Report 2019

Institute for Environmental Research

RWTH Aachen University

INSTITUTE FOR ENVIRONMENTAL RESEARCH

RWTH AACHEN UNIVERSITY

ABBt Aachen Biology and Biotechnology

RWTH AACHEN UNIVERSITY

Editorial

Institute for Environmental Research

Annual Report 2019

According to our vision,

"Teaching and research for a responsible
treatment of the environment and
technology",

2016 until 2019 have been successful years. Our Masters course Ecotoxicology, established in 2010, has becoming very popular for students. Approximately half of the about 25 students per year enrol in our course after completion of the bachelor's program from external universities, the other half are Bachelor students from our university. The master course has been successfully re-accredited in 2016.

Numerous interdisciplinary research projects with national and international partners have been carried out, which are presented briefly in this brochure.

We thank all the staff of our Institute for their dedicated and goal-oriented work and also acknowledge the financial support by many public and industrial sponsors that have enabled our research.

We hope that the insight into the activities of the Institute for Environmental Research at RWTH Aachen University will pique your interest.

Prof. Dr. Andreas Schäffer, Prof. Dr. Henner Hollert* and Dr. Martina Roß-Nickoll**

* since October 2019 Goethe University Frankfurt

** since November 2019 deputy professor

Units of the Institute

Chair of Environmental Biology and Chemodynamics (UBC)

Prof. Dr. Andreas Schäffer

Community ecology and ecotoxicology

Dr. Martina Roß-Nickoll

Dr. Benjamin Daniels

Quantitative ecology

Dr. Richard Ottermans

Department of Ecosystem Analysis (ESA)

Dr. Martina Roß-Nickoll (Deputy professor)
before Prof. Dr. Henner Hollert

Effect-related ecotoxicology

Dr. Thomas-Benjamin Seiler

Green Toxicology

Dr. Sebastian Heger
Dr. Miaomiao Du

Chemical analysis

Dr. Hannah Holzmann
David Kämpfer
before Dr. Kilian Smith

Environmental chemistry, FZ Jülich

Prof. Dr. Erwin Klumpp

Department of System-Ecotoxicology

Prof. Dr. Matthias Liess (UFZ, Leipzig)

Department of Bioanalytical Ecotoxicology

Prof. Dr. Rolf Altenburger (UFZ, Leipzig)

Department of Exposome Analysis

Prof. Dr. Annika Jahnke (UFZ, Leipzig)

Staff

Chair of Environmental Biology and Chemodynamics (UBC)

Lead: Prof. Dr. Andreas Schäffer

Assistant Professors:
Ottermanns, Richard, Dr.
Roß-Nickoll, Martina, Dr.

Postdocs:

Stibany, Felix, Dr.
Daniels, Benjamin, M.Sc.

PhD students:
Bach, Alexander, M. Sc.
Benner, Lena, M. Sc.
Bursche, Vanessa, M.Sc.
Byun, Jae-Gyun, M.Sc.
Furchte Hanna, M.Sc.
Heine, Peggy, Dipl. Ing.
Holzmann, Hannah, M.Sc.
Jedamski, Jana, M. Sc.
Kämpfer, David M. Sc.
Kathmann, Wiebke, M. Sc.
Kraemer, Klara, M.Sc.
Lopez Gordillo, Ana Paulina, M. Sc.
Luks, Ann-Kathrin, M. Sc.
Nguyen, Kim, M.Sc.
Penssler, Eva, M. Sc.
Politowski, Irina, M. Sc.
Roeben, Vanessa, M.Sc.
Schmidt, Felix, M. Sc.
Siedt, Martin, M. Sc.
Sybertz, Alexandra, M. Sc.
Wijntjes, Christian, M. Sc.

Department of Ecosystem Analysis (ESA)

Lead: Dr. Martina Roß-Nickoll

Assistant Professors:
Seiler, Thomas-Benjamin, Dr.

Postdocs:
Du, Miao Miao, Dr..
Heger, Sebstian, Dr.

PhD students:
Alert Henriette, M.Sc.
Brendt, Julia, M.Sc.
Deutschmann, Björn, M.Sc.
Dorn, Alexander, M.Sc.
Gundlach, Michael, M.Sc.
Haigis, Ann-Cathrin, M.Sc.
Heger, Sebastian, M.Sc.
Kämpfer, Christoph, Dipl. Gyml.
Lackmann, Carina, M. Sc.
Müller, Anne-Kathrin, M.Sc.
Müller, Yvonne, M. Sc.
Nuesser, Leonie, M. Sc.
Shuliakevich, Aliaksanda, M.Sc.
Volz, Sina, M. Sc.

Technicans:
Goffart, Birgitta, TA
Patti, Hilde, TA,
Thiede, Brigitte, TA

Secretaries:
Goebele, Dennis
Lubczyk, Leonie

Cooperations in Research and Teaching

Industry	Research	Regulation
Bayer Crop Science	**gaiac**	EFSA
Bayer Material Science	ERASMUS (Brno, Örebro, Stockholm, Amsterdam, Sassari)	**Umweltbundesamt (UBA)**
Syngenta	University of Saskatchewan (Canada)	BVL
BASF	National Research Centre for Environmental Toxicology (EnTox, Australia)	MUNLV
Fintelmann & Meyer	FHNW/Basel	LANUV
ECT	EAWAG/Zürich	**BfG**
Stadtwerke Karlsruhe	University of Marburg	vTI
Dupont	ZALF Müncheberg	BfN
IBACON	University of Freiburg	LUBW
Knöll Consult	**UFZ Leipzig**	**RKI**
	FZ Jülich	
	FZ Karlsruhe	
	University of Heidelberg	
	IME, NERI	
	Montenegro (Eco Education Center)	
	SMNK Karlsruhe	
	University of Curitiba	
	TZW	
	IUTA	
	FIW	
	ISA	
	VU Amsterdam	

**Bold* = *Teaching cooperations*

Expert panels

- BFR
- Cefic
- KBU
- Advisory Board of the Eifel National Park
- OECD Expert panels and Guideline comments (Statistics, Ecotoxicology)
- DIN Workgroups (Biotests, Genotoxicity)
- SETAC Advisory groups

Contact

Institute for Environmental Research

Chair of Environmental Biology and Chemodynamics (UBC – Prof. Dr. A. Schäffer)
Department of Ecosystem Analysis (ESA – Dr. Martina Roß-Nickoll)

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Highlights

01.10.2019 | Professor Hollert moved to Goethe University Frankfurt; Dr. Roß-Nickoll deputy professor

Henner Hollert became full professor at the university in Frankfurt in the field of Evolutionary Ecology and Environmental Toxicology. Martina Roß-Nickoll, group leader of Community Ecology and Ecotoxicology took over the deputy professorship.

05.12.2018 | Professor Hollert awarded as a SETAC Fellow

Henner Hollert, head of the department of ecosystem analysis, receives the prestigious SETAC Fellows Award 2018. The Society of Environmental Toxicology and Chemistry (SETAC) aims at developing principles and practises to maintain a sustainable environment, encourages communication between scientists and provides a forum for professionals in all fields of environmental science and regulation. The SETAC Fellows award was created in 2010 to honour members of for their significant long-term contributions to scientific or science policy and for their service and leadership within SETAC. Both, leadership within the professional and the scientific field, e.g., ecotoxicology or risk assessment, as well as in SETAC mark the SETAC Fellow. Up to now, only 2 % of SETAC members hold the Fellow status. Henner Hollert will be officially awarded during the 29th SETAC Europe annual meeting 2019 in Helsinki, Finland.

01.12.2018 | Leopoldina Discussion Paper

We are currently observing a dramatic loss of animal species worldwide. On closer inspection, this loss of species is particularly severe in areas used for agriculture. One of the reasons for this is the current practice in crop protection. The current authorization system is complex and attempts to minimise environmental problems related to pesticide application. Unfortunately, only with moderate success. Many ecological effects in the field are not or not sufficiently mapped. As a result, their use has unintended harmful effects on ecosystems. After application, for example, the chemicals can often be detected in soil and water for much longer than predicted in the approval process. The direct and indirect effects on organisms that are not the target of pesticides are also not sufficiently predicted at present.

We summarized problems related to “chemical agriculture” and provided options to improve the situation in a Leopoldina discussion paper and a paper in Envrionmental Sciences Europe:

(https://www.leopoldina.org/uploads/tx_leopublication/2018_Diskussionspapier_Pflanzenschutzmittel_EN.pdf) and a related publication in Environmental Sciences Europe

https://enveurope.springeropen.com/articles/10.1186/s12302-019-0203-3.

01.12.2018 | Project FunGi

One of the shortcomings in the authorisation procedure for pesticides is the fact that degradation and effect studies are carried out with individual active substances and authorised product mixtures. However, the complex mixtures of pesticides that occur in reality are not taken into account. For example, 20 or more active substances are often applied in the course of a season as part of standard spraying series.

In this context, we investigate the influence of fungicides on the degradability of other pesticides applied in parallel in soil and water-sediment systems. At the same time, the influence of fungicides on the fungal biomass in these ecosystems will be investigated using molecular biological methods.

01.12.2018 | Project Soil Amendments

We investigate the impact of different organic soil amendments with the aim to characterize their suitability to be applied to arable fields. Numerous benefits of an increase of organic matter in soils regarding soil fertility and carbon storage are known and recently discussed on an international political level to address issues in food production and global climate change. Being a key component in the complex network of interactions in the soil, the organic matter is a setting screw to counteract threats derived from arable land to the biodiversity of adjacent habitats, such as nutrient surpluses and residues from plant protection products. We propose a list of criteria to judge the suitability of different organic materials for their use as a soil amendment in sustainable agriculture and focus on benefits for the soil’s structural and physical properties, water and nutrient retention, microbial life as well as pesticide sorption and degradation.

31.10.2018 | DemO3AC – Phase 2 startet

Mit der feierlichen Einweihung der großtechnischen Demonstrationsanlage zur Ozonung von Abwasser auf der Kläranlage Soers ist für das DemO3-Projekt die zweite Phase angelaufen.

Im Rahmen des Projektes „Demonstrationsvorhaben Ozonung des Abwassers auf der Kläranlage Aachen-Soers“ (DemO3AC) wurde durch den Wasserband Eifel-Ruhr (WVER) eine großtechnische Abwasserozonung als weitere Reinigungsstufe in den Klärprozess integriert. Neben der grundsätzlichen Eignungsprüfung und der Evaluierung von Optimierungsmöglichkeiten liegt der Fokus der begleitenden Untersuchungen vor allem auf dem Einfluss der Abwasserozonung auf die Wurm, die der Kläranlage als Vorfluter dient. Das Institut für Umweltforschung nutzt in diesem Projekt eine sehr umfassende Batterie von Biotestverfahren und auch In situ-Methoden.

Zunächst wurde in Phase 1 (bis Ende 2017) der Status-quo des Gewässers anhand verschiedener Analysen erhoben. In Phase 2 des Projektes wird nun der Einfluss des ozonierten Abwassers auf das Gewässer mit einer angepassten Biotestbatterie erneut untersucht und mit den erhaltenen Daten aus Phase 1 verglichen. Dabei liegt unser Hauptaugenmerk auf der Frage, ob die organische Restverschmutzung durch den Einsatz der Abwasserozonung weiter verringert und so die Gewässerqualität der Wurm verbessert werden kann.

Ort der Forschung ist die Abwasserreinigungsanlage Aachen-Soers, der das Gewässer Wurm als Vorfluter dient. Die vom WVER betriebene Kläranlage trägt mit ihrer Einleitung bis zu rund 70 % der Wasserführung der Wurm bei. Gefördert wird das Projekt durch das Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen. Projektpartner des Gesamtprojektes sind das Institut für Siedlungswasserwirtschaft (Prof. Pinnekamp), das Institut für Angewandte Mikrobiologie (iAMB, Prof. Dr. Miriam Agler-Rosenbaum) und das Forschungsinstitut für Ökosystemanalyse und -bewertung (gaiac) an der RWTH Aachen (Dr. Monika Hammers-Wirtz)

Leitung des Teilprojektes am Institut für Umweltforschung: Prof. Dr. Henner Hollert und Dr. Sabrina Schiwy;

Bearbeitung: MSc Yvonne Müller, MSc Aliaksandra Shuliakevich; Simone Hotz

01.09.2018 | Project Nowelties

Kilian Smith leads a project in the European Marie Skłodowska-Curie Innovative Training Network in which 11 doctoral students from abroad work on water treatment technologies. The primary objective of NOWELTIES is to organize a platform that will provide training opportunities for the education of tomorrow`s water treatment experts. The core activity is the research program aimed at development of inventive water treatment technologies (advanced biological treatments, innovative oxidation processes, hybrid systems) that allow catering for the varied treatment demands for a plethora of interconnected streams arising from recycling loops. These technologies will be able to control contamination by organic micropollutants.

01.08.2017 | Project UBA AgriMon

Pesticides are introduced into the environment in a targeted and regular manner. Due to their efficacy on target and non-target organisms, there are now numerous indications that the current use of these active substances has considerable harmful effects on ecosystems and biological diversity. There are many reasons for the negative consequences of intensive agriculture with large-scale use of pesticides.

The actual effects of PPPs on biodiversity depend primarily on the actual application rate, their drift, the respective toxicity, the fate of the substances and thus their accumulation in the ecosystem. At present, there is no access to actual application quantities per agricultural field over time, so that a correlation or causal relationship to effects of pesticide use on biodiversity is not possible. It is therefore necessary to collect such data combining chemical-analytical monitoring of pesticide residues and biodiversity monitoring. Focus of the project on behalf of UBA is the terrestrial agricultural landscape, since chemical-analytical monitoring programs of pesticides are lacking so far and corresponding data are only collected within the framework of research projects

16.05.2017 | Successful NORMAN WG2 meeting

The NORMAN Working Group (WG) 2 on Bioassays and biomarkers in water quality monitoring, in partnership with the Institute of Environmental Research, RWTH Aachen University, hosted a very successful meeting last month (26.04.2017). The scientific

committee of the meeting included Prof. Dr. Henner Hollert (RWTH), Dr. Sarah Crawford (RWTH), Dr. Valeria Dulio (INERIS), and was organized with the help of several ESA student volunteers. The focus of the meeting was on “the integration of bioassays and biomarkers in water quality monitoring and neurotoxicity assessment”. The overall aim of the activity is to contribute towards the implementation of bioassays within the Working Group “Chemicals” of the CIS (common implementation strategy) of the Water Framework Directive (WFD) on EU level. Highlights of speakers included Dr. Jessica Legradi (Vrije Universiteit Amsterdam, NL), Prof. Dr. Markus Hecker (University of Saskatchewan, CAN), Dr. Sebastian Buchinger (BfG, Fedeal Hydrological Institute, GER), Dr. Cornelia Kienle (Ecotox Centre, Eawag, CH) and Prof. Dr. Beate Escher (UFZ, Center for Environmental Research, GER). Talks and discussions touched on the challenges and integration of neurotoxicity testing as well as the application of bioanalytical tools to address emerging pollutants in water. From the discussions of this meeting, a draft of a common position within the wider scientific community on how to use bioassays and biomarkers for water quality monitoring will be produced (i.e., methodology to define effect-based trigger values; recommendations for a common battery of bioassays; quality/performance criteria for the benchmarking of bioassays).

A follow-up meeting for the NORMAN WG2 will be hosted June 20-22 at the Swiss Ecotox Centre (Eawag) in Dübendorf, CH on the “Estrogen Monitoring final project meeting” (Moderated by: Robert Kase and Mario Carere), “Estrogen Monitoring recommendation workshop” together with NORMAN and SOLUTIONS Networks (Moderated by: Valeria Dulio) and the “Effect-based trigger value (EBT) discussion workshop” (Moderated by: Beate Escher, Robert Kase, Henner Hollert).

15.02.2017 | Projekt ACCESS! ist gestartet

How mobility systems in the future will look like is the main question that the NRW-Project ACCESS! will address in an interdisciplinary cooperation with eleven research groups of RWTH Aachen University.

The concepts and tools developed in the project will be tested within two practical projects, representing a rural area – Kreis Heinsberg- as well as an urban space – MetropoleRuhr.

Our sub-project will investigate how future mobility systems might impact the amounts and types of contaminants, and if there are practical options to reduce negative effects.

One way to manage rising pollutant emissions is by using urban vegetation such as parks, gardens and roadside greenery. These can play an important role in air quality regarding gaseous and particle-bound pollutants. To investigate the role of urban green areas in altering the mass flows of traffic-related gaseous and particulate pollutants we will focus on organic “marker” pollutants (e.g. PAH). Deposition samples will be collected and surface run-off investigated using passive sampling, to determine the concentrations and distribution of the marker contaminants.

