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Impact of Microplastics in Day to Day Life

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Abstract: Manmade synthetic products like plastics were originally invented for comfort as they were inexpensive, lightweight, durable and hydrophobic but in the long run they posed to be non degradable causing air, water and soil pollution. With mechanical degradation, chemical degradation, exposure to UV radiations and even biological degradation by certain microorganisms, plastics are converted to micro-plastics. The increase of certain factors like increased levels of pollution and greenhouse gasses are depleting the Ozone layer. Leading to increased temperature and ambient humidity the degradation potential of plastic polymers by UV- B radiations increases. Micro-plastics including polyethylene terephthalate, polyethylene, polystyrene, polypropylene, polyvinyl chloride were determined in bottled water. With the increasing use of plastics in day-to-day life, microplastics are leaching out into environment. After leaching out in the environment these microplastics are entering into food web, causing lot of threats to living organisms. For detection of microplastics in water samples, dyes like Rose Bengal and Nile Red are being used for making better contrast under microscopy. Now a day's use of techniques like Pyrolysis-GC/MS, micro Raman spectroscopy, and IR/FTIR spectroscopy has made the detection of microplastics an easy task. Microplastics entering the food chain are usually inert in nature possessing different sizes and shapes. These microplastics when enter into a cell or tissue cause mechanical damage to them. Microplastics induce inflammation, disturbs metabolism and even lead to necrosis of cells and tissues. The objective of this publication is to present and discuss sources, identification and toxicological impact of microplastics in drinking water.

Key words: Microplastics, drinking water, degradation and toxicity.

1. Introduction

Humans have invented lots of unnatural products to bring comfort and ease to their lives. In 1940, the first industrial production of plastics came into business and over the past decade it has been used customarily as it is easy to manufacture, the production is inexpensive, the plastic itself is hydrophobic, lightweight and durable and as a result so many products have been formed from it (Hassanpour & Unnisa 2017). It can be moulded into any shape like that of food and drink containers, toys, cars, wrappers, carry bags, toothbrushes, pens and facial cleansers, and of all these about 40% is a single use plastic. Plastic products are used worldwide in different forms causing them to enter the environment and consequently cause pollution. When this single use plastic enters the environment, it causes pollution. Ziajahromi et al (2017) conducted sampling in October 2015 from various treatment stages of three Waste Water Treatment Plants (WWTPs). This sampling was designed to be done specifically for wastewater-based micro-plastics. The sample material was rinsed on mesh screen with 100 to 500 mL ultra-pure water. After rinsing, water samples were concentrated to 100 mL by drying in an oven at 90°C. Furthermore, the samples were treated with a solution of 30% hydrogen peroxide to digest the organic matter present in it. All water samples were stained with Rose-Bengal solution (4, 5, 6, 7-tetrachloro-2′, 4′, 5′, 7′-tetraiodofluorescein, Sigma- Aldrich, 95% dye content), for the visual separation of plastic and non-plastic particles. They confirmed micro-plastics to be PET fibers, mostly white and transparent along with several shiny green ones (80%; 10 particles), and blue coloured PE (20%; 2 particles), with size ranging from 25-500 µm after FT-IR analysis. This occurrence of micro-plastics in several water bodies, has put the environmentalists in dire straits. Data published from 1972 to 2017 was assimilated and analyzed for the study of interaction between micro-plastics and selected chemicals which can bring toxicity to the ecological balance. Data analysis revealed a certain sorption behaviour between micro-plastics and the chemicals. Adherence of these chemicals to the micro-plastics was found to be higher in samples from larger cities or highly industrialized areas, as compared to the smaller cities or remote areas. Further, these micro-plastics enter the living organisms' food chain. It causes hazardous effects on the environment and human well-being, seeking public attention for more studies (Wang et al. 2018).

