113*, 336–348. **[Crossref]**

Beheary, M., El-matary, F., El-hamid, H. T. A., Rahman, A. & Al, M. (2018). Removal of some Pesticides from contaminated Water using lowcost Materials. *Advances in Environmental Biology*, *12*(8), 3-8. **[Crossref]**

Bharti, P.K. & Gajananda, K.H. (2013). Environmental monitoring and assessment in Antarctica, In: Environmental Health and Problems, *Discovery Publishing House, Delhi*, 178-186.

Bosun Banjoko (2014). Intech. Open Science/Open Mind. Environmental Pharmacology- An Overview. (pp. 1-172). **[Crossref]**.

Chukwu, O., Segi, S. & Adeoye, P.A. (2008). Effect of Car-wash effluent on the Quality of Receiving Stream. *Journal of Engineering and Applied Sciences 3*(7), 607-610.

Dalvie, M.A., Myers, J.E., Thompson, M.L., Robins, T.G., Dyer, S., Riebow, J., Molekwa, J., Jeebhay, M., Millar, R. & Kruger, P. (2004). The long-term effects of DDT exposure on semen, fertility, and sexual function of malaria vector-control workers in Limpopo Province, South Africa.*Environ. Res. 96*(1),1-8. **[Crossref]**

Deng, Y., Zhang, Y., Lemos, B. & Ren, H. (2017). Tissue accumulation of microplasticss in mice and biomarker responses suggest widespread health risks ofexposure. *Scientific Reports 24*(7), 46687. **[Crossref]**

deOliveira,M., Frihling,B.E.F., Velasques,J., Filho,F.J.C.M., Cavalheri,P.S. & Migliolo,L. (2020). Pharmaceuticalsresiduesandxenobiotics contaminants: Occurrence, analytical techniques and sustainable alternatives for wastewater treatment. *The Science of the Total Environment 25*(705), 135568. **[Crossref]**

Duis, K. & Coors, A. (2016). Microplastics in the aquatic and terrestrial environment:

sources (with a specific focus on personal care products), fate and effects. *Environmental Science Europe*. *28*(2), 1-25. **[Crossref]**

Ebele, A.J., Abou-Elwafa Abdallah, M. & Harrad, S. (2017). Pharmaceuticals and personal care products (PPCPs) in the freshwater aquatic environment. *Emerging Contaminant*, *3*(1), 1-16. **[Crossref]**

Elfikrie, N., Ho, Y.B., Zaidon, S.Z., Juahir, H. & Tan, E.S.S. (2020). Occurrence of pesticides in surface water, pesticides removal efficiency in drinking water treatment plant and potential health risk to consumers in Tengi River Basin, Malaysia. *The Science of the Total Environment* *10*(712), 136540. **[Crossref]**

Embrandiri, A., Kiyasudeen, S.K., Rupani, P.F. & Ibrahim, M.H. (2016). Environmental Xenobiotics and Its Effects on Natural Ecosystem. *Environmental Science*. 1-18. **[Crossref]**

Firdaus, M., Trihadiningrum, Y. & Lestari, P. (2019). Microplastics pollution in the sediment of Jagir Estuary , Surabaya City , Indonesia. *Marine Pollution Bulletin*. *1*(150),110790. **[Crossref]**

Gasperi, J., Wright, S.L., Dris, R., Collard, F., Mandin, C., Guerrouache, M., Langlois, V., Kelly, F.J. & Tassin, B. (2018). Microplasticss in air: are we breathing it in?*Current Opinionin Environmental. Science & Health1*(1), 1-5. **[Crossref]**

Hoppin, J.A., Umbach, D.M., London, S.J., Henneberger, P.K., Kullman, G.J., Coble, J., Alavanja, M.C., Freeman, L.B. & Sandler, D.P. (2009). Pesticide use and adult-onset asthma among male farmers in the Agricultural Health Study. *The European Respiratory Journal 34*(6), 1296-1303. **[Crossref]**.

Huang, Z., Liu, C., Zhao, X., Dong, J. & Zheng, B. (2020). Risk assessment of heavy metals in the surface sediment at the drinking water source of the Xiangjiang River in South China. *Environmental Sciences Europe*. **[Crossref]**

Jambeck J, Geyer R, Wilcox C, Siegler T, Perryman M. & Andrary A (2015) Determination of Microplasticss in Surface Water and Sediment of Kelantan Bay. *Earth and Environmental Science347(*6223), 768. **[Crossref]**

Karthigadevi, G., Manikandan, S., Karmegam, N., Subbaiya, R., Chozhavendhan, S., Ravindran, B., Chang, S.W. & Awasthi, M.K. (2021).Chemico-nanotreatment methods for the removal of persistent organic pollutants and xenobiotics in water—A review. *Bioresource Technology*, *324*, 124678. **[Crossref]**