Determining the pollutant mass flows in different situations (e.g. heavy vs. light traffic) and in relation to the types and size of green areas (e.g. urban vs. rural), inferences can be made as the possible impacts of mobility systems in the future and how these might be made more sustainable.

01.02.2017 | EU Horizon 2020 Projekt „GRACE“ läuft

Marine research in Aachen - with a fresh water model organism

Oil spills in cold Baltic and Arctic Sea waters are a special challenge to investigate, and hence they are the research focus of a new EU H2020-funded collaborative project "Integrated oil spill response actions and environmental effects – GRACE". The project is coordinated by Kirsten Jörgensen of SYKE in Helsinki, Finland. Thomas-Benjamin Seiler from the Department of Ecosystem Analysis headed by Henner Hollert leads the project part at RWTH, and the whole work package 3 which investigates the effects on biota.

GRACE strives with partners from Finland, Denmark, Estonia, Spain, Norway, Greenland, Sweden, Germany and Canada to comprehensively investigate the environmental impact of oil spills and provide measures for mitigation. At RWTH the zebrafish will be established as a model organism for oil spill detection and assessment. Sarah Johann and Leonie Nüßer work within their PhD theses on the project.

The whole project aims at developing novel tools and strategies for oil spill response, and increase the knowledge on the distribution, mobility, severity, impact and possibilities for mitigation of oil contaminations.

01.01.2017 | CEFIC – Projekt mit schwer löslichen Substanzen in vollem Gange

Andreas Schäffer, Kilian Smith, and Felix Stibany, together with Stefan Trapp of the Technical University of Denmark (DTU) and the German Environmental Protection Agency (UBA), have been awarded a project by CEFIC (CEFIC LRI-ECO32) to investigate the environmental risks of poorly soluble substances. The project aims to develop improved tools for assessing their biodegradation and (de)sorption, and will develop models to describe this. Chemicals with very low aqueous solubilities are often used in a broad range of applications. For example, in personal care products 2–5 % of the total annual production in Germany is estimated to consist of highly hydrophobic compounds where they are used as emulsifiers among other things. Their typical way of application promotes the release of substantial amounts of these chemicals into wastewater and the aquatic environment. Therefore, reliable assessments of the environmental fate and potential toxicity are urgently needed for poorly soluble chemicals. This project therefore continues the recent research into poorly soluble substances (ECOSM).

10.10.2016 | Neue Veröffentlichung aus NORMAN-Gruppe frei zugänglich

Under lead of Prof. Henner Hollert and Carolina Di Paolo the working group on Bioassay of the international NORMAN network on emerging pollutants conducted an international Bioassay battery interlaboratory investigation of emerging contaminants in spiked water extracts with 11 partners. The results of the study are published in a recent article in Water Research by Di Paolo et al. Together with other ongoing activities for the validation of a basic bioassay battery, the present study is an important step towards the implementation of bioanalytical monitoring tools in water quality assessment and monitoring.

01.09.2016 | NANO-Transfer – Transfer kohlenstoffbasierter Nanomaterialien in der aquatischen Umwelt: Verbleib, Effekte, Bioakkumulation,Nahrungsnetzübertragung ,Schafstofftransport und Einsatz in der Remediation belasteter Gewässer

Das EU-Projekt NANO-Transfer untersucht umfassend das Schicksal von kohlenstoffbasierten Nanomaterialien in der aquatischen Umwelt sowie deren potenzielle Anwendung für die Altlastensanierung. Das Projekt, das offene Fragen der Charakterisierung, hinsichtlich der Risikoabschätzung und Entwicklung dieser Nanomaterialien erforscht, wird vom Institut für Umweltforschung an der RWTH Aachen koordiniert. Es besteht aus einem Konsortium von sechs universitären und außeruniversitären Forschungseinrichtungen in Deutschland, Spanien und Rumänien.

Eine Vielzahl von Produkten wurde bereits mit Hilfe von Kohlenstoff-basierten Nano-materialien (C-MNM) aufgrund ihrer außergewöhnlichen mechanischen, ther-mischen und elektrischen Eigenschaften verbessert. Forschung und Industrie sehen daher für die Zukunft ein großes Wachstumspotenzial dieser Technologie. Bei der Verwitterung von C-MNM haltigen Werkstoffen können die Nanomaterialien freigesetzt werden und in die Umwelt gelangen. In NANO-Transfer werden der Verbleib, die Anreicherung, die Nahrungsnetzübertragung und toxische Langzeit-Effekte von Schadstoffen in Anwesenheit von C-MNMs als Schadstoffträger in der aquatischen Umwelt untersucht. Aufgrund ihrer Bindungsfähigkeit von hydrophoben (fettliebenden) organischen Chemikalien haben C-MNMs das Potential, zur Reinigung belasteter Gewässer eingesetzt zu werden. Auch diese Anwendung wird in NANO-Transfer mit verschiedenen Schadstoff-Modellsubstanzen untersucht und gleichzeitig die Sicherheit solcher Methoden evaluiert.

01.10.2016 | Kombinierte In-Situ-Beprobung und In-Vitro-Testung

Im DFG-Projekt PASSEDOBLE werden seit Januar 2016 zum ersten Mal Daten zur Toxizität der Porenwasserkonzentration von Schadstoffen in Ostsee-Sedimenten mit sehr geringer Unsicherheit erhoben, direkt mit einer chemischen Analyse korreliert und schließlich über entsprechende künstliche Mischungen verifiziert.

Erhobene Daten sind daher in hohem Maße repräsentativ für die tatsächliche Belastungssituation vor Ort. Desweiteren werden die analysierten Schadstoffmischungen künstlich wiederhergestellt, um sie mittels passive dosing in unterschiedlichen Konzentrationen in Bioassays zu untersuchen. Damit sollen Konzentrations-Wirkungskurven erstellt werden, die es erlauben, das von den sedimentgebundenen Schadstoffen ausgehende Risiko abzuschätzen (Mischtoxizität).

Das Projekt ist eine Kooperation mit der Arbeitsgruppe von Prof. Gesine Witt an der HAW in Hamburg. Thomas-Benjamin Seiler vom Lehr und Forschungsgebiet für Ökosystemanalyse leitet den Projektteil an der RWTH zusammen mit Henner Hollert.

Bearbeitet wird es von Hendrik Hercht im Rahmen seiner Doktorarbeit über die Integration von passive dosing in Biotestsysteme.

01.09.2016 | Martina Roß-Nickoll und Richard Ottermanns sind Mitglieder im DKN

Martina Roß-Nickoll und Richard Ottermanns arbeiten als assoziierte Mitglieder im Deutschen Komitee für Nachhaltigkeitsforschung (DKN) innerhalb Future Earth. Diese Arbeitsgruppe möchte eine methodologische Diskussion über die angemessene Berücksichtigung des Gesellschaftlichen in sozial-ökologischen Modellen und Simulationen der Nachhaltigkeitsforschung anstoßen und nähert sich dieser Thematik am Beispiel der Risikobewertung oder des Fleischkonsums, um neue Kriterien zu testen und zu schärfen.

01.08.2016 | Martina Roß-Nickoll als RWTH Lecturer ausgezeichnet

Zusammen mit acht anderen wissenschaftlichen Mitarbeiterinnen und Mitarbeitern unterschiedlicher Fakultäten wurde Martina Roß-Nickoll als RWTH Lecturer ausgezeichnet.

Diese Auszeichnung ehrt die herausragende Art und Weise, in der sich Martina Roß-Nickoll für ihre Lehre engagiert und forscht. Dieser Ehrentitel ist mit einem Geldpreis in Höhe von 15.000 Euro verbunden und wird unbefristet für die Dauer ihres Beschäftigungsverhältnisses an der RWTH verliehen.

01.03.2016 | Andreas Schäffer member of the Leopoldina Environment Commission

The Academy of Sciences Leopoldina is the national academy of Germany. Aim of this organization is to scientifically review and address key issues of prospective significance to society. Its findings are conveyed to policy makers and the public. The commission on environmental issues prepares documents on current environmental issues, such as risk assessment of chemicals, climate change, biodiversity loss, water resources, etc.

Teaching

Bachelor of Sciences in Biology

Compulsory Modules:

- Quantitative Biology and Computer Applications
- Ecology

Specialization Module

- Environmental Sciences

Additional Qualifications

Project oriented methodological practical courses

Bachelor's Thesis & Colloquium

Master of Sciences in Biology

Modules:

- Ecology of Terrestrial Systems
- Ecology of Limnic Systems
- Ecological Field Courses
- Environmental Analysis of Pollutants
- Environmental Chemistry of Pollutants
- Concepts of Ecotoxicology
- Methods of Ecotoxicology
- Soil Ecology

Additional Qualifications

Master's Thesis & Colloquium

Master of Sciences in Ecotoxicology

Compulsory Modules:

- Ecology of Limnic **or** Terrestrial Systems
- Environmental Analysis Pollutants **or** Environmental Chemistry of Pollutants
- Concepts of Ecotoxicology
- Methods of Ecotoxicology
- Regulatory Ecotoxicology
- Statistical and Mechanistic Modelling in Ecotoxicology **or** Modelling of Fate and Behaviour of Chemicals in Organisms and the Environment **or** Statistics in Ecotoxicology

Elective Modules:

- Ecology of Terrestrial Systems
- Ecology of Limnic Systems
- Environmental Analysis of Pollutants
- Environmental Chemistry of Pollutants
- Statistical and Mechanistic Modelling in Ecotoxicology
- Modelling of Fate and Behaviour of Chemicals in Organisms and the Environment
- Statistics in Ecotoxicology
- Soil Ecology
- Toxicology
- Sanitary Environmental Engineering and water Engineering
- Applied Geography
- Microorganisms
- Phytopathology
- Climatology and Hydrology

Master's Thesis & Colloquium

Research projects

iMulch (2019-2022)

Antonia Weltmeyer, Christoph Kämpfer, Thomas-Benjamin Seiler, Henner Hollert, Martina Roß-Nickoll

The iMulch project investigates the impact of polymers on the terrestrial ecosystem represented by mulch films which are applied in agricultural farming. The project is funded by the European Regional Development Fund (ERDF - or EFRE in German) and has a term of three years (01/2019-12/2022).

Project partners

- Institute for Energy and Environmental Technology e.V. (IUTA, Corrdination)
- Fischer GmbH
- Fraunhofer Institute for Molecular Biology and Applied Ecology (IME)
- Fraunhofer Institute for Environmental, Safety, and Energy Technology (UMSICHT)
- Institute for Applied Microbiology at the RWTH Aachen (iAMB)
- Institute for Environmental Research at the RWTH Aachen

Content

iMulch is structured in 6 work packages of which the Institute for Environmental Research coordinates the package 4 “Environmental behavior and effects”.

Research focus is set on ecotoxicological assessment of the mulch films themselves and emanating leaching products. Thereby not only commonly applied petroleum-based but also biobased mulch films are investigated.

Using representative organisms, such as the earthworms Lumbricus terrestris or Eisenia andreij and the collembolan Eisenia andreij, the main goal is to assess the influence of mulch films and their residues on terrestrial fauna. Moreover, we aim to estimate the potential synergistic effects between mulch film residues and pesticides, which might bind preferentially to plastic particles and then enhance bioavailability when taken up by animals (trojan-horse effect).

Next to the directly affected terrestrial ecosystem, leaching products of mulch films are especially interesting concerning their mechanistic effects which expands the necessary assessment area to aquatic systems. Aquatic species can be affected by leaching products and/or bound pesticides through various modes of action (MoA). MoA are substance specific functional or anatomical changes resulting from exposure of organisms. For animal health reasons, highly specific and sensitive in vitro assays have been development and are commonly used to assess MoA. Recommended effects-based tools are in vitro methods addressing specific MoA such as genotoxicity (mutagenicity, also leading to cancerogenicity), endocrine disruption, and activation of cellular defense mechanisms, e.g., dioxin-like acitivity (Brack et al. 2019), which are applied in this project. Possible inducers originating from plastics are plasticizers and stabilizers, which are partly already restricted through the European Chemical Agency (ECHA) because of their potential hazard and endocrine activity.

Due to the large discrepancy in plastics ecotoxicological research interest in aquatic and terrestrial ecosystems, potential effects on terrestrial organism are not completely understood to this day. Mulch films thereby only represent one single source of entry into the environment next to sewage sludge or fibers and particles transported via air and water.

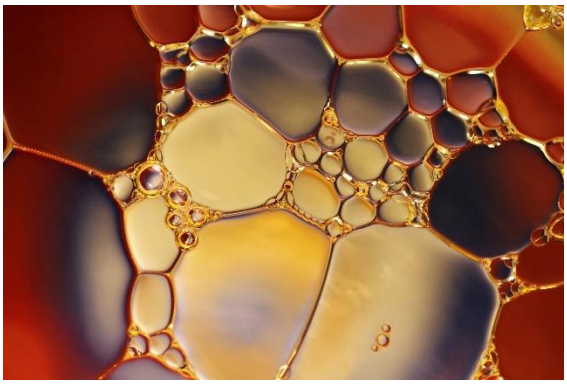
Thus the whole project will also try to cover up existing knowledge gaps concerning fate, behavior, degradation, methods of detection, etc., to develop an eco-balance and a holistic strategy of substitution for mulch films.

Sources

Brack, W., Ait-Aissa, S., Backhaus, T., Dulio, V., Escher, B.I., Faust, M., Hilscherova, K., Hollender, J., Hollert, H., Müller, C., Munthe, J., Posthuma, L., Seiler, T.-B., Slobodnik, J., Teodorovic, I., Tindall, A.J., De Aragão Umbuzeiro, G., Zhang, X., Altenburger, R. (2019):
Effect-based methods are key. The European Collaborative Project SOLUTIONS recommends integrating effect-based methods for diagnosis and monitoring of water quality Environ. Sci. Eur. 31, art. 10

Limitierung mikrobieller Degradation von Mitteldestillaten - Limiting microbial degradation of fuel distillates (2019 – 2022)

Felix Stibany, Paul Böhm, Andreas Schäffer



Description of the Project

The storage of fuel distillates such as oils bears the risk of microbial degradation, leading to fuel filter clogs and storage tank damages. The purpose of the project is to tackle this issue by limiting microbial growth. With regard to regulatory conformity (e.g. REACH), the focus lies on limitation through absence of degradable compounds, rather than the addition of biocides. Desired outcomes are a list of identified components that pose a risk of microbial activity in fuel distillates as well as a quick test for potential microbial degradation of middle distillates. The three partners involved in this project focus on:

1: The acquisition and characterization of investigated fuel oils and storage tank optimization (OWI Science for Fuels GmbH)

2: Microbial activity in different fuel oils under storage tank conditions (Institute of Applied Microbiology)

3: Identification of microbial activity promoting compounds using chemical analytical methods and development of a quick test for microbial activity in fuel oils under optimized growth condition by applying passive dosing (Institute for Environmental Research)

Activities in 2019

The project started in 11/2019 and experimental work will begin soon. Fuels will be tested for microbial activity by the iAMB and selected for either high or low activity. Selected fuels will then be further investigated by the Institute for Environmental Research by analytical methods and the development of a passive dosing based test system for microbial degradation. Fuel loaded polymers will be used to dose the fuel to the water phase and to measure the microbial activity. Samples from the storage tank conditions as well as the passive dosing experiments will be investigated via GCxGC-MS analysis. Optionally, passive sampling methods will be applied to accelerate analytical procedures. The analytical data will help to identify specific activity promoters and to characterize activity promoting substance classes.

Optimization strategies for microbial growth limitation will be developed hand in hand with the OWI and the iAMB to aid small and medium-sized enterprises.

Outlook

In case of successful identification of microbial growth promoting compounds, fuels can subsequently be optimized towards a better storability. Also a successfully developed quick test will help to promote accelerated fuel optimization and can be further developed towards a higher technology readiness level (TRL) from TRL 4 to 6 or 7.

Cooperation Partners

• OWI Science for Fuels gGmbH

• Institute of Applied Microbiology (iAMB), RWTH Aachen University

The project is part of the German Joint Industrial Research program (Industrielle Gemeinschaftsforschung, IGF) within the German Federation of Industrial Research Associations (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen, AiF), supported by the German Scientific Society for Oil, Gas and Coal (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V., DGMK). The program is funded by the German Federal Ministry for Economic Affairs and Energy.

