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Effects of Microplastics on Animal Health and Nutrition*

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Abstract: Macro plastics are defined as plastics that are larger than 20 cm. Plastics that measure between 5-20 cm are referred to as mesoplastics, while those between 1-5 mm are known as large microplastics. Plastics that measure between 1-1000 μm are called small micro plastics, and those that are smaller than 1000 μm are referred to as nanoplastics. Microplastics are particles that result from the degradation of plastic products or are specifically produced in the form of small pieces. They are considered to be less than 5 μm in size. Micro plastics have come to the fore in recent years and are pollutants of major concern to the environment. Plastic materials are commonly used on farms, but they can have negative effects on farm animals. Ruminants such as cattle, sheep and goats require cellulolytic microorganisms for fiber digestion in their diet. The micro biota of the digestive system varies according to dietary habits. The digestive system and other organs can be adversely affected by sudden changes and damage to the micro biota. The ingestion of large plastic materials causes rumen complications such as rumen atony, indigestion and tympani in livestock. Ingested plastic fragments degrade in the digestive tract, increasing the number of small particles likely to be ingested. In a recent study, the presence of low-density micro plastics in sheep feces suggests that animals can ingest micro and macro plastics from their environment and feed. The increase in demand for the consumption of plastics worldwide is increasing the production of plastics. This situation causes the presence of micro plastics to increase rapidly day by day. Even if the production of plastics decreases, the continuous degradation of plastic waste in the earth will continue the formation of micro plastics and cause environmental pollution. The effects of microplastics in our country should be investigated by conducting detailed studies from the perspective of veterinary medicine.
Keywords: Animal nutrition, micro plastic, sustainability

Mikroplastiklerin Hayvan Sağlığı ve Beslenme Üzerine Etkileri
Öz: Makroplastikler >20 cm altında kalan plastiklerdir. 5-20 cm arasında kalan plastikler mesoplastikler, 1-5 mm arasında olanlar büyük mikroplastiklerdir. 1-1000 μm yer alan plastikler küçük mikroplastikler; <1000 μm altında kalan mikroplastikler nanoplastikler olarak adlandırılırlar. Mikroplastikler, plastik ürünlerin parçalanmasıyla oluşan veya özellikle küçük parçalar şeklinde üretilen, boyutu 5 μm'den daha küçük kabul edilen parçacıklardır. Son yıllarda gündeme gelmiş olup; çevre için büyük öneme sahip kirleticilerdir. Plastik malzemeler çiftliklerde de sıklıkla kullanılan ürünlerdir. Bu malzemelerin çiftlik hayvanları üzerinde olumsuz etkileri olabilir. Sığır, koyun, keçi gibi ruminantlar tükettikleri yemlerdeki lif sindirimi için selülolitik mikroorganizmalara ihtiyaç duyarlar. Sindirim sistemi mikrobiyotası beslenme alışkanlığına göre değişiklik gösterir. Mikrobiyotada meydana gelen ani değişimler ve hasarlar sindirim sistemi ve diğer organları olumsuz etkileyebilir. Büyük ebatlardaki plastik materyallerin yutulması besi hayvanlarında rumen atonisi, hazımsızlık ve timpani gibi rumen komplikasyonlarına neden olur. Yutulan plastik parçaları sindirim sisteminde parçalanarak emilme olasılığı yüksek olan küçük parçacıkların sayısını arttırır. Yapılan çalışmalarda koyun dışkısında düşük yoğunluklu mikroplastik varlığının tespit edilmesi çiftlik hayvanlarının çevrelerinden ve yemlerinden mikro ve makroplastikleri alabileceklerini göstermektedir. Dünya genelinde plastik tüketimine olan talebin artması plastik üretimini de arttırmaktadır. Bu durum mikroplastik varlığının her geçen gün hızla artmasına neden olmaktadır. Plastik üretimi azalsa dahi yeryüzünde var olan plastik atıkların devamlı parçalanması sonucu mikroplastik oluşumu devam edecek ve çevresel kontaminasyona sebep olacaktır. Mikroplastiklerin ülkemizdeki etkileri veteriner hekimliği açısından detaylı çalışmalar yapılarak araştırılmalıdır.
Anahtar kelimeler: Hayvan besleme, mikroplastik, sürdürülebilirlik