Due to the high use and low recovery of non-degradable materials, plastics keep accumulating in the environment exponentially and its durability allows it to persist for hundreds to thousands of years (Barnes, Galgani, Thompson, & Barlaz, 2009), as it is lighter in weight and easily transported from one place to another through wind, water and humans. Transport of micro-plastics to environment is greatly affected by size, shape, density and chemical composition and their availability [Rocha-Santos & Duarte 2015].Micro-plastics are small pieces of plastic, less than half a centimeter in size. Micro-plastics having size <5mm are coming into existence in environment when plastics having size >5mm are exposed to sunlight and other environmental actions break up into smaller pieces (Andrady, 2015). As humans are intensifying the use of plastics, micro-plastics are amassing in the environment. It has been reported in agricultural fields, barren lands, freshwater lakes, streams, ponds, rivers, sea shores, deep sea and even in

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Arctic sea ice. Due to inescapable plastic pollution, traces of micro-plastics are entering food web, through primary producers to primary consumers and secondary consumers. Pervasive occurrence of micro-plastics have been identified in terrestrial as well as aquatic environments locating their traces in food items, beverages and even in seafood products. Many scientists have expressed concern that micro-plastic pollution is causing a variety of sub-fatal and fatal effects on living organisms entering through food chain (Rochman et al. 2016). Plastic and micro-plastic debris, when enter the animals, causes suffocation, scraping of food cavity, and /or deprivation of food can lead to death (Wright, Thompson, & Galloway, 2013). Studies have shown their presence in bottled mineral water and other beverages packed in plastic bottles. Public concern and safety related issues are raising due to the increased awareness through various sources. Increased awareness is due to the technology and improved analytical methodsbeen used to detect micro-plastics in food and beverages [Welle & Franz 2018].

2. Occurrence and detection of Micro-plastics in drinking water Micro-plastic contamination intap water

M. Kosuth et al, (2017) analyzed 159 samples of tap water from six regions in five continents. Plastic particles about 83% were found to be there in the 159 samples analyzed. In most of the samples fibers (99.7%), ranging between 0.1 - 5 mm in length were found. Tap water taken from North America revealed the highest density of plastic per volume of tap water while European countries showed lowest densities in tap water tested. Micro-plastics in water and food are receiving much attention in recent years as new emerging pollutants. As compared to food particles or sea water, studies on tap water micro-plastic contamination are lesser in number. Investigation done by Huiyan Tong et al, (2020) showed the presence of micro-plastics in tap water. They took 38 tap water samples from different cities of China. Their study revealed that the amount of micro-plastics in tap water varied from 440 ± 275 particles. In most of the water samples investigated particles smaller than 50 μm were predominant. Among the particles identified by micro-Raman spectroscopy were found to be fragments, fibers and spheres, where fragments comprised of polyethylene and polypropylene were abundant. These micro-plastics in water pose potential eco-toxicological effects on humans. As the water treatment plants face the problem for the removal of micro-plastic pollution.

Micro-plastics contamination in bottled water

Schymanski et al, (2017) for their study took water samples from 22 reusable and single-use plastic bottles, 9 glass bottles and 3 beverage cartons and they observed that the small (-50-500 μm) and very small (1-50 μm) fragments of micro-plastics were found in each bottle. The findings they obtained were that maximum micro-plastic particles found were in the range of 5 to 20 μm resulting in about 80% of the particles. Five size ranges were set to be measured as: 5-10 μm, 10-20 μm, 20-50 μm, 50-100 μm and >100 μm by using μ-Raman spectroscopy at 532 nm wavelength, the spectrum obtained for each particle was compared to a reference library (rapID, Berlin) for identification as the analytical techniques used in previous studies were not able to detect particles between 5 and 20 μm. As most of the reusable plastic bottles are composed of polyethylene terephthalate (PET), 84 % and polypropylene (PP), about 7 %, micro-plastic particles found were PET and PP, while from single-use plastic bottles fewer number of PETs were found. Types of micro-plastic particles found in glass bottles and beverage cartons, differs from reusable and single-use plastic bottles as polyethylene or polyolefin coatings are found in beverage cartons, while their caps are treated with lubricants.