Project management: Dr. Felix Stibany, MSc Paul Böhm, Prof. Dr. Andreas Schäffer

Nowelties (2019 - 2022)

Ana Paulina López Gordillo, Andreas Schäffer

Description of the Project

The primary objective of NOWELTIES is to organize a platform (European Joint Doctorate) that will provide cutting edge training opportunities for the education of tomorrow's water treatment experts. The core activity is the research programme (composed of 14 individual research projects) aimed at development of inventive water treatment technologies (advanced biological treatments, inovative oxidation processes, hybrid systems) that allow catering for the varied treatment demands for a plethora of interconnected streams arising from recycling loops.

In our sub-project the PhD student will develop polymer-based tools to measure and control the bioavailable dissolved concentrations of organic micropollutants during their biological treatment for better understanding the key factors limiting bioavailability and thus OMP removal by microorganisms. The focus will be on two aspects: (i) using passive sampling to measure changes in the bioavailable dissolved concentrations in analogous reactors to those used for the biological treatment in other sub-projects, and (ii) applying passive dosing to investigate whether there are threshold concentrations of OMPs that are required for induction of the catabolic pathways. By measuring the bioavailable dissolved concentrations, the role of factors influencing supply (e.g., chemical properties, matrix sorption) as well as removal (e.g., microbial growth in the presence of co-substrates) will be studied in order to identify bottlenecks in the biotransformation process. In addition, this data will be used as input into existing biodegradation models. By testing decreasing bioavailable dissolved concentrations, the hypothesis that there is a threshold concentration for OMPs biotransformation will be examined. Pollutant transformation will be examined at the cell level (i.e., enzyme activity) but also at the molecular level (i.e., protein and gene induction/repression).

Green Toxicology for a Green Bioeconomy (GreenToxiConomy) (2019 – 2021)

Christoph Kämpfer, Sarah Johann, Thomas-Benjamin Seiler, Sebastian Heger, Henner Hollert, Martina Roß-Nickoll

Description of the Project

Bioeconomy bears the potential to significantly reduce environmental pollution based on the integrated use of sustainable resources and processes. In this context, the toxicity of novel products is of uppermost importance. The integration of (eco)toxicological test systems in the development process of these novel compounds enables an early identification of potentially harmful effects, and, thus, the focus of the product development on less toxic products and production pathways without delay or financial losses. In this project, a substance-specific and exposure-based proof-of-concept "Green toxiclogy" strategy should be developed for the first time within the Bioeconomy Science Center (BioSC). Two different product categories, biosurfactants, (rhamnolipdies, mannosylerythritol lipids, ustilagic acid) as well as microgel-based pesticide release systems will be investigated. Both substance groups have a high probability to end up in the environment. Therefore, an assessment of their toxicity with regard to aquatic and terrestrial ecosystems by means of an ecotoxicological test battery adapted to their physico-chemical properties is very important. In addition to the toxicity testing, computational toxicity prediction tools will be used for an early prioritisation of compounds to be tested. Moreover, results on the product toxicity obtained within this project can be used for further applications, such as Life Cycle Assessments or socioeconomic studies.

Outlook

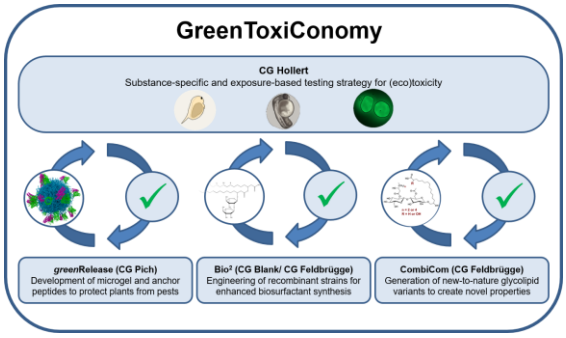
For the future it is planned to validate the expression rates and genes using qPCR.

Cooperation Partners

Institute of Applied Microbiology, RWTH Aachen University (Prof. Dr. Lars Blank, Dr. Till Tiso)

Institute for Microbiology, Heinrich-Heine University Düsseldorf (Prof. Dr. Michael Feldbrügge, Dr. Kerstin Schipper)

Institute of Technical and Macromolecular Chemistry, RWTH Aachen University and DWI - Leibniz Institute for Interactive Materials e.V. (Prof. Dr. Andrij Pich, Dr. Christian Bergs)



Searching for refiNed in vitro Approaches to Predict bioconcentration in FISH – SNAPFISH (CEFIC LRI-ECO47) (2019 – 2021)

Felix Stibany, Kilian Smith, Andreas Schäffer

Description of the Project

Chemical regulations require information as to whether a chemical is bioaccumulative. Steady-state bioconcentration factors (BCFs) in fish reflect the net result of the various chemical uptake versus loss processes, and can be determined directly (e.g., using OECD TG 305 for water-only exposure). However, this requires large numbers of animals and is also costly and labour-intensive. In the context of the Replace, Reduce and Refine targets (3Rs) for the use of animals in scientific research, alternative approaches to derive BCFs based on *in vitro* and/or *in silico* approaches are thus required.

One approach is the application of assays based on hepatocytes (HEP) or liver S9 fractions (S9) isolated from fish. The metabolic rates are then applied to estimate whole fish biotransformation losses as input to mass balance models describing fish bioaccumulation to predict steady-state BCFs (Nichols et al., 2013). This *in vitro – in vivo* extrapolation (IVIVE) has to account for the different amounts of metabolically active components (hepatocytes, microsomal protein or S9 material) in vitro and in vivo, along with differences in sorption in both cases. The equation that is commonly used in the context of BCF estimation originates from Obach (1996) and has first been used by Nichols et al. (2006). The applied BCF estimation scheme uses information on the actual hepatic metabolism kinetics in an organism as well as information about up-take kinetics and on other elimination kinetics such as excretion via the gills, urine or faeces.

However, the equation still requires further refinement to address existing experimental and IVIVE uncertainties and to provide more reliable BCF estimates especially for hydrophobic organic compounds (HOC), and avoid these BCF estimates to incorrectly exceed the associated regulatory thresholds.

This project has three main focus areas:

1) Further improve the reliability of measured HEP and S9 in vitro metabolic rates for HOC.

2) Determine how enzymatic turnover is impacted by differences in chemical availability between the media used in in vitro assays and liver blood.

3) Incorporate the above experimental information to improve existing IVIVE and other BCF prediction models.

Activities in 2019

The project has started in 09.2019 and the experimental work has started with the implementation of first liver S9 assays and the adaptation to passive dosing and passive sampling techniques.

Cooperation Partners

- Helmholtz Centre for Environmental Research (UFZ)
- University of Saskatoon (UofS)

The project was funded by the European Chemical Industry Council (CEFIC) within the long-research initiative (LRI) program.

Project management: Dr. Felix Stibany, Dr. Kilian Smith, Prof. Dr. Andreas Schäffer

Effects of fungicides on the degradation of pesticides in water-sediment systems (2018 - 2021)

Christiaan Wijntjes (PhD thesis), Andreas Schäffer

Description of the Project

The environmental risk assessment of pesticides is based on investigations of single substances or products. However, in the agricultural practice, due to spray series – in orchards up to about 20 times per season – and in tank mixtures, prepared by the farmer, multiple pesticides are applied on the crops. Due to spray drift, runoff, and drainage, pesticide residues will enter nearby surface waters.

An important process affecting the fate and behaviour of a pesticides is the degradation in the soil by bacteria and fungi. Data on the degradation of individual active substances and their transformation products in water-sediment systems are available from regulatory studies within the authorization process of pesticides. It is unknown how the degradation of pesticides in the water and sediment is affected by the presence of other active substances. If the tank mixture or spray series contains fungicides, this could lead to reduced degradation of the active substance considered, as soil fungi are involved in the degradation of natural and synthetic organic chemicals. Through the application of fungicides, the degradation half-life of an active substance may possibly be prolonged by inhibiting effects on the saprotrophic fungi. Overall, the active substance remains longer in the water-sediment system, which would have an impact on its persistence in the environment

Within the just started PhD project, it will be investigated whether the degradation of ^{14}C-labeled Iodosulfuron-methyl sodium is affected by the presence of the fungicides Tebuconazole and Prothioconazole in a water-sediment system.

Activities in 2016 – 2018

Since the PhD study just started, no activities can be reported at the present.

Outlook

As a first step, degradation experiments of the test substance alone and in combination with the fungicides will be investigated.

Cooperation Partners

IES Ltd – Innovative Environmental Services, Switzerland

Soil Amendment's Influence on Microbial Diversity, Pesticide Degradation and Leaching of Nutrients (SAMPL) (2018 – 2020)

Martin Siedt, Kilian Smith, Martina Roß-Nickoll, Andreas Schäffer and Joost van Dongen

Description of the Project

Soils have a key function in ecosystems as well as in agriculture. When aiming to secure biodiversity on the one hand and productive farming on the other, a sustainable soil management is inevitable.

Since an agricultural soil is the basis for the field's crop, any farmer should be interested in a soil that is long lasting, easy to manage, free from pollutants and has an efficient water and nutrient balance. Such a healthy soil directly contributes to protect the biodiversity of the surrounding environment. Leaching of excess nutrients and pesticides from field areas to adjacent ecosystems is a main thread to their integrity.

The interaction of soil organic matter and microbial community is the key to address this issue. Organic content is a structural and functional important part in soils. With its diverse molecular structure it is able to adsorb nutrient surpluses, pesticides and their metabolites, as well as pollutants like antibiotics from livestock. Furthermore, an increased organic content will enhance microbial growth. Their activity can improve nutrient cycling and the degradation of pesticides in soil. Being at the basis of the soil's food web, microbial growth can also promote higher soil organisms, which further contribute to soil functions on their own.

A higher organic content will also improve the soils structure and thereby optimize air- and water balance and reduce erosion. The increased nutrient content and enhanced soil functions can lead to a reduced need of pesticides and fertilizer, which can allow a sustainable management and protection of surrounding environment in the long-term.

Our aim is to investigate different organic amendments for soil on their influence on microbial biodiversity, pesticide degradation potential and nutrient leaching in an agricultural soil.

Activities in 2016 – 2018

Since the project started in November 2018, no activities are to be reported at the present.

Outlook

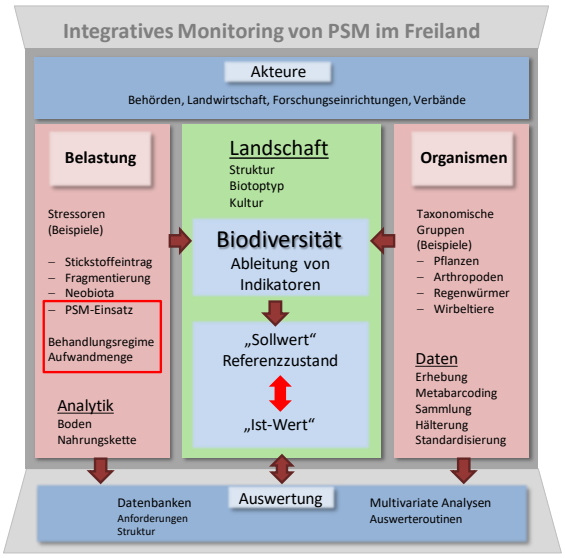
We will compare different organic amendments on the degradation of ^{14}C-labelled pesticides Metalaxyl and MCPA, which were used as a tank mix in a spray series on potato fields. These amendments will furthermore be applied to soil columns to compare their influence on the leaching of nutrients and pesticides. In addition to that, microbial communities of bacteria and fungi will be analysed via genome sequencing. In a third step, the most promising amendment will be tested under field conditions to assess the applicability of laboratory results to agricultural management.

Cooperation Partners

Federal Agency for Nature Conservation (BfN)

Integrated monitoring in agricultural landscapes in Germany - recording the ecological effects of chemical plant protection products (2018-2020)

Benjamin Daniels, Alexandra Sybertz, Andreas Schäffer, Martina Roß-Nickoll



Description of the Project

The project focuses on the research question: How can the entire effects of chemical plant protection products on biodiversity in agricultural landscape in Germany be assessed? For this objective, exposure monitoring of pesticides, ecological effect monitoring and monitoring of additional influencing factors (stressors like soil tillage and structural fragmentation) must be combined within an integrated approach. Our approach is structured in a three-step process:

1. analysis of existing surveys and monitoring activities with regard to objectives, scope, compatibility and quality

2. development of a target-oriented combination of already existing monitoring projects with new modules to be developed

3. financial and practical implementation of the developed monitoring concept.

Activities in 2018

The project has started in May 2018. A literature review was conducted to find existing monitoring approaches in agricultural landscapes. In the course of this process, potential stakeholders such as authorities, state and federal ministries as well as non-governmental environmental associations and organizations were identified.

Based on these findings, the framework of an integrated monitoring concept was developed. The approach is based on a modular assessment of the condition of three main components: the landscape structure, biodiversity at different aggregation levels and the pesticide load of a site. These factors have to be monitored spatially and temporally coordinated. The approach is to be implemented on national representative sampling areas (“bundesweit repräsentative Stichprobenflächen”) throughout Germany.

Outlook

The conceptual approach to integrate the monitoring of plant protection products in agricultural landscapes will be elaborated in detail during the next period of the project. The practical implementation as well as the financial requirements of this monitoring concept are to be determined. In a subsequent step, the approach will be communicated to and discussed with potential stakeholders in further workshops, conferences and publications.

Cooperation Partners

gaiac, Forschungsinstitut für Ökosystem-analyse und –bewertung, Aachen, Germany.

German Environment Agency, Dessau-Roßlau, Germany.

Effects of fungicides on the degradation of ^{14}C-MCPA in soil and Impact on the Soil Fungal Community (FUNgi) (2018 - 2021)

Kim Thu Nguyen (PhD thesis); Andreas Schäffer, Joost van Dongen, Kilian Smith

Description of the Project

To date, the risk assessment of plant protection products (PPP) is essentially an individual substance assessment based on toxicological and environmental information on the respective active substance and a representative PPP formulation for selected example applications. Binding guidelines for the regulation of mixtures are still lacking, although organisms are exposed to a variety of heterogeneous, potentially toxic substances within their habitat due to common agricultural practice.

An important process affecting the fate and behaviour of a PPP is the biodegradation in the soil by micro-organisms (bacteria, fungi, protozoa, etc.). Data on the degradation of individual active substances and their transformation products in soil are available, as they are collected within the framework of the Regulation (EC) No 1107/2009 concerning the placing of PPP on the market and the German Plant Protection Act (PflSchG). However, PPP tank mixtures or spray series in a growing season may cause different active ingredients to be present in the soil at the same time. In general, it is not known to what extent the degradation of a pesticide in the soil is affected by the presence of other active substances. If the tank mixture or spray series contains fungicides, this could lead to reduced degradation of the active substance considered, as soil fungi are involved in the degradation of natural and synthetic organic chemicals. Through the application of fungicides, the degradation half-life of an active substance may possibly be prolonged by inhibiting effects on the saprotrophic fungi. Overall, the active substance remains longer in the soil, which would have an impact on its persistence in the environment.

Accordingly, the (tank) mixture to be expected in the environment after application is decisive for the assessment of the environmental effects. The cited discrepancy between the currently isolated view of active substances on the one hand and the agriculture practice on the other poses a major challenge to authorities, research and industry. All in all, the question arises as to whether and to what extent the current regulatory review ensures the legally required level of protection.

Within the present PhD project, it will therefore be investigated in different scenarios whether

I) the degradation of 14C-labeled 2-methyl-4-chlorophenoxyacetic acid [14C-MCPA, herbicide] is affected by the presence of methyl N-(methoxyacetyl)-N-(2,6-xylyl)-D-alaninate [metalaxyl-M, fungicide] and manganese ethylenebis(dithiocarbamate) (polymeric) complex with zinc salt [mancozeb, fungicide] and

II) to what extent the soil fungi are involved in the degradation of 14C-MPCA and which impacts the fungicides will have on the soil fungal community profile.

Activities in 2016 – 2018

Since the PhD study just started, no activities can be reported at the present.

Outlook

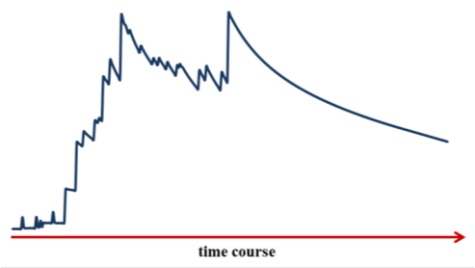
As a first step, degradation experiments of MCPA alone and in combination with fungicides will be investigated. Subsequently, microbiological studies will be performed to have a look at the response of fungal communities on the fungicide treatment.