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Introduction

The production of plastics has become an environmental hazard due to the discovery of synthetic polymers (Hidalgo-Ruz et al., 2012). The most commonly used synthetic plastics include polyethylene (low and high density), polystyrene, polyvinyl chloride, polypropylene, and polyethylene terephthalate. Polymers are used in the textile, fiber and synthetic leather industries; packaging and wrapping materials, toys; building and construction materials, drainage pipes; electronics, automotive, aircraft, and railway industries; dental and prosthetic materials, lenses; medical and disposable materials (Bansal and Singh, 2022). Micro plastics are present in various cosmetic products, including face wash gels, creams, and makeup (Auta et al., 2017). Plastics are synthetic polymers composed of long chains of carbon, hydrogen, oxygen, and chlorine atoms. They are in high demand and production due to their durability, lightness, low cost, and versatility (Bansal and Singh, 2022). Micro plastics are particles that are produced by the degradation of plastic products or in the form of particularly small pieces, considered to be smaller than 5 µm in size. They have been on the agenda in recent years. They are pollutants of great importance to the environment (Rainieri and Barranco, 2018). The environmental impact of micro plastics is influenced by several factors. Micro plastics of different sizes and polymers have different sorption and desorption times. Additionally, the concentration of micro plastics in soil is an important factor (Wang et al., 2019). Microplastics in soil can impede the absorption of water and nutrients by plants. These micro plastics negatively affect the biochemical structure of plant tissues, the root structure of the plant and the microorganism activity of the soil in which the plant grows (De Souza Machado et al., 2019). Micro plastics inhibit the growth and reproduction of microorganisms in soil and pose a threat to the soil biome by disrupting microbial diversity (Wang et al., 2019). The most frequently isolated polymers from water samples are polyethylene, polypropylene, polystyrene, and polycarbonates. Polystyrene polymers can cause oxidative stress by producing free oxygen radicals. Additionally, they have genotoxic effects on aquatic organisms by inhibiting DNA repair (Koelmans et al., 2019).

Table 1. Synthetic polymers commonly used

Polyester	High-density polyethylene (HDPE)
Polyethylene (PE)	Polycarbonate (PC)
Polyethyleneterephthalate (PET)	Cellulose acetate
Polypropylene (PP)	Cellulose nitrate
Polystyrene (PS)	Polylactic acid (PLA)
Polyvinyl chloride (PVC)	Melamine
Alkyd, polyurethane (PUR)	Polybutylene succinate (PBS)
Nylon (polyamide) (PA)	Polyhydroxyalkanoates
Polymethyl methacrylate (PMMA)	Polyethylene sülfonlar (PES)
Polyacrylonitrile (PAN)	Styrene-butadiene rubber (SBR)
Polyvinyl alcohol (PVA)	Polyvinyl acetate (PVA)
Poly acrylonitrile butadiene styrene (PABS)	

Classification of micro plastics

Micro plastics are classified based on their size, morphology, density and material composition (Amelia et al., 2021). Macro plastics are plastics below >20 cm. Plastics between 5-20 cm are meso plastics, and plastics between 1-5 mm are large micro plastics. Plastics between 1-1000 µm are called small micro plastics; micro plastics <1000 µm are called nanoplastics (Hanvey et al., 2017). According to another classification method, micro plastics are classified as primary and secondary micro plastics. Industrially produced as microbeads of different sizes, primary micro plastics are used in personal care products or as raw materials for the manufacture of various products. Plastics can degrade and break down in the environment due to exposure to oxygen, heat and radiation. These micro plastics formed as a result of physical and chemical decomposition are secondary micro plastics (Barnes et al., 2009; Rillig, 2012; Andrady, 2017). The main synthetic polymers commonly used today are given in the table (Bansal and Singh, 2022).

According to their morphology, microplastics are classified as fibers, fragments, beads, and films (Amelia et al., 2021).

