Agilent Technologies

Agilent 8700 LDIR Chemical Imaging System

Recent Publications

Publications – Microplastics

Marine Environments

Microplastics in the Mississippi River and Mississippi Sound, James Cizdziel, Mississippi Water Resources Research Institute, 2020.

> Field and analytical methods were developed to analyze the microplastics present in the Mississippi and major tributaries. The concentration, morphology, particle count, and composition of MPs found were outlined.

Occurrence of Microplastic Pollution at Oyster Reefs and Other Coastal Sites in the Mississippi Sound, USA: Impacts of Freshwater Inflows from Flooding, Austin Scircle, James V. Cizdziel, Louis Tisinger, Tarun Anumol, Darren Robey, Toxics, 2020

> Microplastics affecting oyster farms in the Mississippi were studied. The effects of freshwater intrusion on levels of MP pollution were observed, as was the nature of the MPs that oyster populations are exposed to.

A baseline for microplastic particle occurrence and distribution in Great Bay Estuary, Matthew L.H. Cheng, Thomas C. Lippmann, Jennifer A. Dijkstra, Gabriela Bradt, Salme Cook, Jang-Geun Choi, Bonnie L. Brown, Marine Pollution Bulletin, 2021

> This study analyzed the presence of microplastics in the Great Bay Estuary, finding that particle morphology varies by location and depth. Particle transport modelling was used to analyze MP distributions across the Bay.

Coastal ecosystem inventory with characterization and identification of plastic contamination and additives from aquaculture materials, Arno Bringer, Stephane Le Floch, Andreas Kerstan, Helene Thomas, Marine Pollution Bulletin, 2021

> An area of Atlantic coast was studied for the presence of macro- and microplastics, specifically those related to aquaculture tools and materials. Pollutants present on these plastics were also characterized.

Spatial distribution of microplastics in the tropical Indian Ocean based on laser direct infrared imaging and microwave-assisted matrix digestion, Hildebrandt, L., El Gareb, F., Zimmermann, T., Klein, O., Kerstan, A., Emeis, K.-C., & Pröfrock, D. , Environmental Pollution, 2022

Suspended particulate matter was collected from subsurface (6 m) water along an E-W transect through the tropical Indian Ocean using a specialized inert (plastic free) fractionated filtration system. LDIR imaging facilitates the analysis of up to 1000 particles/fibers (<300 µm) within approximately 1–2 h. In comparison to FTIR and Raman imaging, it can help to circumvent uncertainties, e. g. from subsampling strategies due to long analysis and post-processing times of large datasets. Over 97% of all particles were correctly identified by the automated routine - without spectral reassignments. Moreover, 100% agreement was obtained between ATR-FTIR and LDIR-based analysis regarding particles and fibers >300 µm

Identification and Quantification of Microplastics in the Marine Environment Using the Laser Direct Infrared (LDIR) Technique, Ourgaud, M., Phuong, N. N., Papillon, L., Panagiotopoulos, C., Galgani, F., Schmidt, N., Fauvelle, V., Brach-Papa, C., & Sempéré, R. , Environmental Science & Technology, 2022

Here, we evaluate for the first time the performances of the newly developed laser direct infrared (LDIR) technique and propose an optimization of the initial protocol for marine microplastics (MPs) analysis. Our results show that an 8 µm porosity polycarbonate filter placed on a Kevley slide enables preconcentration and efficient quantification of MPs, as well as polymer and size determination of reference plastic pellets of polypropylene (PP), polyethylene (PE), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene terephthalate (PET), with recoveries ranging from 80–100% and negligible blank values for particle sizes ranging from 200 to 500 µm.

Soils, land, riverine, and wastewater environments

Are microplastics correlated to phthalates in facility agriculture soil?, Qinglan Li, Anrong Zeng, Xin Jiang, Xueyuan Gu, Journal of Hazardous Materials, 2021

Agricultural soil samples from greenhouses and non-greenhouses in China were found to contain microplastics and phthalate esters, with higher content in non-greenhouse soils.