Oßmann et al. (2018) in their study took 32 samples of mineral water for investigating micro-plastic contaminants; all bottles possess variable amounts of micro-plastics. They found that micro-plastics were present in higher amounts in reusable PET bottles and glass bottles than single-use PET bottles, predominantly polyethylene terephthalate indicating that this came from the bottle material itself. Polyethylene and/or styrene-butadiene-copolymer were found to be coming from during the filling process, from bottle caps, or washing machinery in glass bottles. Due to aging of bottles by use and reuse PET bottles showed more number of micro-plastics as compared to the fresh ones. In addition to the presence of micro-plastics, certain other pollutants were also found such as pigmented particles that are heavily used for labelling these bottles. Contaminants also enter during the washing and cleaning processes used for these bottles. Their study revealed that the pigmented particles and micro-plastics of size ≤5 μm were found to be 90 % and of size ≤5 μm to be 40 %. Mason et al, (2018) conducted tests for finding micro-plastic contamination using Nile Red dye instead of Rose Bengal as plastics easily adsorb Nile Red allowing their detection via fluorescence. They took 11 globally recognized bottled water brands purchased from nine different countries. They processed total 259 bottles, out of which 93% bottles showed some sign of micro-plastic contamination including an average of 10.4 particles/L micro-plastic entering water during the processing of water bottles. FTIR spectroscopy suggested that 66% particles were fibers, 54 % being polypropylene, and 4% industrial lubricants. All these particles were of size >100 μm per litre of bottled water, for micro-plastics having size lesser than 100 μm Nile Red dye was used. Spectroscopic analysis using Nile Red dye indicated that on an average 325 micro-plastic particles found ranged between 6.5 and 100 μm in size per litre of bottled water. Micro-plastics enters human body via water and food toxicologically affecting them, this helps in analyzing even the smallest micro-plastic entering the body. The dye Nile Red been used has a solvatochromic nature.

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It offers identification of micro-plastics by categorization on the basis of surface polarity characteristics of plastic particles (Maes et al. 2017).

2.1 Toxicological impacts of microplastics on living organisms and cells Micro-plastics also take the same route as any other food material. They are firstly taken up by the body along with food and water, where they are translocated to different parts and accumulated there before being finally eliminated. As these micro-plastics are of very small size they are retained for prolonged times making an impact on living organisms. Plastics and microplastics are inert in nature having different size, shapes, solubility and surface charges leading to cytotoxic influence including oxidative stress, apoptosis, inflammation, necrosis and genotoxicity on cells and tissues in vivo. When these micro-plastics remain sustained for prolonged periods they pose threatening outcomes including fibrosis, carcinogenesis and tissue damage (Wright & Kelly, 2017).

Prolonged exposure to micro-plastics and their impacts across different levels i.e., cellular to organism level has been studied. At cellular level, direct microplastics exposure or a stress response to chemical exposure initiates oxidative stress as a biological response. Micro-plastics have the capacity to interfere with components of the immune system, cause inflammation and initiate immunological response. At tissue-organ level, gastrointestinal tract is the main site where microplastics make most of their impact related to obstructing and mechanically damaging it, inducing inflammation, increasing mucus production and even inducing goblet cell hyperplasia. Micro-plastics also affect hepatic tissues including disturbance in metabolism of Liver, glycogen depletion that gradually leads to liver cell necrosis. At an organism level, micro-plastics make an impact on the behaviour of organism like causing false contentment, growth restrictions and reduced levels of energy reserves, inducing neurotoxicity and disturbances in feeding behaviour. Longer persistence and widespread occurrence of these micro-plastics in environment is adversely affecting the biogeochemical cycle, food webs and ecosystem processes (Ašmonaitė & Almroth, 2018). “World Health Organization” has emphasized on ubiquitous presence of micro-plastics in environment impacting human health entering via contaminated food water and through air inhalation. Cox, K. D, (2019) reported presence of micro-plastics in food items as sugar (0.44MPs/g), salt (0.11MPs/g), alcohol (0.03MPs/g), and bottled water (0.09MPs/g). Microparticles < 2.5 µm, when ingested enter the gastrointestinal tract via M cells of Payer’s Patches (that transport antigens from the lumen to cells of the immune system) resulting in inflammation confirmed by findings from stool testing. Polyethene and polypropylene ranging between 5 to 500 mm were found in every 10 g of stool. Approximately 90 % of micro-plastics are excreted with stool, the remaining 10 % cause inflammation (Campanale et al, 2020).

2.2 Separation and identification of micro-plastics

2.2.1 Separation of micro-plastics

Micro-plastics are separated using sieves with mesh sizes ranging from 0.038 mm to 5 µm in a series of filtration processes. For micro-plastics < 1 µm, active separation, and passive separation. Active separation is done by field flow fractionation (FFF) technique used for macro to nanoparticles. Separation depends on size and molar mass fractionation of fluid suspension when pumped through a long, narrow channel, a perpendicular force field is applied to the direction of fluid suspension flow. Stratification of fluid suspension occurs and solute layers are formed and displaced along with a longitudinal flow. Analytes are eluted depending on their distance from the accumulation wall on the basis of size and molar mass.