Transmission pathways

Plastics can enter the soil in different ways. These ways include agricultural interventions, the usage of sewage and sludge in agricultural lands, and indiscriminate disposal of plastics into the environment (Rodriguez-Seijo et al., 2019). Studies show that micro plastics have been found in sewage treatment plants. Micro plastics of low density and small size in soil and water can be transported by wind and deposited back into soil and water through precipitation events (Lee et al., 2022). Plastics used in agriculture can also accumulate agrochemicals, making them a source of primary pollutants. Micro plastics can also accumulate pesticides. This creates a larger environmental problem. In a study of earthworms, it was reported that they ingest micro plastics through the digestive tract or the skin and carry them deep into the soil through their movements (Rodriguez-Seijo et al., 2019). Exposure to plastics is more likely in urban center and areas with factories producing synthetic polymers. Plastic pellets can leak into the environment during production, transportation, recycling, or use (Andrady, 2017). According to Prata et al. (2022), mammals are primarily exposed through respiration and diet. Micro plastics are often found in the fiber structure of the atmosphere. Textile products are dispersed into the environment under the influence of the atmosphere and human activities. Micro plastics in the atmosphere have the biggest role in the pollution of the water environment. Accordingly, the routes of exposure to micro plastics have expanded from contaminated food and beverages in the food chain to inhalation (D'Angelo and Meccariello, 2021). Microplastics are taken into the gastrointestinal tract by drinking contaminated water or using such water to wash food, and by consuming fish living in the sea and oceans. Aquatic animals also ingest micro or nanoplastics through their gills (Bansal and Singh, 2022). Plastic materials are commonly used in farms for feed transport pipes, taps, drinkers, and plastic bottles for disinfectants or medicines. However, overtime, these plastics break down due to chemical, physical, and biological reactions, forming micro plastics. As a result, microplastics can be transported in these ways and be a source of microbial contamination for livestock and poultry. Additionally, microplastics from the environment can enter manure during the composting process. Composting animal manure is a common method, but it can also pose a threat to the ecological system due to the presence of micro plastics. A study reported that microplastic contamination, including PP, PE, and PR fibers and fragments, occurred in farm and poultry enterprises. This provides evidence that the direct application of manure can potentially contaminate soil with micro plastics (Wu et al., 2021). Micro plastics and nanoplastics not only act as environmental pollutants but also pose a hazard by interacting with toxic metals such as cadmium and mercury (Yong et al., 2020).