Microplastic pollution alters forest soil microbiome, Ee Ling Ng, Silk Yu Lin, Ashley M. Dungan, John M. Colwell, Sarah Ede, Esperanza Huerta Lwanga, Ke Meng, Violette Geissen, Linda Louise Blackall, Deli Chen, Journal of Hazardous Materials, 2021

The effects of microplastic pollution in soil was tested by examining the impact on microbiome composition & activity, as well as physiochemical changes in the soil. An increase in soil respiration was observed.

Automated identification and quantification of invisible microplastics in agricultural soils, Jia, W., Karapetrova, A., Zhang, M., Xu, L., Li, K., Huang, M., Wang, J., & Huang, Y. , Science of The Total Environment, 2022

Here the laser direct infrared (LDIR) and Fourier–transform infrared (FTIR) methods were combined to investigate the microplastics in farmland with long– term agricultural activities. The results showed that the total abundance of microplastics reached 1.98±0.41×105, 1.57±0.28×105, 1.78±0.27×105, and 3.20±0.41×105 particles/kg soil in cotton fields with film mulching of 5, 10, 20, and >30 years, respectively. LDIR results indicated that microplastics ranging from10 to 500 μm accounted for 96.5–99.9%of the total microplastic amounts in the soils.

Characterization of microplastics in sediment using stereomicroscopy and laser direct infrared (LDIR) spectroscopy, Cheng, Y.-L., Zhang, R., Tisinger, L., Cali, S., Yu, Z., Chen, H. Y., & Li, A. , Gondwana Research, 2022

The analysis of microplastics (MP) becomes more difficult for smaller sizes, especially in complex matrices such as sediment of natural waters. In this work, we analyzed MPs in sediment using laser direct infrared (LDIR) imaging, a relatively new technique in environmental MP studies. LDIR is significantly faster thus allows the characterization of larger number of particles in high-throughput MP analysis. Based on these observations, we expect to see growing uses of LDIR in environmental particle research and the standardization of environmental MP analysis based on advanced technologies in the future.

Comparison of Detection Methods of Microplastics in Landfill Mineralized Refuse and Selection of Degradation Degree Indexes, Ying Zhang, Yawen Peng, Chu Peng, Ping Wang, Yuan Lu, Xiaosong He, Lei Wang, Environmental Science & Technology, 2021

Mineralized refuse in a landfill was analyzed for the presence of microplastics. MPs were detected in residual solids that had been subjected to flotation, suggesting that the quantity of MPs is often underestimated.

Enhanced degradation of microplastics during sludge composting via microbially-driven Fenton reaction, Xing, R., Sun, H., Du, X., Lin, H., Qin, S., Chen, Z., & Zhou, S. , Journal of Hazardous Materials, 2023

It has been increasingly documented that the hydroxyl radical (•OH) can promote the transformation of organic contaminants such as microplastics (MPs) in various environments. However, few studies have sought to identify an ideal strategy for accelerating in situ MPs degradation through boosting the process of •OH production in practical applications. In this work, iron-mineral-supplemented thermophilic composting (imTC) is proposed and demonstrated for enhancing in situ degradation of sludge-based MPs through strengthening •OH generation. The LDIR was used to identify MPs in the study.

Characterization of microplastics in the septic tank via laser direct infrared spectroscopy, Liu, N., Cheng, S., Wang, X., Li, Z., Zheng, L., Lyu, Y., Ao, X., & Wu, H. , Water Research, 2022

In this study, the LDIR was employed for the qualitative and quantitative analyses of the distribution characteristics of MPs in the septic tank.

Research progress on microplastics in wastewater treatment plants: A holistic review, Gao, Z., Chen, L., Cizdziel, J., & Huang, Y. , Journal of Environmental Management, 2023

This paper summarizes techniques used to characterize microplastics in different matrices. This paper states that LDIR is another analytical technique that only takes full spectra from particles detected on its surface, eliminating redundant data, and reducing data processing time. It examines the data produced from Clarity and the positives and negatives of the instrument.

An innovative evaluation method based on polymer mass detection to evaluate the contribution of microfibers from laundry process to municipal wastewater, Yujie Tian, Zhuo Chen, Jiayao Zhang, Zhengzhuofan Wang, Yujiao Zhu, Ping Wang, Tao Zhang, Jian Pu, Hongwen Sun, Lei Wang, Journal of Hazardous Materials, 2021

The presence of polyester microfibers from washing clothes was quantified in wastewater samples from wastewater treatment plants. PET MFs from laundry were found to contribute 50% of total PET MFs in wastewater.