Hydrodynamic chromatography (HDC) utilizing hydrodynamic and surface forces to separate particles ranging from 10 nm to 1000 nm passively from liquid samples. Samples are added to packed column of solid beads, a velocity force is applied among the channels. Larger analytes migrate in the centre, while smaller analytes migrate closer to the channel walls and are separated on the basis of hydrodynamic effect and van der Waals interactions (Fu, W., et al,. 2020). Micro-plastics of various polymer types, shapes and sizes are difficult to identify from composite matrices present in environment. By opting any one analytical method it is very difficult to identify micro-plastics occurring in variable shapes, sizes and types from the environment. Mostly microscopic techniques were used for the detection and identification of micro-plastics. Now they are been combined with IR/FTIR spectroscopy, micro Raman spectroscopy or Pyrolysis-GC/MS for the identification of micro-plastics.

2.2.2 Identification and characterization methods for Micro-plastics Pyrolysis-GC/MS

This technique analyses the chemical composition of micro-plastics with two simple steps. In the first step Evolved Gas Analysis provides a clarity of the sample complexity. The sample is placed in the furnace keeping temperature between 40-100˚C. After some time temperature of furnace is increased to higher temperature between 600-800˚C. As temperature rises compounds “evolve” from the sample and detector EGA thermogram, identifies the thermal zone where specific compounds of interest evolve from the sample and perform multiple analyses (Belganeh & Pipkin 2018, Hermabessiere et al. 2018). Pyrolysis-GC/MS is best suited for the analysis of small size particles and can overcome many of the analytical challenges associated with these small particles (Fischer & Scholz-Bottcher 2017). This

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technique differentiates low density with high density forms of micro-plastics like PET, PTT and PBT by providing details about their structure (Scott 2019). Platinum filament-based Pyrolysis-GC/MS method has the advantage of minimal sample preparation with short analysis times. For quantification of polystyrene (PS) and polyethylene (PE) the platinum filament-based Pyrolysis-GC/MS requires little sample preparation were 0.03 mg and 1 mg absolute, respectively giving relative standard deviation of the analytical method of 11 % only (Funck et al. 2020). Since the last two-three years, Pyrolysis-GC/MS has been used to identify and analyze the composition of plastic polymers as well as micro-plastics. This technique is advantageous over other techniques to be relevant to specifically identify polymers and plastic additives. It has limitation of not being able to discriminate the type of polymerization between polyethylene and polystyrene (Hermabessiere et al. 2018).

Raman Spectroscopy

Raman spectroscopy is a proven and effective means for identifying micro-plastics since the mid-1980s. It is improving with the technological advancements having increased sensitivity for polymer characterization (Howard 2019). High reliability while identifying microplastics with in different samples successfully makes Raman spectroscopy a good choice. In Raman spectroscopy the sample is irradiated with a monochromatic laser source of wavelengths ranging between 500 and 800 nm. Monochromatic light interacts with the molecules and atoms of the sample causing vibrational, rotational, and other low-frequency interactions. As a result light is back scattered which is then compared with the irradiating light frequency leading to sample-specific Raman spectra. Each plastic polymers possess a specific Raman spectra set as a reference spectra and is compared with the samples being analysed and allows for the identification of a broad range of sizes below 1 µm (Cole et al. 2013, Howard 2019). Micro-Raman spectroscopy is capable of detecting smallest, and abundant, particle of sizes in micrometres (Schymanski et al 2018, Radel & Creasey 2020). Raman micro-spectroscopy has been evaluated extensively for its suitability for microplastics analysis as it is non-invasive and can be applied directly on the filter holding the extracted particles (Kniggendorf et al. 2019). Raman spectroscopy is able to extract the chemical structure of the samples being viewed. It collects the variation of reflectance or emittance of a material with respect to wavelengths at the point illuminated (Dahl et al. 2019).

Infrared (IR) Spectroscopy/Fourier-transform infrared (FTIR) spectroscopy

Infrared (IR) spectroscopy is the primary analytical technique for the identification and detection of polymers and microplastics of only a few microns in size according to their characteristic IR spectra. FT-IR spectroscopy is cost efficient, reliable and easy to use. FT-IR micro-spectroscopy (micro-FTIR) when combined with microscopy can identify and compare smaller samples due to the higher number of spatial resolution spectra (n × n pixels) where each pixel in the detector array provides an independent infrared spectrum. For identification of microplastics through Micro-FT-IR little sample preparation is done on membrane filters and analyses of plastics is performed in either reflectance or transmission mode (Tagg et al. 2015). FT-IR Mapping detects plastic particles with visual methods and characterize them point by point with chemical mapping. This approach is done with ease but it requires lot of time when searched manually. After point by point mapping is done it is compared with readily available infrared spectral reference libraries for almost all commonly found polymers.