Importance of micro plastics in animal nutrition

Micro plastics are present in both land and water ecosystems (Akçay et al., 2020). Exposure to micro plastics is significant for poultry and other livestock in land ecosystems. It is not yet clear whether plastic species are included in the food chain after they are broken down into micro plastics. However, it has been observed that microplastics enter the food chain when animals consume feed and food contaminated with micro plastics. Microplastics that enter the aquatic ecosystem accumulate in the intestines of animals living in this ecosystem. It has been reported that these microplastics will not have a direct impact on human health since the intestines of aquatic animals offered for human consumption are removed before consumption. However, as the removed intestines are added to animal feed, animal health and indirectly human health are affected. (Atakan et al., 2021). A study was conducted on chickens and the area where they were raised to determine the transfer of low-density polyethylene (LDPE) plastic residues. The study examined the feces, gizzards, soil, and earthworms in which the chickens live, as well as the feed they eat. While 0.87±1.9 particles/g micro plastics were found in soil samples, 1.8±28.8 particles/g micro plastics were found in earthworms, 82.3±129.8 particles/g in chicken feces, and 10.2±13.8 particles/g in chicken gizzards. No micro plastics were found in the feed (Huerta et al., 2017). Ruminants, such as cattle, sheep, and goats, require cellulolytic microorganisms to digest the fiber in their feed. The micro biota of the digestive system varies depending on dietary habits. Sudden changes or damage to the micro biota can have adverse effects on the digestive system and other organs. Ingestion of large plastic materials can cause rumen complications, such as rumen atony, indigestion, and tympani, in livestock (Ramachandraiah et al., 2022). Ingested plastic fragments break down in the digestive tract, increasing the number of small particles that are likely to be absorbed. According to a study by Beriot et al. (2021), the presence of low-density micro plastics in sheep feces suggests that livestock may ingest micro and macro plastics from their environment and feed. Micro plastics are anthropogenic pollutants found in soil, oceans, air and biota, especially in urban environments (Prata et al., 2021). In a study conducted on dogs and cats living in Porto, micro plastics were detected in postmortem kidney, lung, ileum, liver, and blood samples using Nile Red Staining and Micro-Raman Spectroscopy methods (Prata et al., 2022). Micro plastics can carry pathogenic microorganisms and alter the microbial diversity of the environment. Micro plastics carry antimicrobial resistance genes, which can persist due to their effects on the carbon cycle and metabolism of micro biota (Wu et al., 2021; Eckert et al., 2017). Additionally, micro plastics damage gastrointestinal villi, leading to reduced nutrient absorption and feed intake in animals (Wu et al., 2021). According to Wang et al. (2019), micro plastics ingested by animals cannot be digested and can cause obstructions in the gastrointestinal tract. In a study by Lei et al. (2018), polystyrene nano- and micro plastics were found to damage cholinergic and GABAergic neurons. In studies on fish, it was observed histopathologically that micro plastics accumulate in the intestines, gills and livers of larvae and adult fish (Lu et al., 2016). The main pathological symptoms of micro plastic and nanoplastic toxicity in the intestine are disruption of epithelial integrity, inflammation, oxidative stress, changes in intestinal biomarkers and disruption of intestinal biota (Chen et al., 2018). When fish ingest micro plastics, changes in liver metabolites and liver enzymes can occur. In some cases, micro plastics have also been found in the brains of fish, where significantly inhibited acetyl cholinesterase activity has been observed (Ding et al., 2018). Barboza et al. (2019) observed that wild fish consumed by humans, which had microplastics in their intestines and other tissues, had significantly higher levels of lipid peroxidation and acetylcholinesterase in their brains, gills, and dorsal muscles compared to fish without micro plastics. In a study on mice, micro plastics and nanoplastics were detected in the intestine, liver, and kidney. The distribution of microplastics in tissues is influenced by particle size. A study found that micro plastics with a diameter of 20 µm were evenly distributed among all tissues, whereas those with a diameter of 5 µm accumulated more in the intestine. The data indicate that micro plastics accumulate not only in the digestive system but also in other tissues through the circulatory system. In mice exposed to micro plastics, researchers observed a decrease in ATP concentration and an increase in LDH activity in the liver, as well as disrupted lipid metabolism (Deng et al., 2017). High concentrations of micro plastics and nanoplastics are cytotoxic, and cell death can occur through necrotic plasma membrane rupture or programmed cell death. Plastic-associated surfactants can disrupt the lipid layer of the plasma membrane at high concentrations. They can also inhibit cellular signaling processes that rely on cellular surface structures, such as proteoglycans, extracellular matrix components, and ligand-receptor interactions, even at moderate concentrations. As a result, cellular physiology may be affected to varying degrees. Nanoplastics are taken up by endocytosis, which depends on the cell type, and nanoplastics released into the cytosol can affect key organelles such as mitochondria or the nucleus, as well as cellular events such as mitotic spindle formation during cell division and chromosome migration. Micro plastics and nanoplastics can disrupt transport events along the exocytosis pathway within cells, which may hinder the expression of vital signaling receptors or membrane transporters. Additionally, the accumulation of nanoplastics in endosomes or lysosomes can lead to the degradation of these organelles, ultimately inhibiting macrophage and autophagic cell death (Yong et al., 2020). A study conducted on female mice exposed to micro plastics found that these animals experienced tissue damage, impaired immune response, decreased live births in offspring, changes in sex ratio, decreased body weight, and changes in lymphocyte composition in the spleen (Park et al., 2020). Additionally, micro plastics have been observed to cause inflammation in male reproductive cells and abnormal spermatozoon formation (D'Angelo and Meccariello, 2021). A study conducted by Hou et al. (2020) found that adding different doses of micro plastics to the drinking water of male mice reduced the number of live spermatozoa in the epididymis and caused morphologically abnormal spermatozoa.

The negative effects of microplastics were observed in many systems of the organism, particularly the digestive system. In order to prevent this situation, it is necessary to be familiar with the methods of analysis that can detect the presence of microplastics in any substance that is contaminated with microplastics.

Microplastic analysis methods

Collection of samples

Micro plastic samples are collected using selective, bulk, and reduced volume sampling methods. Selective sampling is used when plastic debris is visible to the naked eye. This method is easy and straightforward. However, this method has the disadvantage of only detecting larger micro plastics and being unable to detect them when mixed with other substances. Bulk sampling is a method of sampling without reducing the volume of the material to be sampled. However, this method negatively affects the representativeness of the entire sample as it only allows for a small sample to be collected. This method ensures better representativeness of the entire sample. On the other hand, reduced volume sampling involves rapid filtration to reduce the volume of the sample, with a small portion retained for analysis. Esmeray and Armutcu (2020) found that rapid filtration leads to the discarding of a large portion of the sample and a significant loss of micro plastics.