Funding

RWTH Scholarships for Doctoral Students According to the Guidelines for the Promotion of Young Researchers at RWTH Aachen

Umweltrisiken von PSM zwischen Prognose und Realität: Wie belastbar sind Ergebnisse der ökotoxikologischen Risikobewertung zum einzelnen Mittel vor dem Hintergrund der üblichen Anwendungspraxis (Tankmischungen, Spritzserien) im Hinblick auf Wirkungsmodelle? (from 2018)

Alexandra Sybertz (PhD thesis), Martina Roß-Nickoll, Richard Ottermanns



Description of the Project

The increased application of pesticides in the agricultural landscape results in mixtures within the soil. Pesticide combinations are released into the environment in various ways. When applying pesticides by spraying, the active substances can be released into the environment using several substances in one tank, a so-called tank mixture, or a combination product. A further source for mixtures is the so-called spray series, which are several sprays in chronological order in the course of a year. Delayed degradation allows the substances to remain in the environment for longer periods of time. Due to the constantly varying number of authorised pesticides, it is difficult to estimate their impact on biological communities in the agricultural landscape.

A model will be developed to improve prediction of the direct and indirect effects of pesticide mixtures in the agricultural landscape. This model is supposed to consider the effects of pesticides on populations or biological communities.

Finally, the developed model should be able to estimate the effects of intensive agriculture for relevant spray series on the living environment based on existing knowledge.

Outlook

A model for modelling time-dependent exposure to pesticides in soil is already developed. In the next steps models and model approaches have to be detected in order to derive a time-dependent effect from the time-dependent exposure. Following the literature search, the model approaches will be applied to evaluate the possibility of a linkage between the approaches and the time-dependent exposure.

Cooperation Partners

The PhD thesis is supported by a scholarship of the “RWTH-Graduiertenförderung”.

Dream Ressource (2017 – 2020)

Predicting long-term tree growth change by integrating regeneration, mortality modules and specific managements into tree growth simulator

Carina Lackmann (MSc Thesis), Jake Ouellet, Sarah Crawford,
Henner Hollert, Thomas-Benjamin Seiler

Description of the Project

The overall aim of the project is to improve physical, chemical and environmental properties of surfactants by including carbon dioxide (CO_2) as an alternative building block. This should be achieved for high-volume applications such as reactive polyols (e.g. hard foam) or surface-active substances (e.g. dispersants or non-ionic surfactants) by expanding the propylene oxide/CO_2-technology to ethylene oxide/CO_2-technology. Investigations of the new substances hence include not only checking the physical and chemical properties, but also determining their ecotoxicological potential.

Activities in 2016 – 2018

The project started in 2017 with the expansion of the propylene oxide/CO2-technology to ethylene oxide/CO2 technology. After various polymers could be produced using this technology their chemical properties were checked to select the most promising compounds. During the summer of 2017 first samples of surface active substances were ready to be investigated regarding their ecotoxicological properties. The potential biodegradation of these newly synthesized compounds was compared to structurally similar commercially available reference compounds. Overall, two new polymers and two references were assessed according to the OECD guideline 301 F (manometric respirometry). The results showed that unlike the commercially available references the newly synthesized compounds are readily biodegradable. After further improvements slightly modified compounds were used for further ecotoxicological assessments. For assessments of aquatic toxicity three different trophic levels were investigated with the algae inhibition-, daphnia immobilization- and fish embryo toxicity test (FET).

The results of the FET and algae inhibition test showed that one of the newly synthesized compounds is significantly less toxic than the reference compounds. The daphnia immobilization tests are not completed yet but the tendencies during the range findings show the same as the other two aquatic test systems. Furthermore, assessments of endocrine activity and QSAR-modelling for mutagenicity were conducted. No endocrine activity using the ERα CALUX assay was detected for sublethal concentrations for any of the surfactants, indicating that their structures do not allow them to bind to the estrogen receptor.

Outlook

Further assessments will include tests for mutagenicity, as the QSAR-modelling was deemed an inconclusive tool for the investigation due to inadequate data sets. Furthermore, increased concentrations of the catalyst will be tested to exclude any toxicity coming from the catalyst which remains in the final product due to cost effectiveness. An investigation of the toxicity of possible metabolites is also envisaged to further investigate these substances.

Cooperation Partners

Covestro Deutschland AG
CAT Catalytic Center RWTH
LTT Chair of Technical Thermodynamics RWTH
Puren GmbH
PSS Polymer Standards Service GmbH
BYK-Chemie GmbH
Associated partner: F.S. Fehrer Automotive GmbH

ARAMOB - Semantic enrichment and mobilization of data in distributed repositories for taxonomy and ecology: Solving a Gordian knot in the taxonomy of neotropical jumping spiders and trait-based ecological habitat assessment with spider assemblages (2017 – 2020)

Alexander Bach, Richard Ottermanns, Martina Roß-Nickoll

Description of the Project

The aim of this DFG-funded project is to provide a database that gathered available digital and analogue information on spiders (Araneae) in Germany.
In the course of data selection and processing for evaluation, distributed digital information on spiders in Germany from different repositories will be brought together for the first time and a concept for the processing and semantic enrichment of "old data" from collections and ecological research projects will be developed. Through the definition of standards and the provision of hierarchical lists (biotope types, natural areas, forms of use, strata) including synonyms as well as corresponding tools for annotation and scaling of measurement data, data can be permanently used across studies. Tools and workflows are also suitable or transferable for processing other taxa. The analysis of a large database of spider species from Germany from different data sources (collections, unpublished studies, literature) provides trait-based associations of species with habitats (habitat preferences/checklists) and land use forms. Using the biomass of spiders, the environmental capacity of different habitat types can be calculated and used for their assessment. Site-specific biocoenoses are defined and the relationships between niche realisation and habitats are analysed using specially developed evaluation tools.

Activities in 2016 – 2018

One of the main aspects in the years 2017 and 2018 was the digitalisation and the enrichment of spider data from different sources. All together the ARAMOB database includes about 420 species with 195.000 individuals from 220 sites all over Germany. Every site is geotagged and ecological characterised.

Outlook

The main goal of the last project year is to develop and establish different evaluation tools for different research questions. In detail a tool for calculating ecological niches of spider species related to shading and moisture is in progress and also the automatic determination of reference communities for special habitat types.

Cooperation Partners

Staatliches Museum für Naturkunde Karlruhe

Staatliches Museum für Naturkunde Stuttgart

Staatliche Naturwissenschaftliche Sammlungen Bayerns

Investigation on ecology and diversity of prominent pollinator groups (Hymenoptera; Apiformes, Diptera; Syrphidae) in different habitat and surroundings qualities in the city and agricultural land of Aachen (2017-2020)

Jana Jedamski (PhD thesis), Martina Roß-Nickoll, Benjamin Daniels

Description of the Project

In this project we want to evaluate the species richness and composition of the two most important pollinator groups of wild bees and hoverflies in different qualities of habitats in the city of Aachen and the surrounding agricultural land.

Bees depending on pollen and nectar of flowering plants their whole life cycle, in contrast, hoverflies only during stage of imago. But both of them needs nesting and oviposition habitats, material therefor - products like loam and plants leafs - and nutrition sources in terms of pollen and nectar – many species even in a very specialized manner.

In general, insect pollinators in temperate latitudes require rich-structured and flower-rich open-country habitats. But due to intensification of agriculture, densification of cities and overall land consumption, more than 50% of wild bees and one third of hoverflies are severely threatened in existence. Neglect of the high nature value of species-rich grasslands, extensive field use and pesticide-free areas, lead to majority of flowering herbs as food ressources for insects at risk.

In different areas of agricultural land and greenspaces in cities such negative effects are diverge to a different degree. Beneficial outcomes are supposed by organic farming, richly-structured environment and minimal management of open grassland.

To evaluate the shift in species richness and assemblages in different habitat and surrounding qualities – and obtain knowledge about underlying factors – will be the task of this issue.

Activities in 2016 – 2018

In latter half of 2017 the main task was to find out what is the best method for looking for pollinators in the field in a standardized way. We decided to take a combination of a passive and an active component: catching by blossom-dummies (coloured pan traps) and transect walks with net. Second task was to define experimental sites of field margins and grasslands in agricultural land and greenspaces in the city of Aachen with varieties of ecological quality.

April to September 2018 field margins and grasslands in the agrarian landscape were sampled concerning wild bees, hoverflies and flowering herbs, shrubs and trees along the sampled transects. In 2019 the goal will be, to assess different qualities of urban greenspaces concerning their pollinator and flower potential in the same way.

Outlook

For future outcomes, we want to establish a concept for quality of green infrastructure in agricultural and urban environment to support pollinator habitats. In general it might be necessary to come over an tidy and clean landscape towards structures and species-rich ones with near-natural management.

Regarding this, in January 2019 we submit a project proposal at Bundesamt für Naturschutz (BfN) for the restoration and establishment of natural Tall-Oat-Grass-meadows on intensive lawn fragments in the city and the agricultural land of Aachen. Such species-rich meadows were classical part of our mid-european cultural landscape, until the agricultural sector became industrialized. Today, meadows are very threatened in their extent, similar to their inhabitants, like plants, insects and birds.

By the case, the project became accepted, a second task would be to evaluate, in how far an ecological enhancement of status quo would promote plants, pollinators and predators.

Cooperation Partners

Currently we cooperate closely with the administrative and the executive sections of the green management department of Stadt Aachen and different stakeholders concerning the establishment of near-natural grassland management in Stadt und Städteregion Aachen.

Forschungskolleg ACCESS! Mobility of the future (2016-2020)

Investigating the fate of traffic derived pollutants in urban streets: The impacts of urban vegetation on contaminant loads in surface runoff

Hanna Fuchte, Natascha Beck, Eva Germann, Kilian Smith, Andreas Schäffer

Description of the Project

Forschungskolleg ACCESS! is an interdisciplinary cooperation between eleven research groups of RWTH Aachen University. It aims to answer the question how mobility systems in the future will look like, taking into consideration new developments in infrastructure and technology, mobility needs, societal claims, and global environmental objectives. The concepts and tools developed in the project are to be tested within two practical projects, situated in Kreis Heinsberg (rural) as well as the Metropole Ruhr (urban).

The task of our sub-project is to investigate how mobility systems impact the amounts and types of contaminants, entering the environment, and if there are practical options to reduce these. One possible factor influencing the mass flows of such traffic-related pollutants could be urban vegetation such as parks, gardens and roadside greenery. To investigate this, pollutant mass fluxes in deposition and surface run-off samples are determined in relation to the types and size of the green areas adjacent to the roads. We have focused on organic “marker” pollutants with a wide range of physical-chemical properties, thus allowing for extrapolation to future traffic pollutants.

Activities in 2016 – 2018

To get an overall impression of the pollutant mass fluxes in urban streets, methods have been developed for sampling the organic “marker” pollutants in several compartments

For the freely dissolved fraction in surface runoff passive samplers made of silicone have been chosen and a new calibration approach developed and tested in laboratory and field. Sediment traps that fit in street drains have been constructed to catch the particulate matter in the street runoff and to serve as a water reservoir for installation of the passive samplers. In addition, a method to fractionate and analyse particulate matter on plant leaves has been optimized.

In September 2018 all methods were pretested simultaneously during a sampling campaign on the inner ring road in Aachen, Germany.

Outlook

The main study will be performed in the project region ‘Metropole Ruhr’ in 2019. Methods will be applied along a partly greened high traffic road in Essen at different timepoints throughout the year. Additionally, an interdisciplinary study is planned comparing the intake of pollutants by cyclists on varying routes. Overall, inferences shall be made as the possible impacts of urban green on mobility emissions and how its potential can be better exploited in the future.

Cooperation Partners

<u>interdisciplinary:</u>
ISA Institute for sanitary environmental engineering, RWTH
GDI Gender and Diversity in Engineering, RWTH

<u>transdisciplinary:</u>
adfc Allgemeiner Deutscher Fahrrad-Club e. V.
STAWAG Stadtwerke Aachen Aktiengesellschaft

<u>funded by</u>:
Ministry of Innovation, Higher Education and Research of North Rhine-Westphalia

NANO-Transfer: Trophic transfer and toxicity of carbonaceous nanomaterials in the aquatic environment (2016-2019)

Irina Politowski, Michael Patrick Hennig, Hanna Maja Maes,
Henner Hollert, Andreas Schäffer

Description of the Project

The increasing number of plastic products containing carbonaecous manufactured nanomaterials (C-MNMs), like multiwalled carbon nanotubes (MWCNT) or fullerenes (C_{60}) leads to their potential release in the aquatic environment, mostly after disposal and subsequent environmental degradation. These released C-MNMs are bioavailable for pelagic and benthic organisms. After C-MNMs enter the environment and aquatic biota are exposed to them, there is only little known concerning the environmental fate, chronic effects, bioaccumulation and food web transfer of these nanomaterials in all trophic levels. The information on the influence of C-MNMs on the toxicity of other hydrophobic organic contaminants (HOC) is very scarce as well. Based on their carbonaceous nature and their low environmental concentrations the detection of MWCNT and fullerenes in environmental media (water, soil and sediment) is complex.

The ERA-NET SIINN project NANO-Transfer is divided in 7 work packages (WP). WP0 coordinates the project. In WP1 the fate and distribution of irradiated C-MNMs in environmental media is examined. WP2 and WP3 adress the bioaccumulation and the chronic effects of altered C-MNMs in different aquatic organisms. The food web transfer of C-MNMs is further considered in WP4. As C-MNMs might act as sorbents for hydrophobic organic compounds (HOC), in WP5 the adsorption of two model chemicals, bisphenol A (BPA) and triclocarban (TCC) is investigated. Moreover, the 'trojan horse effect' on several organisms (algae, daphnids, fish) is analysed. In WP6 the dissemination of obtained data is organized.

NANO-Transfer

Activities in 2016 – 2018

Within the second year of NANO-Transfer many results concerning the environmental fate, bioaccumulation and effects on primary producers and primary consumers were obtained. For instance, the distribution of irradiated ^{14}C-MWCNT in a sediment-water system was determined. The time, where 50% of applied radioactivity (AR) dissipated from water (DT_{50}) was calculated at 5 to 6 d; 85% of AR was found in sediment and only 0.06% of AR mineralized after 180 d. Furthermore, the bioaccumulation of irradiated ^{14}C-MWCNT in two green algae (*Pseudokirchneriella subcapitata* and *Chlamydomonas reinhardtii*) was examined with a log BCF (96 h) of 3.3 and 3.9, respectively. It must be considered, that uptake of radioactivity is more accurately described by an interaction and association of ^{14}C-MWCNT with algae cells, than simply by bioconcentration. For fullerenes, no chronic toxicity was measured in river biofilms after exposure with 1µg/L. The combined toxicity of 1 µg/L fullerenes and different concentrations of HOC (50 µg/L venfafaxine, 10 µg/L diuron and triclosan) on river biofilms revealed a modified toxicity and a significatnly reduced bioaccumulation of these chemicals due to an altered bioavailability. First results show, that in mesocosm experiments fullerenes reduced the toxicity of TCC on *Daphnia magna*.

Outlook

In the third year, the project will focus on more aquatic invertebrates (snails, blackworms, mayflys) and vertebrates (fish). As the combined toxicity of HOC and C-MNMs on biota is not well understood, it is inevitable to explain the adsorption behaviour of HOC, like BPA on C-MNMs. Especially, the biomagnification of C-MNMs in different aquatic food webs and the combined effects of C-MNMs and BPA on fish will be more thoroughly examined in the last year of the project.

Cooperation Partners

funded by: Bundesministerium für Bildung und Forschung (BMBF) under agreement with the FP7 ERA-NET SIINN

Partners: Technical University of Dresden, Politehnica University of Bucharest, Spanish Council for Scientific Research, Research Institute for Ecosystem Analysis and Assessment gaiac, Catalan Institute for Water Research

GRACE (2016 – 2019)

Integrated Oil Spill Response Actions and Environmental Effects

Sarah Johann, Leonie Nüßer, Henner Hollert, Thomas-B. Seiler

Description of the Project

The overall objectives of GRACE are to explore the true environmental impacts and benefits of a suite of marine oil spill response technologies in the cold climate and ice-infested areas in the northern Atlantic Ocean and the Baltic Sea. The main contribution to GRACE carried out at RWTH Aachen University is the development of a novel biosensor for oil spill detection that is based on the behavioral response of zebrafish embryos and the determination of impacts of oil and dispersant on biota using effect-based tools and environmental risk assessment. We aim to assess in particular the impacts on fish of naturally and chemically dispersed oil, in situ burning residues and non-collected oil using highly sensitive biomarker methods, and to develop specific methods for the rapid detection of the effects of oil pollution on biota.