FT-IR imaging reduces human error and risk of missing smaller particles which are common in other automatic visual detection techniques (Bruker.com).Pyrolysis-GC/MS is having advantage of detecting both polymer and plastic additives contained along with it simultaneously however, it has limitation that it works only for isolated particles, the ability of handle particles manually is low and the particles get destructed during the analysis. FT-IR spectroscopy when coupled with microscope provides chemical structure information with high lateral resolution and overcome limitations of Pyrolysis-FT-IR (Käppler et al.

2015).Chemical identification of microplastics for getting particular size and shape different invasive techniques such as Pyrolysis-GC/MS) spectrometry and non-invasive techniques such as optical microscopy, electron microscopy and fluorescence microscopy using Nile Red dye have been employed. But all these techniques do not allow the identification of the polymer composition of these particles. Staining microplastic samples with Nile red causes it's binding with other particles such as lipids, natural and synthetic polymers giving false positive report. To cope up with this problem Micro-FTIR (combination of infrared spectroscopy with an optical microscopy) is used to identify the polymer composition. Micro-FTIR is non-destructive and reproducible technique used for detecting microplastics in different samples (Corami et al. 2020).

Compare tap and bottled drinking water in term of microplastics pollutions

Mintenig S.M. et al, 2018 analysed ground water and drinking water for the presence of microplastics (N20 µm) using FTIR imaging. They took samples from different positions of the drinking water supply chain. Determined concentrations ranged from 0 to 7 microplastics m−3 raw water or drinking water with an overall mean of 0.7

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microplasticsm−3. They identified microplastics with an overall mean concentration of 0.7 m-3 with sizes ranging between 50 and 150 μm as polyethylene, polyamide, polyester, and polyvinylchloride or epoxy resin.

Martin Pivokonsky et al 2018 analysed54 L water sample in total including 27 L of raw water and 27 L of treated water collected from urban areas of the Czech Republic in winter. They found microplastics in all water samples ranging from 1473±34 to 3605±497 particles L−1 in raw water and from 338±76 to 628± 28 particles L−1 in treated water, depending on the water treatment plants. They identified microplastics using FTIR as polyethylene terephthalate, polypropylene and polyethylene to be present. These microplastic samples present were about 70 % in water samples studied.

Sources of microplastics pollution in drinking water:

Stratospheric ozone depletion is causing increase in UV-B levels in terrestrial sunlight causing damage to synthetic and biopolymer materials when exposed to. Susceptibility of the polymer depends upon solar UV-B radiations as well as the complexity of the weathering environment to which it is exposed. Photo-degradability of plastic polymers by UV radiations depends on processing while manufacturing of the product and additives used in plastics. With the increase in temperature and ambient humidity the degradation potential of plastic polymers by UV- B radiations increases (Andrady et al. 2003, Cruz-Pinto et al. 1994). Cooper & Corcoran (2010) conducted a study on the 5 beaches of island of Kauai, they sampled plastic particles primarily fragments of larger debris. Textural investigations using SEM indicated that the largest fragments obtained were angular, while most of the larger fragments were round. They indicated the textural changes in plastic particles may be resulted due to the sediment load and weathering of chemical composition on beaches. Results suggested that oxidative processes due to collisions are more conducive to polyethylene debris compared to polypropylene. Aging enhances intrinsic susceptible of all plastic polymers degradation due to oxidation (Celina, 2013). Study conducted by Ahrens R. H., in year 2014, published in August 2015 enlisted products of different production units accounting for the release of microplastics in environment. The manufacturing units including Rossmann, Schwarzkopf & Henkel, L'Oréal, Procter & Gamble, Body Shop und Yves Rocher produce shampoos, cleansers for body care, shower gels and liquid soaps, body care, hair-care products and colorants, lipsticks, powder/foundations and toothpastes, contact lens cleaner, eye shadow, lipsticks, skin-care and sun protection products. All these products mainly contain polyethylene (PE), polypropylene (PP) and polyamide (PA) along with traces of ethylene-vinylacetate copolymers (EVA), polyurethane (PUR) and acrylonitrile copolymers with ethyl acrylate or other acrylates (ANM).