Trail running events contribute microplastic pollution to conservation and wilderness areas, Forster, N. A., Wilson, S. C., & Tighe, M. K. , Journal of Environmental Management, 2023

> This study investigates whether runners are source of microplastics along running trails. In the trail running events, abrasive wear to shoe outsoles produced an average of 0.3 ± 0.1 to 0.9 ± 0.2 MPs/linear meter/runner, and clothing produced 0.7 ± 0.3 to 2.0 ± 0.3 fibers/linear meter/runner, with fibers accounting for 63–69% of MPs.

Microplastic surface retention and mobility on hiking trails, Forster, N. A., Wilson, S. C., & Tighe, M. K. , Environmental Science and Pollution Research, 2023

> This study, we simulated heavy rainfall (100 mm/h) on trail surfaces with existing MP pollution (in situ MPs) and spiked with 99 ± 2 rubber MPs (100–940 µm). Runoff was collected for 15 min and spiked and in situ MPs were quantified. The LDIR was used to quantify microplastics in runoff from vegetated, loose, low slope and bare, compacted, low slope trail surfaces.

Microplastic pollution on hiking and running trails in Australian protected environments, Forster, N. A., Wilson, S. C., & Tighe, M. K. , Science of The Total Environment, 2023

> A total of 760 MPs from the trail surfaces of the Dumaresq Dam Loop Track (flat rock) and Washpool Walking Track (sloped soil) and atmospheric fallout in the open grassland were characterized with Laser Direct Infrared Imaging (LDIR) analysis. The most abundant polymers were PS, PU, PET, followed by small amounts of PA, polyethylene (PE) and polyvinyl chloride (PVC).

Riverine microplastic and microbial community compositions: A field study in The Netherlands, Lapo Mughini-Gras, Rozemarijn.Q.J. van der Plaats, Paul.W.J.J. van der Wielen, Patrick S. Bauerlein, Ana Maria de Roda Husman, Water Research, 2021

> Microplastics and their associated microbial communities were analyzed in water samples from the Rhine River. The microbial composition varied greatly with MP size and composition.

Spatiotemporal dynamics of microplastics in an urban river network area, Fan, Y., Zheng, J., Deng, L., Rao, W., Zhang, Q., Liu, T., & Qian, X., Water Research, 2022

> The temporal variation in microplastic concentration in river networks was found to be due to the dynamics in plastics production and seasonal impacts. Common commercial polymer types were identified by the LDIR.

Quantifying environmental emissions of microplastics from urban rivers in Melbourne, Australia, Samandra, S., Singh, J., Plaisted, K., Mescall, O. J., Symons, B., Xie, S., Ellis, A. V., & Clarke, B. O. , Marine Pollution Bulletin, 2023

> This study aims to understand the amount and type of microplastics flowing into Port Phillip Bay from urban rivers around Melbourne. Water samples were collected from the Patterson, Werribee, Maribyrnong, and Yarra Rivers, which contribute 97 % to the total flow into Port Phillip Bay. On average, the rivers contained a mean of 9 ± 15 microplastics/L and ranged from 4 ± 3 microplastics/L (Patterson) to 22 ± 11 microplastics/L (Werribee). Of the eight polymers investigated, polyamide and polypropylene were the most frequently detected polymers. Microplastics were quantified and identified with an Agilent's 8700 Laser Direct Infrared (LDIR) imaging system to analyze particles sized between 20 µm and 500 µm.

A high-throughput, automated technique for microplastics detection, quantification, and characterization in surface waters using laser direct infrared spectroscopy, Whiting, Q. T., O’Connor, K. F., Potter, P. M., & Al-Abed, S. R. , Analytical and Bioanalytical Chemistry, 2022

> A high-throughput approach to detecting, quantifying, and characterizing microplastics (MPs) by shape, size, and polymer type using laser direct infrared spectroscopy. This method was able to quantify MPs down to a diameter of 20 µm, a size comparable to that of MPs quantified by other techniques such as Fourier transform infrared spectroscopy (FTIR) and Raman spectroscopy. Also (LDIR) spectroscopy in surface water samples is demonstrated. Center for Marine Debris Research Polymer Kit 1.0 standards were analyzed by LDIR and compared to the given FTIR spectra by HQI, showing that LDIR obtains similar identifications as FTIR analysis. The simplicity and automation of the LDIR allows for quick, reproducible particle analysis, making LDIR attractive for high-throughput analysis of MPs.