Koelmans, A. A., Hazimah, N., Nor, M., Hermsen, E., Kooi, M., Mintenig, S. M. & France, J. De. (2019). Microplasticss in freshwaters and drinking water : Critical review and assessment of data quality. *Water Research*, *155*, 410-422. **[Crossref]**

Kosuth, M., Mason, S.A. & Wattenberg, E.V. (2018). Anthropogenic contamination of tap water, beer, and sea salt. *PLoS One13*(4), 1-18. **[Crossref]**

Kumar, D. & Chopra, S. (2020). Xenobiotic Compounds in the Environment: Their Fate, Transport and Removal.*Journal of Xenobiotic.11*(4), 130-141. **[Crossref]**

Kumar, S., Sharma, A.K., Rawat, S., Jain, D. & Ghosh, S. (2013). Use of pesticides in agriculture and livestock animals and its impact on environment of India. *AsianJournal Environmental Science*, *8*(1), 51-57.

Lushchak, V.I., Matviishyn, T.M., Husak, V.V., Storey, J.M. & Storey, K.B. (2018). Pesticide Toxicity: A mechanistic approach. *EXCLI Journal*, *8*(17), 1101-1136. **[Crossref]**

Maloschik, E., M¨ortl, M. & Sz´ek´acs, A. (2010). "Novel derivatisation technique for the determination of chlorophenoxy acid type herbicides by gas chromatography-mass spectrometry, *Analytical and Bioanalytical Chemistry.397*(2),537-548. **[Crossref]**.

Manoj, K. & Avinash, P., (2012). A review of permissible limits of drinking water. *Indian Journal of Occupational and Environmental Medicine*, *16*(1), 1-6. **[Crossref]**

Mathew, B.B., Singh, H., Biju, V.G. & Krishnamurthy, N.B. (2017). Classification, source, and effect of environmental pollutants and their biodegradation. *Journal of Environmental. Pathology. Toxicology. and Oncology.36* (1), 55-71. **[Crossref]**

McKnight, U.S., Rasmussen, J.J., Kronvang, B., Binning, P.J. & Bjerg, P.L. (2015). Sources, occurrence and predicted aquatic impact of legacy and contemporary pesticides in streams. *Environmental Pollution200*, 64-76. https://doi.org/10.1016/j.envpol.2015.02.015.

M ortl, M., N´emeth, G. & Juracsek, J. (2013). "Determination of glyphosate residues in Hungarian water samples by immunoas- say," *Microchemical Journal107*, 143-151. [Crossref]

National Water-Quality Assessment(2021). Water resources; Continuous water-quality and suspended sediments, transport and monitoring in San Francisco.

Nurain, S., Mimi, L. A. B. & Nur A. I. (2020). Determination of Microplasticss in Surface Water and Sediment of Kelantan Bay. *Journal of Earth and Environmental Science549*(1), 012059. [Crossref]

Oros, G.; Cserháti, T. & Szo˝gyi, M. (2012). Chromatography of xenobiotics in biological and environmental matrices. *European Chemical Bulletin*, *1*(3-4), 81-93. [Crossref]

Pourkhabbaz H. R., H. F. and C. & M. (2018). Determination of Heavy Metals Concentration at Water Treatment Sites in Ahwaz and Mollasani Using Bioindicator. *ECOPERSIA*, *6*(1), 55-66. [Crossref]

Roccaro, P., Sgroi, M. & Vagliasindi, F.G.A. (2013). Removal of xenobiotic compounds from wastewater for environment protection: Treatment processes and costs. *Chemical Engineering Transactions*, 32, 505-510. [Crossref]

Sabin, G. P., Prestes, O. D., Adaime, M. B. & Zanella, R. (2009). Multiresidue determination of Pesticides in drinking Water by Gas Chromatography-Mass Spectrometry after Solid-Phase Extraction. *Journal of Brazil Chemical Society20*(5), 918-925. [Crossref]

Samsuddin, N., Rampal, K.G., Ismail, N.H., Abdullah, N.Z. & Nasreen, H. E. (2015). Pesticide exposure and cardiovascular Hemodynamic parameters among Male Workers involved in Mosquito Control in East Coast of Malaysia. *American Journal of Hypertension*, *29*(2),226-233. [Crossref]

SAPEA (2019). A Scientific Perspective on Microplastics in Nature and Society. Evidence Review Report No.4

Sarijan, S., Az, S., Ismid, M., Said, M. & Andu, Y. (2018). Microplasticss in sediment from Skudai and Tebrau river , Malaysia : a preliminary study,*MATEC Web of conferences*, *250*(1), 06012. [Crossref]

Schymanski D. (2018). Analysis of microplasticss in water by micro-Raman Spectroscopy: Release of Plastic Particles from Different Packaging into Mineral Water. *Water Research*. *129*(1), 154-162. [Crossref]

Sharma, A., Kumar, V., Shahzad, B., Tanveer, M., Sidhu, G.P.S., Handa, N., Kohli, S.K., Yadav, P., Bali, A.S. & Parihar, R. D. (2019). Worldwide Pesticide usage and its impacts on Ecosystem. *SNApplied Sciences 1*(11), 1446. [Crossref].