Preparation of samples

Density separation

The density of plastic varies depending on the type of polymer and manufacturing process. Density values can range from 0.8 to 1.4 cubic centimeters. In order to determine the density of the plastic in the sample, saturated solutions are used; such as sodium chloride (NaCl), sodium iodide, zinc chloride and sodium polytungstate solutions. The sample is mixed with a saturated solution and shaken to separate light particles from heavy particles. The sediment settles to the bottom while the low-density plastic fragments remain on the surface. The supernatant, which contains the low-density plastic fragments, is extracted. Saturated sodium chloride solution is commonly used to raise the density of the sample for density separation purposes. NaCl solution can be used to extract micro plastics of low density such as polyethylene, polypropylene, and polystyrene. However, it is not effective for separating micro plastics with higher density such as polyvinylchloride and polyethylene terephthalate (Hidalgo-Ruz, 2012; Esmeray and Armutcu, 2020). To separate high density micro plastics, it is recommended to use higher density salt solutions such as sodium iodide (NaI), zinc chloride (ZnCl), or sodium polytungstate (SPT) (Esmeray and Armutcu, 2020).

Elimination

Micro plastics can be separated from samples by using sieves of different sizes. The remaining samples are collected after sieving. This process categorizes micro plastics according to their size (Hidalgo-Ruz, 2012), reducing the sample volume for extraction (Esmeray and Armutcu, 2020).

Digestion

Micro plastics are persistent and widespread pollutants, which raises concerns about their negative effects. To conduct laboratory toxicity experiments and biomonitoring, it is necessary to remove micro plastics from biological samples using easy and efficient digestion procedures. These procedures typically involve the use of alkaline and acid agents, as well as enzymes (Prata et al., 2021). Samples collected from the environment may contain a variety of organic matter and should be treated accordingly. This process presents challenges in identifying and categorizing micro plastics. The digestion process aims to remove the mixed organic matter in the collected samples (Wang and Wang, 2018). In the case of water and sediment samples, a mixture of 30% hydrogen peroxide (H_2O_2) and sulfuric acid (H_2SO_4) is used (Imhof et al., 2012). Organic material is digested using nitric acid (HNO_3, 22.5 M), hydrogen peroxide (H_2O_2, 32.6 M) and sodium hydroxide (NaOH, 52.5 M) (Claessens et al., 2013). Cleaning the sample with distilled water and ultrasonic cleaning can prevent surface adhesions of the plastic material.

Filtering

In the filtration method, liquid samples containing plastic fragments are passed through filters using a vacuum. The filters separate micro plastics from liquids by allowing only liquid substances to pass through. The size of the filter papers used varies between 1-1.6 µm or 0.45-20 µm (Hidalgo-Ruz et al., 2012; Wang and Wang, 2018). The liquid samples used can quickly clog the filter media because they are full of microscopic particles or debris. Various auxiliary measures can mitigate this issue. These include reducing the solution volume, settling the liquids for a longer time to facilitate the separation of heavier solid particles from the supernatant, performing a pre-filtration step using a filter with a larger pore size, or adding chemicals such as ferrous sulfate to the liquid to flocculate the solid fraction (Wang and Wang, 2018). To remove micro plastics from the aqueous supernatant, tweezers can be used after density separation with fresh water before filtration. Alternatively, for larger particles, water samples can be sieved through a 500 µm pore size sieve (Hidalgo-Ruz et al., 2012). The commonly used filters include glass fibers, nitro-cellulose, polycarbonate membranes, zooplankton, and isoporous filters (Wang and Wang, 2018).

Diagnosis and identification

In order to identify micro plastics, a visual inspection of the concentrated sample residue is required. This can be done with the naked eye or through a microscope. To avoid misidentification of micro plastics, plastic particle selection should be standardized (Hidalgo-Ruz et al., 2012). Once the samples collected from the field are prepared in the laboratory, various approaches can be used to identify microplastics. For this purpose, the analysis of mesoplastics, microplastics, and nanoplastics is conducted using optical, spectroscopic, or thermo-analytical techniques. Spectroscopic and imaging techniques are used to visualize mesoplastics, microspectroscopy and fluorescence techniques are used to visualize microplastics, and electron microscopy is used to visualize nanoplastics (Esmeray and Armutcu, 2020; Wang and Wang, 2018).

Optical techniques

Optical identification is a technique performed with the naked eye or with an optical microscope. This is the most commonly used technique. Shapes and colors are used to determine whether the material examined is micro plastic or not. Microplastic particles are not organic or cellular, and if they are in the form of fibers, they have consistent thickness and color along the entire length. The particles are clear and uniformly colored. To confirm transparent and white particles, high magnification or fluorescence microscopy is necessary. This method can be expensive but is suitable for high volume samples where analytical instruments are not available. It is important to note that weathered microplastics may undergo changes in morphology. Errors in identification can be introduced by the researcher making the identification, the sample matrix, the particle shape and size, or the microscope used, so it is important to be objective and accurate in the identification process. In some suspicious cases, spectroscopy and analytical techniques should be employed (Wang and Wang, 2018).