Activities in 2016 – 2018

It was determined that the application of zebrafish embryo swimming behaviour as a biosensor on the Baltic Sea is not limited by the salinity and that salinity tolerance is sufficient to assess oil toxicity in Baltic Sea water conditions in the Fish Embryo Toxicity Tests (zFET). However, temperature conditions cannot be changed towards the temperatures that are relevant for the study regions of the GRACE project. A prototype for a novel biowellplate (BWP) for the incubation of zebrafish embryos under flow-through conditions in a multiwell plate format was developed in cooperation with Syntecnos Screening Technologies BV. In a first proof of concept study the functionality of the system under permanent operation and its application as biosensor was tested.

Cytotoxicity, genotoxicity, mutagenicity, endocrine activity, dioxin-like activity and oxidative stress of the crude oil and dispersed crude oil were assessed in a battery of in vitro bioassays. Effects on whole organisms were tested in vivo in an adult zebrafish study in cooperation with the University of the Basque Country. Results of toxicity profiling experiments utilizing zebrafish embryos found that the dispersant Finasol OSR 51 alone, oil in the low energy water accommodated fraction (LEWAF) and oil in the chemically dispersed WAF (CEWAF) induced a concentration dependent increase of lethal and sub-lethal effects with increasing exposure concentrations. A concentration response relation was also found for the EROD and acetylcholinesterase activity in zebrafish embryos. The results from a whole transcriptome analysis of zebrafish embryos exposed to LEWAF and CEWAF showed that multiple genes associated with the development of the eye and lens were regulated.

In 2017 a medaka (Oryzias melastigma) husbandry was established at RWTH Aachen University. Medaka embryos will be used in an adapted FET in order to confirm results from the zFET in an organism with high relevance to the marine environment.

Outlook

Once validated in laboratory experiments, the BWP will be implemented on a ferry boat and used for a proof of concept study monitoring the water conditions of the Baltic sea in real-time.

The gene analysis is ongoing and results will be used to focus subsequent experiments using mechanism-specific bioassays and biomarkers.

Cooperation Partners

Finnish Environment Institute, Finland (coordinator)
Aarhus University, Denmark
University of Tartu, Estonia
Tallinn University of Technology, Estonia
University of the Basque Country, Spain
Norwegian University of Science and Technology, Norway
Norut Narvik, Norway
Greenland Oil Spill Response A/S, Greenland
SSPA Sweden AB, Sweden
University of Manitoba, Canada
Lamor Corporation Ab, Finland
Meritaito Oy, Finland

OECD - Necessary adaptations of harmonised testing and risk assessment for earthworms (terrestrial) (2016-2019)

Benjamin Daniels, Richard Ottermanns, Martina Roß-Nickoll

Description of the Project

The project aims to optimize the standardized design of the Earthworm Field Test procedure, which was formerly an ISO guideline (ISO 11268-3, 2014) and is now to be revised to an OECD standard.

In the past, the most important aim of earthworm field studies was to assess if the test substance at intended field rates has any long-lasting effects on earthworm populations. Therefore, the evaluation of effects was mainly based on the results of the last sampling date (i.e. 12 months after application of the test substance). The adapted OECD-guideline should improve the informative value of the field test in case of tested endpoints and statistical power of the test design.

Activities in 2016 – 2018

Based on the results of a literature review and the statistical analyses of an earthworm field-test database provided by the German Environment agency, a pilot earthworm field study was conducted in order to practically test the applicability and statistical strength of an adapted test design.

The pilot study consists of a design that enables to calculate no-observed effect concentration (NOEC) with a higher statistical power than the former test design. Moreover, a derivation of effect level (ECx-calculation) is provided by the new test approach.

We calculated the minimum detectable differences (MDD) of the new test design in comparison to former approaches, tested alternative statistical procedures to identify NOEC (CPCAT), conducted a curve-regression for dose-response testing with all identified earthworm species and a sample size calculation to find a preferable test design that is practically feasible and meet the statistical requirements.

Outlook

The statistical analyses and conclusions towards a sound earthworm field test design will be published in international journals. An adapted test guideline for OECD standardized testing of earthworms will be established presented and elucidated in OECD committees in order to publish the OECD guideline in near future.

Cooperation Partners

ECT Oekotoxikologie GmbH, Flörsheim, Germany.

German Environment Agency, Dessau-Roßlau, Germany.

Reference

ISO (International Organization for Standardization) (2014): Soil quality – Effects of pollutants on earthworms - Part 3: Guidance on the determination of effects in field situations. ISO 11268-3. Geneva, Switzerland.

Modellierung des Waldeswachstums unter verschiedenen Managementvarianten (2016-2018)

Predicting long-term tree growth change by integrating regeneration, mortality modules and specific managements into tree growth simulator

Jaegyun Byun, Martina Roß-Nickoll, Richard Ottermanns

Description of the Project

This project is concerned mainly with constructing new tree growth model to predict long-term beech (*Fagus sylvatica*) tree growth change in Eifel region (Western Germany). Typically, tree growth models consist of diameter-growth, height-growth and mortality equations and they predict tree growth in the near and distant future. The forests in Eifel region are mainly managed with three different strategies such as conventional (Bk), near-natural (Bn) and reserved (Bt) management. Thus, new tree growth model is need to be developed to apply local forest management strategies. Also, model will reflect expert-knowledge from local forester and allow consistent simulation output for long-term period. Using the developed model, it is attempted to define management effect on tree growth. In this project, we considered three components into new tree growth model: (1) seedlings regeneration, (2) SILVA growth model, and (3) mortality adjustment. We will finally develop a new model by adding modules complementary to existing model.

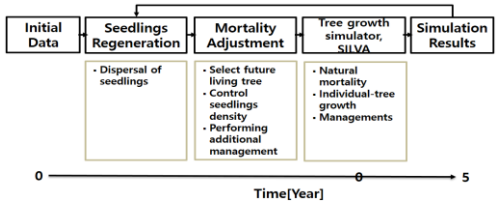
Activities in 2016 – 2018

Various forest growth models were explored to find suitable model individual-based for the long-term simulation. There are three representative forest growth models FORMIND, TREEMIG, SILVA. Among these, SILVA growth model was selected to calculated tree growth because it showed single-tree-based and position-dependent approach with management options. SILVA growth model allowed to simulate long-term tree growth under different management strategies, however, regeneration process was omitted and unexpected tree death was occurred during simulation. Thus, SILVA growth model was decided to use only for each tree growth calculation over 1 period (5 years) as one module. And seedlings regeneration module and mortality adjustment module were developed to complete new tree growth model. In order to run these three modules as one, we had designated a model structure using an automation tool called a wrapper function. Each module was consisted of several parameters and the result varied sensitively depending on the value of parameters. In the seedlings regeneration module, try and error method was repeatedly performed to find realistic seedlings distribution by changing initial number of seedlings and distribution function.

In the mortality adjustment module, unexpected tree death was prevented by selecting trees under various conditions of combination of distance between the trees and the size of the trees. Try and error method was also performed to define proper threshold of parameters. And all the modules were merged through wrapper approach and initial tree growth were simulated over a given time with 5 years' interval. Simulation results were compared with expert-knowledge and parameters of each module were repeatedly calibrated to reach optimal stem volume. In the beginning, it took over 12 hours for getting growth simulation result of 100 years. There were many errors from wrapper function, SILVA growth model, and additional modules as well as parameter calibration during the simulation. So it took a lot of time to construct and decide final parameters and simulation process. For the validation, we used actual tree growth data for 20 years provided by ICP to compare and verify model results. In addition, long-term tree growth was compared using tree information of three different stands in Eifel region that was not used for the model calibration. We have tried various interpretations in terms of the ecological point of view from the simulation results. We compared the growth dynamics with stem volume, basal area, and number of trees. It was also interpreted and discussed about various results such as dbh-height relationship, tree age-dbh, management type-stem volume, and basal area-height heterogeneity.

Outlook

The benefit of this study is that model structure is simply constructed, not a model that only I can understand. This simple structure is advantageous for adding modules freely or modifying existing modules through more abundant literature or expert-knowledge. Also it can provide quantifying prediction on concrete tree growth change under different managements. This model construction is an intuitive study methods and results; thus the model still needs to include qualitative as well as quantitative examination. Therefore, it is necessary to submit a paper to verify and discuss with other expert. Then, using the simulation results, it will be possible to conduct an in-depth analysis of forest management strategies effect. It will also be able to be continuously calibrated for a better model structure.



PBT-assessment of ionic compounds (2015-2019)

Hannah Holzmann (PhD thesis), Burkhard Schmidt, Kilian Smith,
Andreas Schäffer

Description of the Project

For the protection of humans and the environment, the identification and regulation of chemicals with persistent (P), bioaccumulative (B) and toxic (T) properties are central elements within the environmental risk assessment. The criteria for the identification of PBT substances under the REACH regulation (Registration, Evaluation and Authorization of Chemicals) and the guidance for the PBT-assessment have been developed for neutral organic compounds. However, nearly 50 % of the chemicals pre-registered at the European Chemicals Agency (ECHA) are partly or completely ionised under environmental pH conditions (Franco et al. 2010). Since the chemical charge of organic substances strongly influences their properties and environmental behaviour, the currently valid concept under REACH does not allow a sufficient assessment of ionic or ionisable substances.

The objective of the project is to refine the persistence assessment of ionic and ionisable substances. Therefore, simulation tests following OECD guidelines are performed using different types of environmental compartments: Aerobic and Anaerobic Transformation in Aquatic Sediment Systems (OECD 308) and Aerobic Mineralisation in Surface Water (OECD 309). As test substances serve three ^{14}C-radiolabelled chemicals, which solely differ in the charge of their head groups; all three molecules contain a dodecylphenyl moiety as core structure. Based on this choice, it is possible to investigate the influence of a chemical charge on the degradation behaviour of organic chemicals in the environment.

Activities in 2016 – 2018

Sediment and surface water were collected from a rainwater retention basin in Aachen, Germany.

Preliminary tests were conducted to optimise the experimental setup and establish incubation periods. Main studies according to OECD 308 and 309 were performed using all three test substances. Mineralization and formation of non-extractable residues were investigated and compared. Metabolism of the model substances is currently being investigated.

Outlook

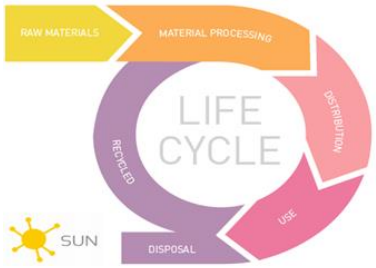
Based on the experimental data, the persistence assessment of ionic and ionisable chemicals will be refined.

Cooperation Partners

German Federal Environment Agency (Umweltbundesamt – UBA)

Sun (2016 - 2018)

Stefan Rhiem, Hanna Maes, Andreas Schäffer



Description of the Project

The EU-FP7-project SUN aimed at investigating and assessing risks of manufactured nanomaterials (MNMs) during their whole life cycle (production, supply, use, and disposal). 35 partners from 12 EU countries participated in this project (www.sun-fp7.eu). The partners developed 1) methods to predict exposure of human and the environment, to quantify effects, and to finally assess the risks of MNMs; 2) tools to support industrial and regulatory decisions, especially regarding safe production, use, and disposal of MNMs; 3) technological solutions for risk management of MNMs within the industry, regarding the environment, and for consumers. We were involved in the work package Environmental Release, Fate & Exposure and investigated the release of carbon nanotubes (CNTs) from composites after disposal due to weathering. Radiolabelled CNTs (^{14}C-CNTs) were embedded in polycarbonate (PC) and polypropylene (PP) composites, and epoxy resin products. The composites were then subjected to simulated sunlight radiation and incubated in several environmental media (soil, sediment, salt and fresh water) to measure the amount of released radioactivity and to mimick disposal site conditions, i.e., shaking in water, rapid temperature changes, soaking in humic acid solution as well as waste water effluent, and, finally, gentle mechanical abrasion. All ageing impacts were applied sequentially, both on pristine (control) and on solar-irradiated nanocomposites. All experiments were accompanied by absolute quantification of radioactive release as well as chemical and morphological analyses of the nanocomposite surfaces using infra-red (IR) spectroscopy, X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM).

The morphological analysis showed that spectral irradiation can uncover CNT networks on the outer nanocomposite surface layers by polymer degradation. After having subjected the solar-irradiated nanocomposite to all studied disposal site effect, the total radioactive release was quantified and was found to be much higher than in the non-irradiated samples (80 times). Solar degradation of polymers was thus found to significantly increase the propensity of the studied polymer nanocomposites to release CNTs during ageing effects at the product's end-of-life typical for disposal sites.

Activities in 2016 – 2018

Several papers have been published on the release experiments.

Outlook

The PhD student finished and started his work in an environmental agency. Also the postdoctoral fellow found a job and now works as a teacher.

Cooperation Partners

Partners of the EU consortium (http://www.sun-fp7.eu/)

RABIT - Environmental risk assessment of poorly soluble substances: Improved tools for assessing biodegradation, (de)sorption, and modelling (CEFIC LRI-ECO32) (2016 – 2018)

Felix Stibany, Kilian Smith, Andreas Schäffer

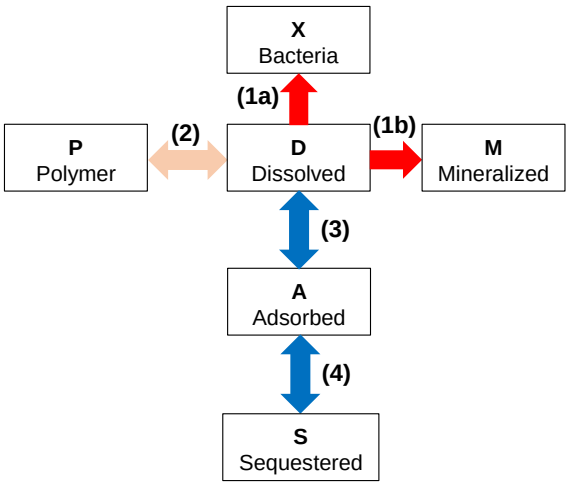
Description of the Project

Hydrophobic organic chemicals (HOC) with an extremely low aqueous solubility in the range of a few µg/L are used in a broad range of applications. However, environmental risk assessment is by no means straightforward for this group of chemicals. Extremely low dissolved concentrations and a huge potential for sorption to any kind of surface complicate experimental investigations. In the case of biodegradability assessment according to standard guidelines the behavior of HOC can lead to the measurement of desorption limited half-lives rather than their inherent degradability. The main objectives of the project were:

- The measurement of aqueous phase biodegradation kinetics of HOC without the influence of bioavailability factors, i.e., without (de)sorption effects.

- The reliable assessment of desorption rates of HOC from soils, sediments and/or WTP sludge over time.

- The fusion of both, biodegradation and (de)sorption, in one model and the application of this model to differentiate between (de)sorption and biodegradation in standard tests.



Activities in 2016 – 2018

This project has represented a first attempt of using novel test setups and a unified modelling approach for predicting reliable biodegradation of HOCs. The main conclusions were the following:

- Passive dosing and passive sampling strategies can be successfully applied to OECD based biodegradation tests (e.g., OECD 309) and abiotic desorption tests.

- Evaluating the biodegradation of HOC is possible by combining novel testing methods and modelling.

- The unified model is capable of describing the obtained experimental results.

- Model predictions indicated that either limited bioavailability or intrinsic recalcitrance can explain HOCs persistence.

- First-order rates typically derived from OECD test results and used to describe biodegradation kinetics have shown to be not adequate due to e.g., significant changes in microbial biomass. Furthermore, currently used persistence indicators (e.g., half-lives) may not adequately describe true biodegradation of HOC, as they are influenced by bioavailability limitation.

Overall, the outcome of this project has raised questions about the regulatory need to clearly distinguish between biodegradation and dissipation together with the definition of a distinct terminology, particularly in the context of persistence assessment.

Cooperation Partners

• Technical University of Denmark (DTU)

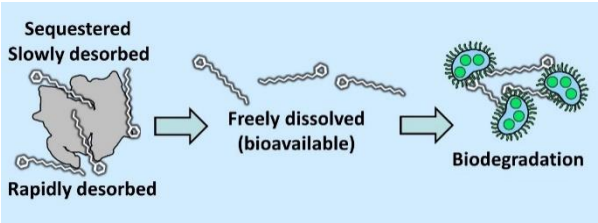
• German Environment Agency (UBA)

The project was funded by the European Chemical Industry Council CEFIC within the long-research initiative (LRI) program.

