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AND APPLIED ECOLOGY IME

WELCOME

Potentially problematic substances present in the environment require investigation relating to their exposure and effects by means of adapted test and analysis methods. This includes substances such as for feed ingredients and additives in aquaculture, for plastics in films for agriculture and horticulture, or for the spectrum of perfluorinated and polyfluorinated surfactant compounds in human blood.

In the portrait we introduce Dr. Steve Ayobahan, whose doctoral thesis and subsequent activity in our young scientist group »Eco'n'Omics« will support the production of environmentally friendly substances during their development stage in the future.

Yours sincerely

Prof. Dr. Christoph Schäfers

Photo: Research facility for aquaculture studies.
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In this issue you can read:

SAFETY FOR CONSUMERS AND THE ENVIRONMENT

Innovative research facility for aquaculture studies

The importance of aquaculture in the global supply of fish and seafood continues to grow. In fact, human consumption of aquaculture products exceeded consumption of wild fish for the first time in 2014.

In recirculating aquaculture systems (RAS) the aquaculture of fish, algae or crustaceans takes place in tanks. The holding water is cleaned in an integrated water treatment system and then fed back into the holding basin. The use of circulation technology enables a significant reduction in water consumption compared to conventional continuous systems. »However, the low exchange rates also lead to a potential accumulation of organic substances, feed additives, substances for water treatment, as well as active ingredients which are applied to the circulation system« says Prof. Dr. Christian Schlechtriem, Head of Department Bioaccumulation and Animal Metabolism. ▶

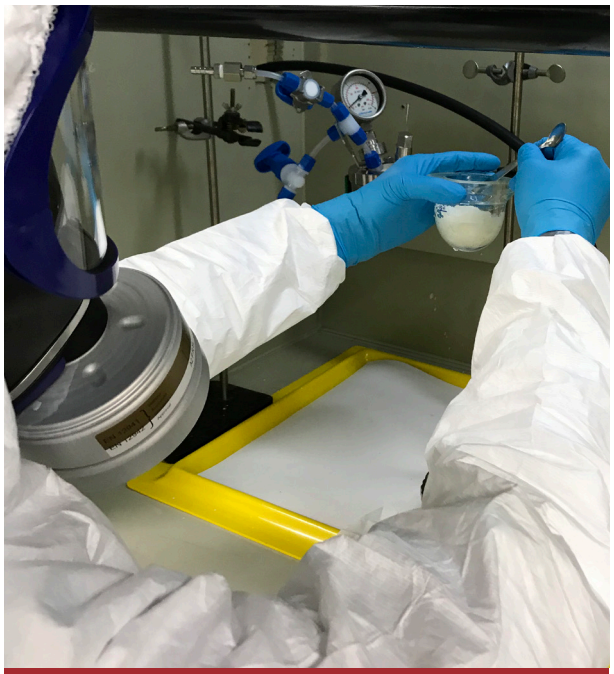
From summer 2021, a globally unique RAS research facility will be available at Fraunhofer IME, which enables the investigation of the physico-chemical and biological processes in RAS systems. The system made of stainless steel consists of seven individual circuits and allows the use of ^{14}C-labeled substances. This enables valuable information to be obtained on the whereabouts of feed-borne and biogenic substances in the production chain. The research facility can thus help to optimize the composition of fish feed and the properties of feed additives, improve the cleaning performance of recirculation systems and thus support the development of products that offer a high degree of safety for consumers and the environment. The new RAS system can run in fresh and salt water mode. Different types of fish such as rainbow trout (*Oncorhynchus mykiss*), nile tilapia (*Oreochromis niloticus*) or the European sea bass (*Dicentrarchus labrax*) can be used for the feeding experiments.

Fish metabolism studies for safe food

Fish feed that is used in commercial fish farming already contains a significant proportion of vegetable raw materials. It is therefore important to understand the potential for pesticide residue transfer into edible tissues from farmed fish. In the EU, fish metabolism studies are required as part of the regulatory approval of pesticides if treated crops are used as raw material in fish feed and there is a risk of residues being carried over to edible tissues. Fraunhofer IME, together with representatives from regulatory authorities and the industry, developed a test concept for carrying out fish metabolism studies and has been carrying out these studies under GLP conditions for several years. Part of the new research facility for aquaculture studies in Schmallenberg are two modern stainless steel flow-through systems that will enable the studies to be designed even more flexibly in the future. ■

IMULCH-PROJECT: INVESTIGATION OF THE FATE OF MULCH FOILS IN AGRICULTURAL SOILS

Novel approach to investigating the behavior of mulch films which, in current agricultural practice, remain in the soil after use.



Laboratory syntheses of the radioactive PE copolymer. Photo: @ Fraunhofer IME / Dieter Hennecke

The presence of synthetic polymers in the environment is increasingly the focus of social discussions. In marine and fresh water systems, the appearance, distribution and effects of synthetic polymers and microplastics (synthetic polymer particles < 5 mm) have already been well investigated. However, little information is available on microplastics in soils. »This is primarily due to the challenge of detecting microplastics in soils« says Dr. Dieter Hennecke, Head of Department Ecological Chemistry.

At the IME, work with ^{14}C-radioactive labelled plastics is carried out under field conditions. Radioactive labeling is a technique that is often required by the authorities for registration studies of for example pesticides. It enables statements to be made on the fate of the material, which are not possible without labelling, in particular on previously unknown degradation products. Thus, conclusions on transport (e.g. relocation into the subsoil, discharge into the leachate, uptake by crop plants) and degradation (e.g. mineralization, reduction of average molecular size, identity of degradation products) become possible.