Scanning electron microscopy (SEM)

The SEM method involves exposing the sample surface to a high intensity electron beam. This produces high-resolution images of the sample, which are scanned in a raster scanning model. The method allows for the display of surface details of the examined sample at high magnification ratios, making it possible to determine the organic-inorganic impurities of the material. SEM has been successfully used to study the surface properties of micro plastics. However, this technique requires significant time and effort for sample preparation, making it unsuitable for processing large numbers of samples (Wang and Wang, 2018).

Fourier transform infrared spectroscopy (FTIR)

The principle of FTIR analysis is based on three different modes of operation. Fourier Transform Infrared Spectroscopy (FTIR) is a method of analysis that operates in three different modes: transmission, reflection, and attenuated total reflection (ATR). It is important to note that FTIR analysis is based on objective measurements and not subjective evaluations. To hold the samples in place during the scanning process, a water-resistant and mechanically stable filter substrate with pores to allow filtration of aqueous samples is used. The filter material must also give a minimal spectral response. The transmission mode of analysis involves the beam passing through the sample and being collected. However, this mode is not suitable for colored materials due to their high absorption of the beam, resulting in weak or no beam reaching the detector. Reflection mode, on the other hand, is not affected by this issue. In reflection mode, the incident beam is reflected off the IR reflective substrate and passes through the sample. Attenuated total reflection involves using an ATR crystal, a high refractive index material, which is placed in optical contact and beamed onto the surface. ATR-FTIR is a fast method that requires minimal sample preparation. However, the crystal material can degrade over time due to surface scratching or cracking. It is important to ensure that the crystal material used is covered by the particle under investigation, as small-sized fragments in the crystal may not produce the desired spectrum (Xu et al., 2019).

Raman spectroscopy

Raman spectra are recorded by a Raman microscope system with a laser wavelength of 633 nm and 50x magnification (Imhof et al., 2012). This method is frequently used and reliable for the determination of microplastics. A laser beam is applied to the sample, and the molecular and atomic structure of the sample causes the beams to give light frequencies in the form of absorption, scattering or reflection, known as Raman shift. Different spectra are produced for each of the polymers under investigation. Raman spectroscopy is advantageous for analyzing a large number of samples of microplastics, providing non-destructive chemical characterization. It has the advantage of high spatial resolution, wide spectral range, narrow spectral bands, and lower sensitivity to water interference. This method enables the detection of microplastics as small as 1 µm. Chemicals associated with microplastics, such as dyestuffs, can harm the accuracy of the analysis (Wang and Wang, 2018).

Pyrolysis gas chromatography-mass spectrometry (PYR-GC-MS)

Pyrolysis Gas Chromatography-Mass Spectrometry analyses the thermal degradation products of microplastics. It provides a chemical analysis of microplastics. In this method, solid polymers are processed with a minimal amount of sample. Unlike the FTIR method, this method provides detailed information on the chemical and organic composition of polymers at the same time. This method is insensitive to contamination of the sample being analyzed with contaminants. Small amounts of sample are used for measurement. One single particle is analyzed per cycle. Each measurement takes 30-100 minutes. There is limited applicability for analyzing large sample volumes. Since micro plastic particles are manually placed in the pyrolysis tube, particles large enough to be manually manipulated (>100 µm) are suitable for analysis. Thermo-analytical methods are destructive, provide only chemical characterization, and do not provide detailed information on the morphology of microplastics. Therefore, they should be used in addition to spectroscopic methods (Wang and Wang, 2018).

Conclusion

As the demand for plastic consumption increases worldwide, so does the production of plastic. This situation causes the presence of microplastics to increase rapidly day by day. Even if the production of plastics decreases, the formation of microplastics will continue as a result of the continuous degradation of plastic waste in the earth and will cause environmental pollution (Çağlayan and Aytan, 2021). Plastic pollution has become a global issue. Plastics not only pollute the soil and water but also indirectly pollute the products made from these sources. Alternatives to the use of plastic products in agriculture and animal husbandry should be developed, or disposal methods and protocols should be established after the use of these products. A review of the literature reveals a lack of information on microplastics in feed and their effects on livestock. In vivo and in vitro studies on this topic will contribute to the prevention of plastic pollution, which has become a major problem today.

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