Investigation done by Oßmann et al. (2018) showed microplastics in almost all bottled water samples with varying amounts of microplastics having high uncertainty per bottle type. Results revealed the presence of pigment particles and microplastics in mineral water presumed to be coming from the machinery for bottle cleaning. The liquor used for intensive washing might be contaminated with microplastics. Secondly it may be due to the abrasion of machine parts leading to contamination of the bottles inside, outside, bottleneck and even caps (Schymanski et al., 2018).

For investigating micro-plastics present in freshwater and drinking water, three water treatment plants were selected and their raw and treated water was analyzed for micro-plastics. All water samples contained micro-plastics higher in untreated water as compared to treated water ranging from 1473±34 to 3605±497 particles L−1 in raw water and 338±76 to 628± 28 particles L−1 in treated water. 95% of themicro-plastics found were in the size ranging from 1–10 μm, composed of PET and PP about 70 % along with PE (Pivokonsky et al. 2018). Their study contributes to fill the knowledge gap in the field of emerging micro plastic pollution of drinking water and leads to further research that should quite essentially focus on the determination of small-sized micro-plastics (< 10 μm) in freshwater ecosystems in order to provide better insight into their sources and routes to potable water.

In the year 2017, reports of micro-plastics in drinking water appeared and was published in PLoS ONE in 2018. The important areas considered were first, to find out the evidence of micro-plastics in drinking water second, how do micro-plastics enter drinking water and third, what are some of the effects on humans?

Micro-Fourier Transform Infrared Spectroscopy and micro-Raman spectroscopy was used to investigate presence of micro-plastics in drinking water that detected size ranges between 118 ± 88 particles/L and 4889 ± 5432 particles/L that were unattainable by previous methodology. Micro-plastics were supposed to enter the aquatic environments by effluents from industries, degraded plastics by solar radiations, from cosmetics and instruments made up of plastics. Micro-plastics entering the human body can lead to oxidative stress, producing chronic inflammation and tissue damage in gastrointestinal tract (Eerkes-Medrano D, et al. 2018). Certain small and invisible plastic pieces present in the environment is the cause of its damage. These small pieces of plastics are smaller than 5 mm and are known as micro-plastics. Small plastics specifically produced as glitters, micro-beads and nurdles are added to cosmetics and personal care products that lead to primary micro-plastics. When macro plastics enter the environment, they break down forming secondary micro-plastics in the form of fibers, fragments or films. Breakdown of plastics into micro-

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plastics can occur due to mechanical degradation including physical weathering, washing of synthetic textiles, tyre abrasion, and road wear and tear. Chemical degradation and UV degradation. Biological degradation can also occur by wax-worms, mealworms, and some microbes (Horton & Dixon 2018). Sources of micro-plastics are found in the form of fibers that come from diapers, cigarette butts, fleece clothing from fabrics, as micro-beads from toothpastes, facial cleansers, as fragments from water and cold drink bottles, cutlery pieces, as foams from tea-coffee cups, food containers and many more.

Conclusion

This review summarizes the prevalence of microplastics in drinking water, separation and identification methods with the focus on their toxicological impact on living organisms and cells. Nile Red dye is now preferred over the Rose Bengal as it is absorbed easily by microplastics and it allows detection via fluorescence. Pyrolysis-GC/MS identifies and analyses the composition of particular microplastics. Raman spectroscopy detects the exact chemical structure of microplastic samples by analysing variation of reflectance or emittance of a sample with respect to wavelengths at the point illuminated. FT-IR spectroscopy when coupled with microscope and Nile Red dye provides chemical structure information with high lateral resolution. Wearing and tearing of machines and bottles (glass and plastic) causes leaching of microplastics in bottles, whereas UV-radiations and weathering environment causes release of microplastics in waterbodies. Prolonged exposure micro-plastics living cells and tissues initiates a stress response to chemical exposure causing oxidative stress as a biological response. Microplastics also induces genotoxicity, cardiovascular inflammation and apoptosis.

Once we have a better understanding of microplastics in drinking water their exposure levels to living cells and tissues, and their potential toxicological mechanisms, microplastics in other food products and hence therein possible health effects can be investigated for human welfare.

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