Project management: Dr. Felix Stibany, Dr. Kilian Smith, Prof. Dr. Andreas Schäffer,

CEFIC LRI-ECO32: Environmental risk assessment of poorly soluble substances: Improved tools for assessing biodegradation, (de)sorption, and modelling (RABIT) (2016 - 2018)

Felix Stibany, Kilian Smith, Andreas Schäffer



Description of the Project

Highly hydrophobic organic chemicals (HOCs) are characterized by a log K_{OW} above 5.5, resulting in an aqueous solubility in the µg/L-range or even lower. Owing to their high production volumes and diverse usage, these chemicals may enter the aquatic environment. HOCs tend to persist in natural environments due to their strong sorption to solid phases such as sediments, organisms, and particulate matter in general, making attempts for understanding their intrinsic biodegradability challenging. Therefore, a major part of these chemicals need to be considered as potential PBT-candidates.

Persistence assessment using standardized tests (e.g., OECD guidelines) is one of the main challenges for HOCs. Their properties often hinder a reliable experimental assessment using standard methods. For a reliable experimental determination of both persistence and biodegradability, (de)sorption effects and biodegradation in the aqueous phase have to be consequently decoupled. Further, mechanistic models can provide deeper insights in experimental results and underlying processes. In this context, the key objectives of this study were to develop novel experimental test systems for biodegradation and (de)sorption, and to test the applicability of a unified modelling approach across the spectrum of OECD biodegradation tests and our new experimental approaches for HOCs.

Activities in 2016 – 2018

Two model HOCs were selected, dodecylbenzene (logK_{OW} 8.7) and pyriproxyfen (logK_{OW} 5.6). For the experimental determination of their biodegradation, different passive dosing formats were developed to provide a precise exposure control of the test substance and ensured a constant compound delivery and combined with single degrader strains and natural inocula.

In parallel, the biodegradation of both model HOCs was tested in standard water-sediment systems based upon OECD 309. Additionally, abiotic desorption kinetics of the model HOCs from sterilized sediment, freshly spiked and aged, were determined utilizing silicone O-rings as infinite sink passive samplers. In all tests, ^{14}C-labelled test substance was used to trace the compound distribution to different compartments with high sensitivity.

The modelling approach relied on the use of a unified multi-compartment model, which decouples fast and slow (de)sorption kinetics to solid matrices and describes based microbial degradation kinetics according to Monod equation. The unified model was used, in combination with the Microbial Turnover to Biomass growth yield estimation method, to simulate test substance mineralization to CO_2 and growth of degrading microorganisms. Model predictions were calibrated against the experimental results obtained in the conventional tests and in the novel passive dosing setups. Overall, good agreement between model predictions and empirical data was shown by estimating only the ratio v_{max} / K_S. This ratio denotes the second-order biodegradation rate constant, while accounting for change in microbial abundance over the duration of tests. Different v_{max} / K_S values were shown for the selected HOCs, indicating that either limited bioavailability or intrinsic recalcitrance could explain HOCs persistence.

Outlook

The project was finalized in 2018 and represents a first attempt of using novel test setups and a unified modelling approach for predicting reliable biodegradation of HOCs (validated with OECD 309 test results), showing promising results towards persistence prediction of organic chemicals during regulatory screening.

Cooperation Partners

Technical University of Denmark (DTU):
Dr. Fabio Polesel, Prof. Dr. Stefan Trapp

Umweltbundesamt (UBA):
Daniel Sättler

Funded by the **CEFIC-LRI program**

PASSEDOBLE (2016 – 2019)

An innovative approach to combine chemical and biological analysis of hydrophobic organic chemicals in the pore water of marine sediments

Nora Niehus, Asya Bekerman (BSc thesis), Kendra Majewski (MSc thesis), Henner Hollert, Thomas-Benjamin Seiler

Description of the Project

Assessing the bioavailability and effects of hydrophobic organic contaminant (HOC)-mixtures is a challenge in environmental sciences. We developed a combined passive sampling and dosing approach for direct transfer of *in-situ* sampled mixtures into small-scale bioassays. The principle of passive sampling and dosing is that dissolved HOCs diffuse into or from a polymer (e.g. PDMS) until the thermodynamic equilibrium is reached. We directly introduced passive samplers into a bioassay as a passive dosing phase to transfer the sampled mixture to the medium. As soon as the equilibrium is reached in the medium the native mixture is restored, equalling the *in-situ* sampled concentrations and composition. Thereby, the effects caused by the actual contamination can be investigated. This approach offers reliable and realistic exposure data for environmental management.

Activities in 2016 – 2018

PDMS hollow fibres were deployed *in-situ* in sediments of the Baltic coast for three months to determine the freely dissolved concentration (Cfree) of polycyclic aromatic hydrocarbons (PAHs). These native PAH mixtures were recreated and loaded on silicone fibres. PAHs were chosen as they are the main emission class in the investigated sediments. The artificially loaded fibres were used to adapt the Fish embryo toxicitytest (FET) with *Danio rerio* testing for teratogenic effects, and the EROD assay with the RTL-W1 cells for dioxin-like compounds.

The FET was done in 96-well plates and a suitable ratio of silicone fibre and medium was found to be 30 cm (10 mg silicone) and 200 µL medium per well. This setup was sufficient to maintain a constant concentration for PAHs with a log KOW >4.4 over 96 h of testing. Recreated PAH mixtures caused only sublethal effects like pericardia and yolk sack oedema, which are characteristic effects of PAHs. The *in-situ* fibres caused pericardia oedema, and no embryos hatched. This could also be explained by the presence of PAHs. However the *in-situ* fibres contained much more substances which could have caused these effects. The effects of the *in-situ* fibres show that the native sediment contamination can have an adverse impact, albeit the delayed hatching and the pericardia oedema are reversible effects.

For the EROD assay, the same ratio of silicone and medium as in the FET was used. Strong EROD activity was measured for recreated PAH mixtures. Based on the PAH composition in the *in-situ* fibres, no EROD activities are expected. But again, these fibres contain much more substances that can still cause EROD induction.

Outlook

Currently, a proposal for a PASSEDOBLE follow-up project is drafted that targets the adaptation of further bioassays to passive dosing using PDMS hollow fibres, such as the micronucleus assay (genotoxicity) and the Ames fluctuation test (mutagenicity). A major aim is the development of a fluorescence biomarker battery for zebrafish. More *in-situ* fibres will be tested to collect realistic exposure data, and a non-target analysis of the *in-situ* fibres is intended to identify more substances and potential toxic drivers.

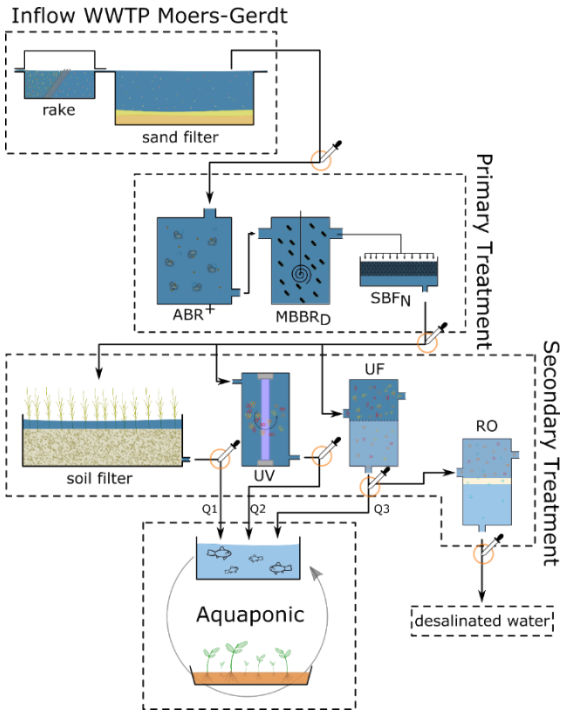
Cooperation Partners

Prof. Dr. habil. Gesine Witt (Hamburg University of Applied Sciences)

Funded by the German Research Foundation (DFG; WI1410/10-1, Ho3330/10-1)

Modular wastewater cleaning procedures for the reutilisation of water, nutrients and energy (awaregio) (2016 – 2019)

David Kämpfer, Yvonne Müller, Sabrina Schiwy, Kilian Smith,
Andreas Schäffer, Henner Hollert



Description of the Project

In the BMBF project awaregio, research institutes from Aachen and Leipzig, as well as small and medium-sized enterprises, are investigating possibilities for reutilising water, nutrients and energy from wastewater treatment. We are focusing on the fate of micro pollutants and their ecotoxicological effects during the treatment process. Mixed wastewaters from households, industry and urban rainwater discharge contain complex mixtures of organic trace substances. Of particular importance are those contaminants which are inefficiently removed by traditional cleaning steps. Further treatment steps are necessary for such compounds to ensure sufficient reduction in their levels and combined toxic effects. For investigating this question, a combined approach of trace analytics and toxicity bioassay is needed. Within the modular pilot plant for wastewater treatment consisting of primary and advanced treatment steps (UV treatment, ultrafiltration and reverse osmosis) the fate of some micro pollutions with a range of physicochemical properties are being investigated using a combination of active and passive sampling.

Furthermore, a set of bioassays has been included for measuring mixture toxicity covering a range of different modes of action. The complementary chemical and biological analyses are aiming at giving a comprehensive view of the different treatment steps and their capability to remove emerging contaminants from the wastewater stream.

Activities in 2016 – 2018

In the first year of the project, a modular pilot plant for the treatment of wastewater has been constructed. Biological and chemical analytical methods have been established and tested during the initial phase of the pilot plant operation. In addition, methods for the integration of contaminant mixture sampling and their toxicity testing are being tested, using Oasis HLB® as the passive sampling and dosing phase. Also, uptake of the persistent antibiotic sulfamethoxazole in radish plants has been investigated using radioanalytical methods to clarify its distribution and metabolism in this typical hydroponic plant.

Outlook

In 2019, an extensive monitoring campaign will be conducted focussing on the removal efficiency during different seasons as well as implementing new passive sampler types for chemical monitoring and passive dosing in *in vitro* bioassays. Furthermore, fish samples from the aquaponics will be examined for biomarkers and gene expression via next-generation sequencing and polymerase chain reaction. Finally, a study with a radiolabelled chemical is planned in order to investigate key removal processes in the soil filter component of the treatment plant, and to evaluate strategies aimed at improving the removal efficiency.

Cooperation Partners

Research Institute for Water and Waste Management at RWTH Aachen (FiW) e. V.

Institute for Infrastructure and Resource Management at University Leipzig (IIRM)

TERRA URBANA Umlandentwicklungsgesellschaft mbG (TUG)

EvU-Innovative Umwelttechnik GmbH (EvU)

A3 Water Solutions GmbH (A3)

Linksniederrheinische Entwässerungs-Genossenschaft (LINEG)

For more information's visit our homepage www.awaregio.net

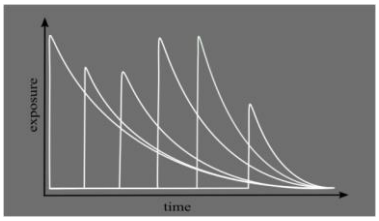
COMBITOX - Environmental risks of pesticides between forecast and reality: How reliable are results of the environmental risk assessment for individual products in the light of agricultural practice (tank-mixes, spray series)? (2015-2019)

Benjamin Daniels, Richard Ottermanns, Alexandra Sybertz, Andreas Schäffer, Martina Roß-Nickoll

Description of the Project

In view of the current agricultural practice, the protectivity of the environmental risk assessment (ERA) for non-target organisms conducted for individual PPP applications is questioned for different reasons. PPPs are commonly applied in tank mixtures that are often not predictable for regulators and formally not considered in legal procedures or a regular risk assessment. For this reason, it is absolutely necessary to know the type of tank mixture, the frequency of its use in spray series and the exact chronological sequence and composition of the spraying sequence within a growing period. Suitable scientific literature available for terrestrial and aquatic ecosystems was reviewed for information on effects in laboratory experiments, semi-field or field studies including single populations and communities that were specifically investigated regarding mixtures of PPPs. In order to improve the environmental risk of PPPs and related PPP mixtures, several assessment models were evaluated and developed.

The COMBITOX project investigates if the common tools of predicting mixture toxicity are valid not only for acute effect data but also for chronic endpoints.



Realistic treatment regimens are intended to be deduced from the combination of common uses and their regional specificities as well as from the economy of plant protection. In the context of the COMBITOX project, we focus on the most significant cultures in Germany in terms of the cultivated area (cereals, oilseed rape, maize, sugar beet and on intensively treated cultures (vine, apples, hops).

Activities in 2016 – 2018

Representative, standardized & unique application data were gathered for 12 main crops in Germany and Austria. A total number of 889 spray series was collected. Major differences in treatment patterns in terms of number of applications, used pesticide classes were identified between crop types. Most of the models investigated are not able to predict the mixture toxicity from individual pesticides within a spray series and do not consider interacting substances. The course of the overall risk of a spray sequence was simulated with a newly developed tool. A risk characterization of four selected spray series from the different crops was performed.

Outlook

The project is in its concluding period. The final report of the project will be written, and results will be published in international scientific journals.

Cooperation Partners

UFZ - Helmholtz-Zentrum für Umweltforschung GmbH, Leipzig, Germany.

German Environment Agency, Dessau-Roßlau, Germany.

DemO$_3$AC (2015 – 2019)

The waste water ozonation demonstration project at the waste water treatment plant Aachen-Soers

Aliaksandra Shuliakevich (PhD thesis), Yvonne Müller (PhD thesis), Sabrina Schiwy, Henner Hollert

Description of the Project

The European Water Framework Directive aimed to achieve a good ecological and chemical status in all European surface waters until now. However, only 20 % of the German surface waters achieved these goals. One reason for this could be the anthropogenic pollutants coming from wastewater treatment plants (WWTP). Not all of these pollutants are completely eliminated in the standard treatment process and thus enter the aquatic environment. Hence, in the DemO3AC-project a case study is conducted to demonstrate the

implementation and an impact of a further treatment step, an ozonation process, to eliminate micropollutants (MPs). The River Wurm carries about 70 % of the treated waste-water. During a first sampling campaign, the status quo regarding MPs occurrence and their potential effects was determined. Following, the analytical data and biotest results will be compared with the data after the implementation of the large-scale ozonation plant. To detect any adverse effects by ozonation as well as improvements by reduction of MPs, a test battery (acute and chronic, mechanism-specific, *in vivo* and *in situ*) is conducted as recommended and recently published in the Technical Report on aquatic effect-based monitoring tools. For testing of the *in vitro* and *in vivo* assays water samples are taken and native as well as extraced samples via Oasis HLB cardriges are tested. The first period of the project is finished and the second phase has started in 2018. Based on the results, the project aims to develop a testing strategy for the investiagtion of the WWTP and the River Wurm after the installation of the advanced cleaning step.

Activities in 2016 – 2018

Until now, results from the first period are fully available. It could be shown that the toxic potential in the WWTP inlet was high for all tested endpoints (*in vivo* and *in vitro).* However, it was already reduced during the conventional treatment steps but not totally eliminated at the conclusion of the main scientific findings will be given.

Experiments in the annular flume were used to monitor different parameters, vary them and identify occurring interactions and effects. The experimental data was used to set-up data used to set-up data driven models.

Furthermore, a numerical model to simulate the experiments conducted in the WWTP outlet, exept for the teratogenic potential in the fish embryo toxicity assay. Also the river samples did not show effects to the fish embryos and larvae after an incubation time of 96 hours. Additionally, the *in situ* experiments with *Gammarus pulex* (evaluation of the feeding rate) did not show a consitent picture of the chemical burden. Further, the reproduction assay with *P. antipodarum* showed a significant increase of embryo production downstream of the WWTP. In contrast, the ERα CALUX® assay indicated a reduced estrogenic activity downstream the WWTP compared to upstream. In the experiments with juvenile rainbow trout an increased detoxification potential upstream the WWTP could be observed. Mutagenic potential was measured at all sampling sites at the WWTP as well as in the stream. It was also possible to show that there is already a chemical impact (Haarbach and WWTP Eilendorf) upstream the WWTP outlet. First results from the second period need to be evaluated.