Soucek, P. (2011). Xenobiotics*In Encyclopedia of Cancer*Schwab, Germany. *Journal of Xenobiot 11*(4), 130-141. [Crossref]

Syafrudin, M., Kristanti, R. A., Yuniarto, A., Hadibarata, T. & Rhee, J. (2021). Pesticides in Drinking Water—A Review.*International Journal of Environmental Research and Public Health*, *18*(2): 468. [Crossref]

Székács, A., Mörtl, M. & Darvas, B. (2015). Monitoring Pesticide Residues in Surface and ground Water in Hungary : Surveys in 1990 - 2015. *Journal of Chemistry2015*, 1-15. [Crossref]

Tanzania Bureau of Standards (2005) Drinking (potable) water: specification (TZS 789:2005). National environmental standards compendium, Tanzania Bureau of Standards. 26-27.

Tuzimski, T. & Sherma, J. (2019). Determination of Targe Xenobiotics and Unknown Compound Residues in Food, Environmental, and Biological Samples. *Analytical and Bioanalytical Chemistry10*(1), 444. [Crossref]

Varsha, Y.M.,Deepthi,N. & Chenna, S. ( 2011). An enphasis on Xenobiotic degradation in Environmental cleanup. *Journal of Bioremediation and Biodegradation02*(4),1-10. [Crossref]

Vinas, P., Mireia, B., Noemi, T., Alicia, C., Sergio, M., Stephanie, R., Nuria, B. and Pere, C. (2022). The Hydration Status of Adult Patients with Oropharyngeal Dysphagia and the Effect of Thickened Fluid Therapy on Fluid Intake and Hydration: result of two parallel Systematic and Scooping Reviews. Journal of Nutrients 14(12): 2497. [Crossref].

Wang, T., Li, B. & Zou, X. (2019). Emission of primary microplasticss in mainland China: Invisible but not negligible. *Water Research.162*, 214-224. [Crossref]

Wang H, Liu D, Lu L, Zhao Z, Xu Y. & Cui F. (2012). Degradation of algal organic matter using microbial fuel cells and its association with trihalomethane precursor removal. *Bioresource Technology*, *116*,80–5. [Crossref]

WHO, UNICEF, (2017). *Progress on Drinking Water, Sanitation and Hygiene*: 2017 Update and SDG Baselines. World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), Geneva.

World Health Organization (2008). *Guidelines for drinking water quality* 3rd Ed. Incorporating the first and second agenda volume recommendations. WHO, Geneva.

Wolfram, J., Stehle, S., Bub, S., Petschick, L.L. &Schulz, R. (2019). Insecticide risk in US surface Waters: Drivers and spatiotemporal modeling. *Environmental Science & Technology*,*53*(20), 12071-12080. [Crossref]

Wright, S.L. & Kelly, F.J. (2017). Plastic and human health: a micro issue? *Environmental Science& Technology*,*51*(12), 6634e6647. [Crossref]

Yadav, I.C., Devi, N.L., Syed, J.H., Cheng, Z., Li, J., Zhang, G. & Jones, K.C. (2015). Current Status of persistent organic pesticides residues in air, water, and soil, and their possible effect on neighboring countries: A comprehensive review of India. *the Scienceof the Total Environ*ment, 511, 123-137. [Crossref]

Yu, L., Zhang, J., Liu, Y., Chen, L., Tao, S. & Liu, W. (2021). Distribution characteristics ofmicroplasticss in agricultural soils from the largest vegetable production base in China.*Science of The Total Environment*, 756, 1–9. [Crossref].

Zaidon, S.Z., Ho, Y.B., Hashim, Z., Saari, N. & Praveena, S.M. (2018). Pesticides contamination and analytical methods of determination in Environmental matrices in Malaysia and Their potential Human health effects–A Review. *Malaysian Journal of Medicine and Health Sci*ence, *14*, 81–88.

Zhang, S., Wang, J., Liu, X., Qu, G., Wang, X., Wang, X., Li, Y. & Sun, Y. (2019). Microplasticss in the environment: a review of analytical methods, distribution, and biological effects. *Trends Analytical Chemistry*,*21*(11), 62-77. [Crossref].

Zubrod, J.P., Bundschuh, M., Arts, G., Brühl, C.A., Imfeld, G., Knäbel, A., Payraudeau, S., Rasmussen, J.J., Rohr, J. & Scharmuller, A. (2019). Fungicides: An Overlooked Pesticide Class? *Environmental Science & Technol*ogy, *53*(7), 3347–3365. [Crossref].