Microplastic contamination of an unconfined groundwater aquifer in Victoria, Australia, Samandra, S., Johnston, J. M., Jaeger, J. E., Symons, B., Xie, S., Currell, M., Ellis, A. V., & Clarke, B. O., Science of The Total Environment, 2022

> This is the first study to show microplastics contamination in an alluvial sedimentary aquifer that has been capped from the atmosphere. In this study, eight of the most commonly found microplastics in the environment (polyethylene, PE; polystyrene, PS; polypropylene, PP; polyvinyl chloride, PVC; polyethylene terephthalate, PET; polycarbonate, PC; polymethylmethacrylate, PMMA; and polyamide, PA) were analyzed in triplicate groundwater samples (n = 21) from five sampling sites across seven capped groundwater monitoring bores from Bacchus Marsh (Victoria, Australia) using Agilent's novel Laser Direct Infra-Red (LDIR) imaging system.

Micro- and nano-plastics (MNPs) as emerging pollutant in ground water: Environmental impact, potential risks, limitations and way forward towards sustainable management, Kumar, V., Singh, E., Singh, S., Pandey, A., & Bhargava, P. C. , Chemical Engineering Journal, 2023

Plastics (primary and secondary) fragmentation results in the formation of micro-and nano-plastics (MNPs). MNPs, once disposed in the environment, persist there for long duration due to their extremely poor degradability. MNPs may act as a carrier for persistent organic pollutants (POPs), thus raising environmental and human health complications. The review recommends significant changes in the approach to research, focusing on more dynamic, integrated technologies that are optimized and validated for characterization, removal, and abundance of MNPs in the ecosystem.

Human and Animal Impacts

A critical synthesis of current peer-reviewed literature on the environmental and human health impacts of COVID-19 PPE litter: New findings and next steps, Gurusamy Kutralam-Muniasamy, Fermín Perez-Guevara, V.C. Shruti, Journal of Hazardous Materials, 2021

This review outlines current research on the impacts of COVID-19 PPE litter. Including the microplastics that enter aquatic environments, chemicals added in PPE production, & potential health hazards.

COVID-19: Performance study of microplastic inhalation risk posed by wearing masks, Li, L., Zhao, X., Li, Z., & Song, K., Journal of Hazardous Materials, 2021

The present study used different types of commonly used masks to conduct breathing simulation experiments and investigate microplastic inhalation risk. Microplastic inhalation caused by reusing masks that underwent various treatment processes was also tested. Results implied that wearing masks considerably reduces the inhalation risk of particles (e.g., granular microplastics and unknown particles) even when they are worn continuously for 720 h. Microplastics were observed and counted under a microscope. Typical microplastics were selected and examined via Raman spectroscopy. The remaining microplastics on the membrane were examined with a Fourier transform infrared spectrometer and a laser infrared imaging system (8700 LDIR, Agilent).

COVID-19: Performance study of microplastic inhalation risk posed by wearing masks, Lu Li, Xiaoli Zhao, Zhouyang Li, Kang Song, Journal of Hazardous Materials, 2021

The risks of microplastic inhalation while wearing face masks was studied, including testing of reused, treated masks. Wearing masks reduces risk of inhaling particles including MPs.

Detection and analysis of microplastics in human sputum, Huang, S., Huang, X., Bi, R., Guo, Q., Yu, X., Zeng, Q., Huang, Z., Liu, T., Wu, H., & Chen, Y. , Environmental Science & Technology, 2022

The purpose of this study was to identify the quantity of microplastic particles in human sputum, using infrared absorption spectroscopy. Both FTIR microscopy and LDIR were used to measure MPs in sputum samples; FTIR for transmission; LDIR for reflectance. It was found that PU, PES, and CPE were the predominant polymers found in sputum.