Outlook

In the second phase of the project the large-scale ozonation plant will be run in different operation modes. The evaluation of the gained results will be done as well as the performance of the remaining bioassays for each sampling time. Further *in situ* experiments will also take place in 2019. After the evaluation of all results of both sampling periods a final evaluation strategy for waste water will be developed.

Funding

The Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia (MKULNV)

Cooperation Partners

Wasserverband Eifel-Rur (WVER)

Institut für Siedlungswasserwirtschaft (ISA)

Institut für Angewandte Mikrobiologie (iAMB)

Forschungsinstitut für Ökosystemanalyse und -bewertung (gaiac)

Olfactory toxicity in zebrafish (2015-2018)

Sina Volz, Sabrina Schiwy, Henner Hollert

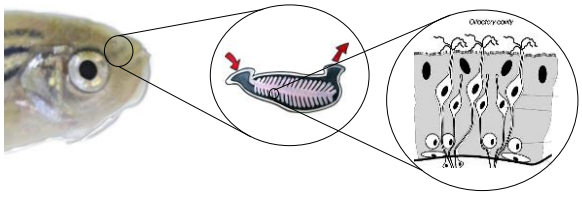
Description of the Project

Fish are dependent on olfaction since a variety of essential behaviors, such as foraging, predator avoidance and mate selection, are mediated by the olfactory system. Consequently, an impairment of the olfactory system can affect both individual fish and whole populations. Despite the importance of olfaction for fish, only few studies investigating an impairment of the latter have been published, so far.

The olfactory epithelium (OE) is located in two pits at the dorsal part of the snout. Through these pits the surrounding water is constantly flowing. The olfactory receptor neurons (ORNs), which are responsible for odorant detection, are situated within the OE and only separated from the environment by a thin layer of mucous. In such an exposed situation dissolved xenobiotics can interact with them as easily as natural odorants do.

Previous studies have shown that several metals and pesticides are able to influence the olfactory system of fish in environmentally relevant concentrations. However, underlying mechanisms predominantly remain unidentified.

The present project aims at assessing the olfactory toxicity of cadmium and three commonly used pesticides by analyzing endpoints on various levels of organization.



Activities in 2016-2018

In order to assess whether zebrafish would detect and choose to avoid the test substances, we conducted choice experiments using a Y maze. We applied 80 mL of 300 µg/L linuron, 1 mg/L cadmium, 20 µg/L chlorpyrifos or 250 ng/L permethrin randomly to one arm of the maze.

Fish did not avoid cadmium, chlorpyrifos and linuron in the respective concentrations, however, they spent significantly less time in the arm containing permethrin.

Gene expression studies showed a decreased expression of ORN marker proteins following exposure to cadmium. Furthermore, cadmium also increased the expression of genes associated with oxidative stress. Hence, it seems to have a general toxic effects on all of the three ORN types. None of the pesticides had a significant effect on the gene expression of our target genes.

In behavioral experiments, we investigated whether exposed zebrafish were still able to react to an alarm substance in a proper manner. For chlorpyrifos and cadmium, we showed that with rising substance concentration, the number of fish exhibiting an alarm response decreased. As a failure to perform the appropriate behavior makes the fish more prone to predation, this endpoint is directly linked to survival. To date, the analysis of fish antipredator behavior is still mainly done manually, which is very time- and labor intensive. Hence, we currently develop an analysis script for the automated identification of certain behaviors from tracking data, which greatly accelerates the evaluation process.

Outlook

To get an insight into effects on the olfactory signal transduction, we want to measure cAMP and cGMP concentrations in the olfactory epithelium. Moreover, we plan on measuring the effect of the test substances on plasma concentrations of 11 Ketotestosterone of male zebrafish following the stimulation with the female pheromone PGF2α.

Cooperation Partners

Jonas Hausen (Core Unit for Bioinformatics Data Analysis, University of Bonn)

This PhD project is funded via a personal fellowship of the German Federal Environmental Foundation

Metalfish (2015 – 2018)

Daniel Koske, Jonas Hausen, Martina Fenske, Richard Ottermanns

Description of the Project

The aim of this project is to investigate the effects of silver among other metals on the development and the gene expression of zebrafish (Danio rerio). Metals are important environmental pollutants as they are not degradable neither chemical nor biological. It is known that exposition can cause severe damage in developing organisms. However, most of the underlying mechanisms of this toxicity are up to now unknown. To examine these mechanisms, fish embryo toxicity tests and microarray analysis are conducted with four different metals (silver, copper, cadmium, cobalt). The toxicity tests allow the determination of EC-values, which are used to define sub-lethal concentrations for the microarray analysis. Data analysis of the microarray data in particular was a second focus of this project. Microarray data sets are often very large, very noisy and have few replicates. As these problems require specific statistics, the development and implementation of a statistical workflow to analyse and compare the data was a focus. The project is a cooperation between Fraunhofer Institute for Molecular Biology and Applied Ecology (IME) and our institute.

Activities in 2016 – 2018

In 2016 data analysis of microarray data for silver was completed. Microarray results for different metals were compared to give insights in metal-specific mechanisms as well as processes involved in toxicity. All results were used in a heuristic approach that combines data-driven and knowledge-based methods for biomarker detection.

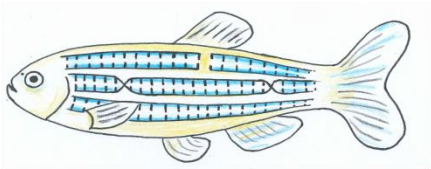
Effect concentrations for AgNO3 turned out to be much lower than known from literature. A strong batch effect was detected in the expression data which resulted from the handling in the FET experiments and should be avoided in future studies. Although the results using different analysis frameworks were mainly comparable, reporting a transparent workflow in GeneSpring was difficult, whereas the workflow developed in this project proved to be transparent and plausible. Using variance decomposition a large number of significantly regulated genes for silver exposition were found and different reaction types (step-wise as well as gradual change of expression rate) were detected by dose-response modelling. These findings could be used in the future to establish a toxicological assessment method based on gene expression data. Using transcriptome analysis significant groups of co-regulated genes as well as functional traits were detected and attributed to specific biological processes, cellular components and reaction types.

Outlook

For the future it is planned to validate the expression rates and genes using qPCR.

Cooperation Partners

Fraunhofer Institute for Molecular Biology and Applied Ecology (IME)



Metal
Fish

Advancing passive sampling for monitoring organic contaminants in the aquatic environment (2014 – 2018)

Yoon Ah Jeong, Andreas Schäffer, Kilian Smith

Description of the Project

Passive sampling is a promising monitoring technique for organic pollutants in aquatic environments providing a measure of the bioavailable dissolved concentrations, lower detection limits than grab sampling, and the possibility of *in situ* sampling as well as interfacing with mixture toxicity testing.

A novel equilibrium passive sampling device was developed targeting both polar and non-polar contaminants. Firstly, the partitioning behavior of a range of environmentally relevant organic contaminants to one of the more widely applied passive sampling receiving phases, Oasis HLB®, was studied as a function of environmental parameters. Secondly, a new mixed polymer passive sampler (MPS) was made by embedding Oasis HLB® in a polydimethylsiloxane (PDMS) matrix in order to enhance the sampler affinity towards the range of polar and non-polar organic contaminants and to avoid membrane sorption artefacts. This monophasic MPS proved to be advantageous in terms of convenient handling and the possibility of isotropic exchange for the eventual application of the performance reference compounds (PRC) approach for in situ calibration. In a laboratory calibration experiment, the equilibrium partition coefficients and sampling rates of a wide range of organic contaminants to both the MPS and POCIS were determined under static and stirred conditions. For the tested analytes (log K_{OW} of –0.03 to 6.26), the POCIS was the more efficient sampler since the relative affinity of the MPS was generally lower. However, the MPS had higher sampling rates for most compounds compared to the POCIS which implies that it can be applied as an equilibrium sampler for providing a “snapshot” of environmental levels. In contrast, the POCIS is a kinetic sampler and provides an integrative measure of environmental levels.

Thirdly, the MPS and POCIS were deployed along the river Saar, river Mosel and the outflow of a waste water treatment plant over five weeks in 2015. The bioavailable dissolved concentrations of 27 organic contaminants, including 8 priority substances of the EU Water Framework Directive, were determined and used to compare the performance of each passive sampler in the field. To advance the applicability of passive sampling within regulatory monitoring programs, a simple mathematical model was adapted to estimate the total water concentrations of the contaminants from the passive sampling measurements for comparison to environm. quality standard levels.

This information can contribute to enhancing the reliability of the passive sampling approach for monitoring trace levels of environmental contaminants in aquatic environments as well as the implementation of the produced data within the regulatory context.

Activities in 2016 – 2018

The thesis was finished in 2018 and the student now works in an Environm. Research Institute.

Outlook

Further passive sampling techniques are currently developed.

Cooperation Partners

Korean Institute of Science and Technology, Saarbrücken (KIST Europe)

Nanomobil (2014-2017)

Engineered silver nanoparticles in the system soil-groundwater: mobility, effects on biocoenosis & interaction between hydro-, pedo- and biosphere

Eva Penssler, Hanna Maes, Michael Hennig, Martina Roß-Nickoll, Andreas Schäffer

Description of the Project

Manufactured nanomaterials are used in a variety of industries and enter the environment via different pathways. Silver nanoparticles (AgNPs) are mainly applied in medicine, textiles, and cosmetics, because of their bactericidal effects. Little is known though about the environmental risks of AgNPs since their fate, behaviour, and effects remain largely unstudied. Nanomobil aims at studying the fate of AgNPs in the soil-groundwater system addressing their behaviour in the hydro-, pedo- and biosphere. To detect AgNPs in different environmental media, one aim of the project NanoMobil is to develop a suitable analytical methodology. The Institute for Environmental Research focuses on the biosphere and investigates the interaction between AgNPs and the compartments soil and groundwater including organisms living there. In soil column experiments, the distribution and transport of surfactants stabilized and surface coated AgNPs are analysed. Effects of the nanomaterials to earthworms and springtails (soil inhabitants) as well as groundwater organisms are investigated. Furthermore, the influence of earthworms on the distribution and transport of two different silver nanoparticles in soil is evaluated. These studies deliver a database for a field study in terrestrial model ecosystems (TME), performed by the institute gaiac, in which effects on the biocoenosis are examined. Results of this project can be used to assess the environmental risk of AgNPs.

Activities in 2016 – 2018

Ecotoxicity tests of AgNPs towards different terrestrial and aquatic organism with various endpoints have been performed. For the differentiation of particulate (AgNPs) and ionic silver ($AgNO_3$) both substances had been tested. $AgNO_3$ expectedly caused mortality of earthworms at lower concentrations than AgNPs. In addition, a species dependent sensitivity was observed: both AgNPs and $AgNO_3$ resulted to effects at lower concentrations for the species *Lumbricus terrestris* than for *Eisenia fetida*. The collembola, *Folsomia candida*, was the most sensitive terrestrial organism and showed a reduction in reproduction at similar concentration levels for both silver types. Very low concentrations (µg/L) caused significant effects of the feeding behaviour of the aquatic organism *Gammarus pulex*.
Beside the ecotoxic effects the influence of earthworms on the mobility of two different AgNPs (surfactant- and polymer-stabilized) in natural soil was investigated. Burrowing activity of the earthworms was responsible for a transfer of AgNPs in deeper soil layers. Furthermore, it was evaluated that coating of the nanoparticles played a role for their transport behaviour in soil. However, only very little leaching of the nanoparticles into soil was observed and most of the applied AgNPs remained in the upper soil layer.

Cooperation Partners

Department of Engineering Geology and Hydrogeology (LIH, RWTH Aachen University); Research Institute for Ecosystem Analysis and Assessment – gaiac: Institute of Bio- and Geosciences, Agrosphere (IBG-3), Forschungszentrum Jülich; Postnova Analytics GmBH; Federal Environment Agency of Germany (UBA)

TEPHA – Technical Product Harvesting (2014 - 2016)

Christoph Kämpfer (PhD thesis), Henner Hollert, Thomas-Benjamin Seiler

TEPHA
Technical Product Harvesting

Description of the Project

Within the interdisciplinary research project "TEPHA - Technical Product Harvesting" scientists from mechanical engineering, architecture, botany and ecology are exploring the options for environmentally friendly and sustainable production. The aim of the entire project is to use suitable biomass for the production of technical products. Specifically, the focus is on organic materials, which are influenced in their natural growth and as defined in required semi-finished or usable components for architecture or mechanical engineering applications. The Department of Ecosystem Analysis at the Institute for Environmental Research investigates the ecological implications of near net shape grown products. The ecological expertise should be firstly integrated into a database in which also the mechanical engineering related and architectural requirements, as well as the botanical properties of potential plants are combined. On the ecological side, specific information on candidate plants such as the nutrient, fertilizer and water requirements, impacts of plant cultivation on humans and ecosystems, as well as information on potential land use, are inserted into the database. The aim of this database is to enable a reasonable and reproducible way of future plant selection, which both meets the technical requirements and is environmentally responsible.
Secondly, the main objective of the environmental sciences subproject is the assessment of the overall environmental impact caused by near net shape grown products. In a Life Cycle Assessment (LCA) all stages of the product life cycle from raw material acquisition, through processing and use phase to the end-of-life treatment are investigated regarding potential adverse environmental impacts. Thus, a reasonable statement about the viability of the near net shape growth of plants, also in comparison to the conventional manufacturing process of corresponding components, from an environmental perspective is strived for. Bamboo grown in Aachen was used as test plant to construct a seat shell which was compared to seat shells made of PP or bamboo imported from China.

Main results

Main categories relevant for the ecological evaluation of the use of certain plants for technical applications where identified for the integration into the plant database to guarantee a sustainable selection of plants for technical application. Besides classical ecological categories related to plant growth, ecotoxicological aspects important in the context of plant materials like toxicity of the plant material or phytoremediation where considered.
The LCA study within the TEPHA project showed that near net shape grown bamboo seat shells are not better in all investigated impact categories than the conventional PP alternative. It was found that the main reasons for this are the growth shapes. But it can be considered more sustainable than bamboo imported from China. A comparison of different materials for the shapes showed a clear potential for improvement.

Outlook

Further LCA studies in subsequent cultivation periods are needed to get a more detailed and realistic impression of the environmental issues connected to the near net shape growth of components for technical application. Regarding the material for the shapes additional investigations are necessary to figure out a trade-off between the environmental advantages and disadvantages of bio-based, renewable materials and fossil-based materials. A further development guided by LCA could result in near net shaped bamboo as a sustainable material for the bio-based economy.

Cooperation Partners

Institute for Machine Elements and Systems Engineering, Chair of Structures and Structural Design (Trako), Institute of Botany and Molecular Genetics (all from RWTH Aachen University)

Funding

Excellence Initiative of the German federal and state governments, grant no. OPBF091

SOLUTIONS for present and future emerging pollutants in land and water resource management (2013 – 2018)

Björn Deutschmann, Ying Shao, Shangbo Zhou, Mirna Velki, Thomas-Benjamin Seiler, Henner Hollert

Description of the project

Toxic effects on aquatic life are frequently observed. However, it remains a challenge to link the occurrence of chemicals with the ecological status of waters, to identify major chemical stressors, and to find solutions for the abatement of pollution-related risks. The 7th EU RTD Framework Program project SOLUTIONS with a consortium of 39 partners addressed these particular topics by linking tools, models, and methods in environmental and water policies. The overall goal of this project was to produce consistent solutions for dealing with the large number of legacy, present and future chemicals posing a risk to European water resources with respect to ecosystems and human health. It was structured into 4 subprojects (SP): SP1 guided the subprojects SP2 on Tools, SP3 on Models, and SP4 on Cases, which developed the underlying bio- and chemo-analytical procedures, the theoretical methods and computational techniques to model chemical behaviour, and the experimental and field data that were integrated and digested into the final solutions.