The results are supplemented by a mass balance, which ensures that no relevant components have been overlooked. For the investigations, the material is introduced directly into the soil in the form of microplastics as this represents the »worst case« with regard to a possible risk.

The production of ^{14}C-labeled polymers is new ground and new synthesis methods have been developed in cooperation with external partners (Fraunhofer IAP, BASF). This allowed the synthesis of a ^{14}C-labeled PE copolymer that represents the most relevant type of plastic in terms of the quantity used in agricultural practice. The second material produced was ^{14}C-PBAT, a polymer classified as biodegradable. Both materials were incorporated into soil contained in lysimeters where agricultural cultivation methods typical for the use of mulch foils were carried out under field conditions. So far, there is no evidence that the applied microplastic particles are relocated into the groundwater or taken up by crop plants. The project is not yet finalized. ■

FOREVER CHEMICALS IN HUMAN BLOOD

Human biomonitoring shows traces of PFAS in all analyzed blood samples.

Per- and polyfluoroalkyl substances (PFAS) are highly persistent and are therefore known as »forever chemicals«. Due to their unique properties these substances are used in various industrial processes and consumer products.

PFAS are not only water, oil and dirt repellent but are also highly stable. These substances are used for example in galvanic industries and in fire-fighting foams, but also in outdoor textiles and food contact materials. »Many of them are considered persistent, bioaccumulative and often toxic. Therefore, it is of high importance to investigate how humans are exposed to this group of substances« says Dr. Bernd Göckener, head of laboratory in the department Environmental and Food Analysis.

Throughout the past decades, various human samples have been collected and stored annually for the German Environmental Specimen Bank. Since 2012, this work is carried out by the Fraunhofer IBMT on behalf of the German Environment Agency. In a recent human biomonitoring study funded by the German Federal Ministry of the Environment and the German Environment Agency, blood plasma samples from the German Environmental Specimen Bank were analyzed for various PFAS. These data now allow retrospective investigation of the trends in the human exposure to PFAS in Germany since 1982.

The results show that the human exposure is mainly characterized by two substances from the group of PFAS. These are perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) which have been used since the 1950ies and were detected in every analyzed sample up until today.

Blood plasma samples from the environmental specimen bank. Photo: @ Fraunhofer IBMT / Dominik Lermen

The trends show that the PFAS exposure was highest in the eighties and nineties. Since then, the human exposure to the legacy PFAS was shown to decrease constantly. In the most recent years, the majority of test persons showed PFOA levels in the range of the current guidance values (HBM-I values) and PFOS levels below these values. Levels below the guidance values imply that, according to current knowledge, there is no risk of adverse health effects and, consequently, no need for action.

»The results demonstrate that production and usage bans as well as voluntary exits from the industry have had an effect. Human biomonitoring serves as an important tool to assess the effectiveness of present regulations and to recognize the need for new regulations« says Dr. Göckener. ■

"Sustainable development of environmentally safe active chemical substances, guarantees a sustainable tomorrow.

Steve Uwa Ayobahan earned his Bachelor of Science degree in environmental science at the University of Benin, Nigeria. Subsequently, he attended the University of Kiel, where he received a masters degree in environmental management. He recently finished his doctorate degree in natural sciences / ecotoxicology at the RWTH Aachen University. The research for his dissertation entitled »Proteomics as an alternative approach for hazard characterization and the identification of specific chemical targets: Elucidation of potential biomarkers for differentiating endocrine disruption from hepatotoxicity« was performed at the Fraunhofer IME. On this topic, Dr. Ayobahan has published two peer-reviewed articles. He is member of the Society of Environmental Toxicology and Chemistry (SETAC).

Dr. Steve Uwa Ayobahan...

… has been working in the department of ecotoxicology since 2015 in the context of his doctoral research project. Since 2019, he is strengthening the Fraunhofer Attract group »Eco'n'OMICs« as a postdoctoral scientist in the development of OMICs-based testing strategies for assessing the environmental impact of newly developed active substances.

For substance evaluation, specificity is of utmost importance for identifying potential endocrine active chemicals. The current testing guidelines for assessing endocrine disruption (ED) rely on changes in apical endpoints. However, these tests do not sufficiently consider the mode-of-action of the applied test substance, resulting in the observed changes in these endpoints. In particular, non-ED substances interfering with ED endpoints, such as hepatotoxic chemicals, could be misclassified as EDs. Therefore, for these substances, additional cost-, animals- and time-consuming higher tier testing is needed. The identification of protein biomarker candidates for differentiating endocrine disrupting and hepatotoxic chemicals in zebrafish was the goal of his dissertation. By integrating a high content proteomics approach into the existing test guideline (OECD 229), he linked substance-induced physiological effects with organ-specific protein expression signatures. He found that substance-induced adverse effects, seen at a higher biological level, could be clearly separated and properly classified at the molecular level.

PROSPECT FOR SUSTAINABLE PRODUCTION OF CHEMICALS AND ENVIRONMENTAL MONITORING

»Combining ecotoxicological and OMICs methodology (transcriptomics, proteomics) for generating a database of substance-specific molecular changes preceding adverse effects, will be one step towards a sustainable development of environmentally safe active substances« says Dr. Ayobahan. After cross-validation, these molecular signatures can be harnessed to develop screening approaches for environmental risk prediction.

Read more about our research activities here: www.ime.fraunhofer.de/en.html

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Applied Ecology
Auf dem Aberg 1
57392 Schmallenberg, Germany

Tel +49 2972 302-0
Fax +49 2972 302-319

Director
Prof. Dr. Christoph Schäfers
christoph.schaefers@ime.fraunhofer.de

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Dr. Kristina Bette-Gaußmann
Public Relations

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