An emerging role of microplastics in the etiology of lung ground glass nodules, Qiqing Chen, Jiani Gao, Hairui Yu, Hang Su, Yan Yang, Yajuan Cao, Qun Zhang, Yijiu Ren, Huahong Shi, Chang Chen, Haipeng Liu, (preprint), 2021

The presence of microfibers and microplastics was demonstrated in human lungs and linked to higher detection rates of pulmonary ground glass nodules. The morphology of MPs was found to influence GGN formation.

Microplastics detected in intestinal tissue of a pig raised near a sludge dump site: a pilot study, Hua Zheng-gang, Li Liang, Na Jun, et al, Chinese Journal of Public Health, 2021

Microplastics were detected in intestinal samples of pigs raised near a sludge dump site. Soil samples from the dump also contained MPs, linking the presence of MPs in the pigs to MP pollution in the soil of the dump.

A reliable method for the isolation and characterization of microplastics in fish gastrointestinal tracts using an infrared tunable quantum cascade laser system, López-Rosales, A., Andrade, J., Fernández-González, V., López-Mahía, P., & Muniategui-Lorenzo, S. , Marine Pollution Bulletin, 2022

The enzymatic-oxidative digestion, coupled to a Syncore automatic evaporation of the extract, and final measurement with an LDIR system revealed as a very reliable methodology to measure microplastics up to 10 µm that may be present in the fish stomachs, with excellent recoveries, ca. 90% for the commonest polymers, PS, PP, PVC, PET, PE and PA6.6. Recoveries for PET fibers were satisfactory, ca. 75%, similar to those reported in literature.

Detection of various microplastics in placentas, meconium, infant feces, breastmilk and infant formula: A pilot prospective study, Liu, S., Guo, J., Liu, X., Yang, R., Wang, H., Sun, Y., Chen, B., & Dong, R. , Science of The Total Environment, 2023

We aim to assess MPs exposure in placenta, meconium, infant feces, breast milk and infant formula samples, and assess the potential sources of pregnancy and lactational exposure to MPs. A total of 18 mother-infant pairs were recruited, and placentas and meconium samples were collected. Infant feces, breast milk and infant formula samples were collected at 6 months of age. We used an Agilent 8700 laser infrared imaging spectrometer to analyze samples. Sixteen types of MPs were identified, and polyamide (PA) and polyurethane (PU) were dominant. >74 % of the MPs found were 20-50 µm in size.

Fragmentation and depolymerization of microplastics in the earthworm gut: A potential for microplastic bioremediation?, Meng, K., Lwanga, E. H., van der Zee, M., Munhoz, D. R., & Geissen, V. , Journal of Hazardous Materials, 2023

The accumulation of microplastics poses potential risks to soil health. Here, we did a preliminary exploration on the potential of *Lumbricus terrestris* (Oligochaeta) to reduce low-density polyethylene (LDPE), polylactic acid (PLA), and polybutylene adipate terephthalate (PBAT) microplastic (20–648 µm) contamination in soils. Our results suggest that ingested microplastics could undergo fragmentation and depolymerization (for certain polymers) in the earthworm gut. Further research is needed to reveal the mechanisms of polymer depolymerization in the earthworm gut and to evaluate the feasibility of microplastic bioremediation with earthworms.

Drinking Water and Food

Microparticles and microplastics released from daily use of plastic feeding and water bottles and plastic injectors: potential risks to infants and children in China, Ke Song, Runrun Ding, Caiyun Sun, Lunguang Yao, Weicheng Zhang, Environmental Science and Pollution Research, 2021

> Plastic feeding and water bottles were found to release microplastics into their contents during opening/closing cycles, with the amount depending on bottle shape and plastic quality, but present in all samples.

Fate of microplastics in the drinking water production, Bäuerlein, P. S., Hofman-Caris, R. C., Pieke, E. N., & Ter Laak, T. L. , Water Research, 2022

> LDIR and optical microscopy were used to assess the effectiveness of drinking water treatment in the removal of microplastics. Gives some details on sample preparation and determination of LOD, LOQ etc.