Activities in 2016 – 2018

The Institute for Environmental Research at RWTH Aachen University was part of four different work packages and leader of the task group for biomarker in fish in a weight-of-evidence approach within the project. Different case studies were used to assess chemical stress and to confirm results of *in vitro* assays in aquatic organisms under a realistic exposure scenario *in situ*. Different study set-ups were used and ranged from large-scale river assessment to the assessment of point-sources with feral and caged fish. Significant variations in DNA damage levels in the River Danube were observed in *Alburnus alburnus* with the micronucleus assay, especially downstream of tributaries loaded with untreated wastewaters. Additionally, significant variations in the liver of both *Neogobius sp.* and *A. alburnus* were demonstrated for biotransformation and compound-specific enzyme activities (EROD, CES, GST and AChE) and oxidative stress parameters (CAT activity). While response patterns were flat and failed to identify clear hot-spots, the same endpoints clearly identified the impact of effluents in feral and caged fish in the smaller rivers Mulde and Holtemme. For the assessment of wastewater treatment plant effluents the use of Next Generation Sequencing with fish liver identified additional biomarkers. We further integrated an effect-based risk assessment with a zebrafish-based investigation strategy to evaluate Danube water sample extracts and fractions. This effect-based strategy revealed that the most toxic mixture covering a logKow range from 2.83 to 3.42 was composed by 12 chemicals. Genotoxicants identification with *in silico* methods, bioassays, chemical analysis and literature information showed that 18 chemicals explained 48.5 % of the genotoxicity in the micronucleus assay. Toxicity analysis of 10 organic micropollutants mixtures which exhibited independent action of the single compounds concluded that they may pose a potential risk for aquatic ecosystems at the measured environmentally concentrations in the Danube River and Rhine River.

Outlook

Since environmental mishaps on aquatic life appeared frequently, the linkage of toxic effects and the identification of major chemicals in the aquatic environment is still a great challenge. The use of effect-based tools and chemical analysis, mixture risk assessment and *in silico* techniques is suggested for future monitoring under the WFD to derive reliable cause-effect relationships. All these experimental results are crucial to assess chemicals that may lead to not only present but also future ecological risk in European water resources.

Cooperation Partners

See http://www.solutions-project.eu

Funding

EU 7th Framework Programme for research, technological development and demonstration, grant no. 603437. Dr. Mirna Velki received funding through an Alexander-von-Humboldt postdoctoral fellowship.

W3-Hydro (2013 - 2016)

Water quality event detection for urban water security and urban water management based on hydrotoxicological investigations

Leonie Nüßer (PhD thesis), Henner Hollert, Thomas-Benjamin Seiler

Description of the Project

W³-Hydro is motivated by three demands: water availability, water quality and water security. Hence, it is important to identify situations when the demands are threatened by sudden, unforeseen and negative events. For detecting contamination in natural waters and water supply systems it is necessary to develop an early warning system in order to secure mankind and the environment. Changes in motoric behaviour of organisms are a sensitive endpoint for the assessment of toxicity of chemicals. We proposed to use behavioral changes of zebrafish larvae for the detection of sudden contamination events in a water stream. Early life stages of zebrafish are not protected as animals until 120 hours post fertilization (hpf), hence zebrafish embryos at the age of 96 hpf were used to establish an animal free vertebrate method for event detection. Since early stages of zebrafish are very sensitive towards toxic substances, and behaviour is a sensitive bioindicator, the system is a promising tool to detect toxic substances fast and in low concentration ranges. In order to determine the sensitivity and reliability of this system a number of experiments are conducted using cadmium and permethrin as models.

Activities in 2016 – 2018

The project was officially completed in 2017 with the submission of the concluding reports to the Federal Ministry of Education and Research (BMBF) in Germany and the Ministry of Science, Technology and Space (MOST) in Israel. In total 21 research papers have been published in the W3-Hydro project. Here, a short conclusion of the main scientific findings will be given.

Experiments in the annular flume were used to monitor different parameters, vary them and identify occurring interactions and effects. The experimental data was used to set-up data used to set-up data driven models. Furthermore, a numerical model to simulate the experiments conducted in the annular flume was developed. The conducted experiments showed that it was possible to resuspend contaminated sediments in the annular flume. This allowed assessing their behavior in turbulent flow over a longer time period and under different bed shear stress situations. Additionally, physical-chemical parameters were monitored to see if it is possible to detect an increased resuspension of contaminated sediments using physical-chemical online measurements. To numerically describe the annular flume experiments a numerical model based on an LBM-DEM approach taking into account cohesive forces in particle-particle interactions was developed. The developed model is a promising tool for investigating processes, influencing factors and interactions during contaminated sediment resuspension. Therefore, it can be used for future investigations to deepen the knowledge about the complex physical, chemical and biological processes and interactions during events, with a high risk potential for water resources. The results from experiments utilizing zebrafish embryo behavioral responses suggest that this system could be a sensitive addition to already existing sensor batteries for water monitoring. The novel segregation parameter that was developed in cooperation with the Technion detected behavioral responses of the embryos exposed to low concentrations of cadmium and permethrin to be different from control embryos. These results show, that the system appears to be sensitive enough to detect concentrations that are relevant for the protection of human health in the context of drinking water quality for certain model substance.

Outlook

The concept of the biosensor based on fish embryo behavior is applied and further developed in the GRACE project were it will ultimately be used to monitor water quality and potential oil spills in the Baltic sea. The successful cooperation within W3-Hydro encouraged the partners to apply for additional funding in ongoing and future projects together.

Cooperation Partners

Dr. Avi Ostfeld, Dr. Elad Salomon (Technion, Israel) Prof. Holger Schüttrumpf, Dr. Cartina Coffalla, Dipl.-Ing. Caroline Ganal (Institute of Hydraulic Engineering and Water Resources Management (IWW) at RWTH Aachen University)

Cluster of Excellence “Tailor-Made Fuels from Biomass” (TMFB) (2012-2018)

Ecotoxicological investigations of biofuels as a basis for computational model-based prediction of ecotoxicological potencies

Sebastian Heger, Miaomiao Du, Andreas Schäffer, Henner Hollert

Description of the Project

The Cluster of Excellence “Tailor-made fuels from biomass” (TMFB) aims at the development of a sustainable and economical design process for biomass-derived fuels. Within this project, ecotoxicological bioassays are integrated in the biofuel development as a “Green Toxicology” approach. It proposes the application of predictive toxicology as part of the sustainable development and production of less harmful chemicals, pharmaceuticals or other products. The basic idea of “Green Toxicology” is the identification of opportunities to design molecules with reduced environmental and human health hazards and, thus, to minimise the intrinsic toxicity of new products.

Activities in 2016 – 2018

The potential biofuels investigated in this “Green Toxicology” approach were the furan 2-Methylfuran, the tetrahydrofurans 2-Methyltetrahydrofuran, 3-Methyltetra-hydrofuran and 2-Butyltetrahydrofuran, the ether Di-n-butyl ether, the ketones Methyl isopropyl ketone and Methyl ethyl ketone, the alcohol 1-Octanol, and the biohybrid fuels Dimethoxymethane and Diethoxymethane. The testing of these biofuel candidates required a number of adaptions to the standardized test systems due to some special physico-chemical properties of the biofuels, such as their high volatility or the tendency of some substances to solve. Toxicity testing of the biofuel candidates was performed with regard to their acute toxicity for *Daphnia magna* and *Danio rerio* as well as their genotoxicity for V79 cells was performed.

The modified acute immobilisation assay with *Daphnia magna* and the modified Fish Embryo Toxicity (FET) test with *Danio rerio* embryos provide important information on the relative aquatic toxic potency of the biofuel candidates.

The biofuel candidates 1-Octanol, Di-n-butyl ether, 2-Butyltetrahydrofuran and 2-Methylfuran were found to induce a strong acute toxic potency. Moreover, 1-Octanol and 2-Methylfuran induced very strong genotoxic effects, with 2-Methylfuran being the most potent inducer. 2-Methyltetrahydrofuran, 3-Methyltetrahydro-furan, Methyl isopropyl ketone, Methyl ethyl ketone, Dimethoxymethane and Diethoxy-methane induced only weak toxic effects in high concentrations that are not biologically relevant. Therefore, it is recommended that further biofuel development focus on the latter biofuel candidates that exhibited weaker toxic effects.

The results of the present research demonstrate that effect-based bioassays can provide important information for biofuel development and that a “Green Toxicology” approach can be successfully integrated into the fuel design process. The identification of the potentially hazardous biofuel candidates 2-Methylfuran, 1-Octanol, Di-n-butyl ether and 2-Butyltetrahydrofuran suggest that focus should be towards the much less toxic biofuel candidates 2-Methyltetrahydrofuran, 3-Methyl-tetrahydrofuran, Methyl isopropyl ketone, Methyl ethyl ketone, Dimethoxymethane and Diethoxy-methane.

Outlook

The research conducted in the TMFB will be integrated in the new Cluster of Excellence “The Fuel Science Center”, starting in January 2019. Further research will be focused on the toxicity of biofuel mixtures.

Cooperation Partners

Lehrstuhl für Technische Thermodynamik (RWTH Aachen)

Aachener Verfahrenstechnik,
Enzymprozesstechnik (RWTH Aachen)

SilValuta – Quantifying the effects of sustainable forest management: a case study in the Eifel region (2010-2018)

Vanessa Bursche, Klara Krämer-Klement, Jaegyun Byun, Alexander Bach, Jonas Kirch, Lisa Siebenaler, Christian van Wersch, Richard Ottermanns, Martina Roß-Nickoll

Description of the Project

In this project, we evaluate the ecological consequences of different types of forest management applied in the Eifel region (Western Germany) in terms of ecosystem integrity. We investigate beech forests without any management, with near natural single-tree selection and with shelterwood cutting system as well as spruce and Douglas-fir forests.

Part of the project focuses on management-related differences in acute and long-term tree stress level and resulting consequences for stand productivity and stability. Therefore, tree vitality parameters are monitored at individual and stand level. In addition, the impact of the management type on structural and functional composition of the forest community is studied. Predators (ground beetles and spiders), herbivores (weevils), saprophages (weevils and isopods) and higher plants at microhabitat and stand scale are used as bioindicators of different trophic levels. Finally, we simulated management related differences in forest structure at stand scale over time. The goal is to achieve in-depth knowledge about drivers and alterations of forest ecosystem integrity and to give recommendations for sustainable silviculture.

Activities in 2016 – 2018

In these years finishing of fieldwork, data analysis and modelling had been the focus of our project work.

For the evaluation of tree vitality, fieldwork was continued with measurement of tree height, dbh increment, soil compaction, C/N ratio, pH value and grain size distribution. Crown volume and tree biomass were calculated for each individual tree and for the whole stand. Continuous measurement of air temperature was finished in early 2017. Canopy openness was calculated from hemispherical canopy photographs. All collected data were checked, transformed and statistically analysed.

For the forest community analysis, carabid beetle, weevil, isopod and spider specimen collected in 2014 and 2015 were identified. Weevils inhabiting higher vegetation strata were sampled in 2016 by net-beating and identified. Species traits were extracted from literature and measured. In order to characterise habitat quality, deadwood amount and decay status were quantified within the sampling units. Stages of natural forest development were mapped stand-wise. Explorative data analyses were carried out in order to explain species patterns with environmental factors.

For the analysis of forest dynamics, a tree growth model was developed to predict future tree growth dynamics. We combined the SILVA model with two new sub-modules for seedling regeneration and mortality adjustment. Firstly, suitable growth models and parameters were explored to merge the modules and to reflect practical forest management scenarios. Then calibration was repeated iteratively until simulated stem volumes matched volume dimensions provided by the local forester. After constructing the new model, tree growth was simulated for a period of 500 years. Simulation results were interpreted and discussed with regard to different parameters such as the dbh/height ratio, tree age-dbh relationship, the correlation between management type and stem volume, and the correlation between basal area and height heterogeneity.

Outlook

The final steps in our project will be further data analysis and interpretation. Different publications for peer-reviewed journals are currently in preparation.

Cooperation Partners

Forestry office Adenau, Germany
Forestry districts Kaltenborn-Hochacht, Nürburg, Reifferscheid and Schuld, Germany
Local forestry district Hümmel, Germany

Funding

Dr. Axe-Foundation
German Academic Exchange Service (DAAD)

Effect of silver nanoparticles on the standard soil arthropod *Folsomia candida* (Collembola)

Panwad Sillapawattana, Burkhard Schmidt, Andreas Schäffer

Description of the Project

Because of their antimicrobial properties, silver nanoparticles (AgNPs) have been widely used and have come into contact with the environment. In the present work, an effect of AgNPs on a standard soil organism, Folsomia candida, was studied (in comparison to silver nitrate) focusing on molecular and cellular alterations as ecotoxicological endpoints.

At the molecular level, an up-regulation of metallothionein-containing protein (MTC) mRNA in AgNP-treated groups indicated toxic heavy metal stress effects caused by the release of silver ions from AgNPs, which is similar to animal groups treated with silver nitrate. Alteration of the steady-state level of glutathione S-transferase (GST) mRNA was detected in animal treated with AgNPs and $AgNO_3$. At the cellular level, the relation between GST activity and the size of the glutathione (GSH) was examined. Change of GST activity from different animal groups was not significant, whereas the GSH pool (reduced and oxidized forms) decreased with increasing concentration of AgNPs. In order to obtain direct evidence whether AgNPs cause oxidative stress, treated animals were incubated with the non-fluorescent probe, 2′,7′-dichlorodihydro-fluorescein diacetate (DCFH-DA). A fluorescence signal was observed in both AgNPs and $AgNO_3$-treated groups pointing to the production of reactive species (RS). Since RS formation in F. candida is difficult to quantify, yeast strain BY4742 (wild-type) and mutants lacking of oxidative stress-related protective enzymes were exploited as a further eukaryote model organism. AgNPs and $AgNO_3$ were found to also affect growth of yeast and induced oxidative stress.

An effect of AgNPs on Collembola and yeast strains is similar to the one from $AgNO_3$. However, AgNPs are less toxic due to the slow release of silver ions. In summary, the toxic effect of AgNPs on F. candida is caused by the combination of the release of silver ions from AgNPs and the formation of reactive species.

We also we investigated the effect of the pesticide imidacloprid on GST. The results suggest that the increased GST activity with higher pesticide cncentrations, the level of GST mRNA, and the glutathione (GSH) level may be involved in the response of the collembola to the exposure of imidacloprid.

Activities in 2016 – 2018

Two papers have been published on these results.

Outlook

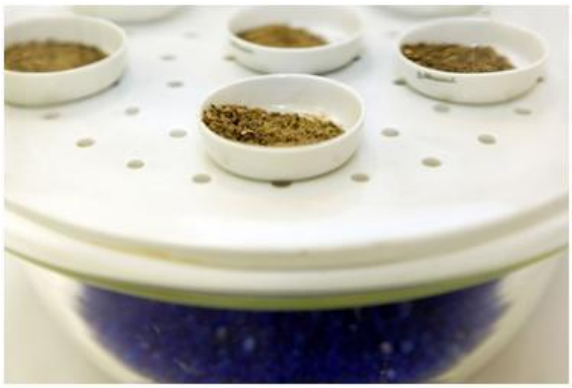
The change of GST activity and GSH level in F. candida may serve as possible endpoints in ecotoxicological risk assessments. In addition, expression of GST and MTC might be a sensitive biomarker to study effects of chemicals on Collembola.

Cooperation Partners

The Ministry of Science and Technology, Thailand; Department of Plant Physiology, RWTH Aachen University (Prof. A.J. Slusarenko, Dr. M. Gruhlke)

Non-extractable residue formation of an herbicide in soil

Ann-Katrin Luks, Burkhard Schmidt, Andreas Schäffer



Description of the Project

Aim of this project is the investigation of non-extractable residues (NER) of an herbicide in soil. The fate of pendimethalin in soil was studied to investigate formation and nature of NER in soil as well as the potential release after various time periods.

After incubation up to about a year, pendimethalin formed ca. 30% NER with respect to applied amount, respectively. Mineralization reached less than about 30% of AR. When pendimethalin was incubated in compost-amended soil, higher amounts of NER wree formed, but less was mineralized.

Humic matter fractionation showed that the residues were more or less equally distributed between fulvic and humic acids, and humins, respectivela. Rather low amounts of non-extractable residues were released by chemical derivatization of the soil organic matter and chromatographic analysis of the released residues revealed that only minor portions could be identified as pendimethalin itself (< 1% AR).

Soil samples containing only NER were re-incubated with fresh soil: significant amounts were mineralized by the added soil microorganisms and became extractable.

The experiments indicate that major fractions of non-extractable pendimethalin residues are tightly associated, i.e. covalently bound, to soil with little chance of remobilization.

Activities in 2016 – 2018

The PhD student started an industry job since about two years and at the same time finishes her thesis and drafts publications.

Outlook

Finishing the PhD thesis and papers.

Cooperation Partners

Dr. Anja Miltner, Prof. Matthias Kästner, Dr. Karolina Nowak, UFZ

BASF, Germany

Publications 2016 – 2018

2018

A comparison of equilibrium and kinetic passive sampling for the monitoring of aquatic organic contaminants in German rivers.

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