Assessing exposure of the Australian population to microplastics through bottled water consumption, Samandra, S., Mescall, O. J., Plaisted, K., Symons, B., Xie, S., Ellis, A. V., & Clarke, B. O. , Science of The Total Environment, 2022

> This is the first study to document the presence of microplastics in bottled water sold in Australia from commercial outlets. In total, 16 brands of bottled water (Australian Sourced: n = 11, Imported: n = 5) sold in the two largest supermarkets in Australia were analyzed in triplicate (n= 48) for the presence of polyethylene, PE; polystyrene, PS; polypropylene, PP; polyvinyl chloride, PVC; polyethylene terephthalate, PET; polycarbonate, PC; polymethylmethacrylate, PMMA; and polyamide, PA. Microplastics were detected in 94% (n=15) of the samples, with PP (n=14, 88%), PET (n=10, 63%), PA (n=7, 44%), and PE (n=6, 38%) the most frequently detected. This study used Agilent's 8700 Laser Direct Infrared (LDIR) imaging system to analyze particles sized between 20 µm and 500 µm.

Methodology

Automated analysis of microplastics based on vibrational spectroscopy: Are we measuring the same metrics?, Mingtan Dong, Zhenbing She, Xiong, Zejiao Luo, (preprint), 2021

Automated analysis techniques for microplastics (vibrational spec., LDIR, Raman, FTIR) were compared. Quantification, detection limit, size measurement, identification accuracy & speed were tested.

Additional comments: Please note that this study is somewhat critical of the LDIR but contains numerous flaws. It is based on only 2 samples that were processed as part of a demonstration rather than a study, it contained no laboratory blanks or other quality control methods and samples were transported between studies. In addition, it misquotes several pieces of literature and, in one instance, cites a study conducted on a different instrument.

Microplastic discharge from a wastewater treatment plant: long term monitoring to compare two analytical techniques, LDIR and optical microscopy while also assessing the removal efficiency of a bubble curtain, Bäuerlein, P. S., Pieke, E. N., Oesterholt, F. I. H. M., ter Laak, T., & Kools, S. A. E. , Water Science and Technology, 2022

Comparison LDIR vs optical Microscopy: LDIR can identify the plastic type as well as shape, while OM cannot determine the plastic type. Furthermore, LIDR has a lower size limit (10–20 µm) than OM (50 µm). While information obtained by OM in general is far less detailed it is more affordable. Bubble curtain has no measurable effect on the particle concentration

Identification of Polymers with a Small Data Set of Mid-infrared Spectra: A Comparison between Machine Learning and Deep Learning Models, Tian, X., Beén, F., Sun, Y., Van Thienen, P., & Bäuerlein, P. S. , Environmental Science & Technology Letters, 2023

Past studies applied a variety of ML models to identify polymers from small or large data sets. Results show that the ensemble ML model, compared to neural network models, takes the least training time to achieve the best performance, i.e., a classification accuracy of 99.5%. This study provides a generic framework for selecting ML models and boosting model performance to accurately identify polymers.

Methodology of Assessing Microplastics and Nanoplastics in the Environment: Recent Advances in the Practical Approaches, Govindu, D., Tippani, R., Porika, M., Sura, S.P., , Micro and Nanoplastics in Soil: Threats to Plant-Based Food, 2023

A review of various methods of microplastics analysis including Mass based analysis and particle focused techniques. Much of the literature cited however is quite old (2020 and earlier) which renders it somewhat dated in this fast-moving arena. LDIR is mentioned in a positive light however it is also noted that comparative performance has not yet been well established.

Laser microdissection pressure catapulting (LMPC): a new technique to handle single microplastic particles for number-based validation strategies, Hildebrandt, L., Zimmermann, T., & Pröfrock, D. , Analytical and Bioanalytical Chemistry, 2023

This study examines laser microdissection pressure catapulting (LMPC) as an innovative method for microplastic research. Laser pressure catapulting as part of commercially available LMPC microscopes enables the precise handling of microplastic particles without any mechanical contact. In fact, individual particles with sizes between several micrometers and several hundred micrometers can be transported over centimeter-wide distances into a collection vial. Therefore, the technology enables the exact handling of defined numbers of small microplastics (or even individual ones) with the greatest precision. The ablated particles showed no evidence of chemical alteration as seen in the particles' IR spectra acquired via laser direct infrared analysis.