**EDITORIAL** 

## **Danio rerio** as a model in aquatic toxicology and sediment research

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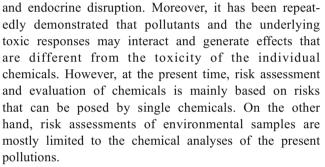
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Worldwide, the zebrafish (*Danio rerio*) has become a prominent model for biomedical research and (eco)toxicology (Strähle et al. 2012). Within favourable conditions, female fish are able to spawn year round every 2–3 days. They spawn up to 200 eggs with a transparent chorion per female. This characteristic makes them a very suitable test organism in biology as their larval development can be observed readily (Scholz et al. 2008). Additionally, zebrafish are easily obtainable, maintainable and inexpensive (Braunbeck et al. 2015) and suitable for being used as an effect-based monitoring tool under the water framework directive (Wernersson et al. 2015).

In our society, we have a high use of chemicals that spread across the world with potential health risks for humans and wildlife. Many of these compounds enter the aquatic system and accumulate in sediments and represent multi-component chemical "cocktails" of pollutants posing different threats not only to wildlife but also to humans. Under regular environmental conditions, organisms can be exposed to multiple chemicals associated with different risks and specific effects, e.g. teratogenicity, immune toxicity and suppression, genotoxicity

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Understanding the effects of mixture toxicity, generally referred to as "cocktail effects," represents one of today's greatest challenges not only in environmental but also in human toxicology. In addition, there is a dire need to develop novel biological test systems and test strategies which can be used for risk assessment of complex environmental samples. Future risk assessment strategies should integrate toxicological endpoints and chemical analysis in order to identify the chemicals causing a threat for the environment. Zebrafish is one of only a few fish species whose genome is sequenced and publicly available and can be also used for investigating mechanism-specific effects. This allows the usage of zebrafish in environmental studies which can provide information regarding the molecular mechanism and related morphological alterations of an organism to changing environmental conditions. Moreover, many of the critical pathways that regulate vertebrate development are highly conserved between humans and zebrafish, and approximately, 70 % of all genes associated with diseases in humans have functional homologs in zebrafish (Langheinrich 2003). Thus, zebrafish represents a prominent model organism to investigate the health risks of pollutants towards humans and the environment.

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Particularly, the use of embryos is receiving increasing attention, since they are considered as replacement method for animal experiments. Zebrafish embryos allow the analysis of multiple endpoints ranging from acute and developmental toxicity determination to complex functional genetic and physiological analysis (Strähle et al. 2012). The zebrafish as a model organism has received an increasing relevance for (eco)toxicological risk assessment of chemicals and complex environmental mixtures to predict acute toxicity (Braunbeck et al. 2015). Zebrafish embryos also provide the possibility to investigate molecular and mechanism-specific alterations to measure the bioavailable hazard potential of contaminated sediments (Hallare et al. 2011; Vincze et al. 2014) or fractions of effect-directed analyses (Di Paolo et al. 2015).

Recently, also a Special Issue of *Environmental* Science and Pollution Research was published elucidating the interactions and adverse effects of PAHs and fish from molecular to individual level (Cousin and Cachot 2014). In particular, the primary importance of sediment-borne toxicity and specific underlying mechanisms of PAH contamination has been emphasized as such hydrophobic compounds are mainly associated with suspended particular matter and, thus, accumulate in sediments.

This Special Issue of *Environmental Science and Pollution Research* highlights selected papers presented at the international symposium on "Methods for the assessment of sediment toxicity using zebrafish (*Danio rerio*)" held at RWTH Aachen University in 2013. Moreover, the present issue aims at presenting the novel results of the joint research project DanTox and for a scientific exchange on recent cutting-edge research using the zebrafish as a prominent model organism in environmental science.

Within the DanTox project (funded by the German Federal Ministry of Education and Research, BMBF from 2010 to 2013), existing assays could be developed further (Garcia-Käufer et al 2015, Hafner et al. 2015), and novel mechanism-specific contact assays were introduced for a comprehensive assessment of the bioavailable toxicity in sediments (Bräunig et al. 2015; Keiter et al. 2010; Kais et al. 2015; Schiwy et al. 2015). New and valuable knowledge concerning the application of such bioassays and the underlying cellular mechanisms have been gained. Moreover, microarray analyses were proven to be able to identify sets of genes, which represent various important cellular pathways and react to environmental contaminants (Hausen et al. 2015).

In detail, 15 papers on the development of novel molecular and mechanism-specific bioassays are presented in this special issue elucidating the following topics:

- Braunbeck et al. (2015) reviews origin, applications and future of the fish embryo test (FET)
- A review on the zebrafish as a model to study the role of DNA methylation in environmental toxicology (Kamstra et al. 2015)
- A review on comparability of behavioural assays using zebrafish larvae to assess neurotoxicity (Legradi et al. 2015)
- Bio-accumulation and molecular effects of sedimentbound metals in zebrafish embryos (Redelstein et al. 2015)
- Development of a novel contact assay for testing arylhydrocarbon receptor (AhR)-mediated toxicity of chemicals and whole sediments in zebrafish (*Danio rerio*) embryos (Schiwy et al. 2015)
- Fish embryo tests with *Danio rerio* as a tool to evaluate the efficiency of waste water treatment plants with respect to the reduction of embryotoxic potentials in surface water and sediment (Thellmann et al. 2015)
- Impact of Prochloraz on masculinization of zebrafish (*Danio rerio*) (Baumann et al. 2015)
- Investigations of BFCOD activity in fish cell lines and zebrafish embryos and its modulation by chemical ligands of aryl hydrocarbon and nuclear receptors (Creusot et al. 2015)
- Investigations of acetylcholinesterase in zebrafish embryos as a tool to identify neurotoxic substances in sediments (Kais et al. 2015)
- Experiments on genotoxic and teratogenic effects of freshwater sediment samples from Rhine and Elbe River (Germany) in zebrafish embryo using a multi-endpoint testing strategy (Garcia-Käufer et al. 2015)
- Larval behavioral disruption in offspring of zebrafish exposed through diet to three environmentally relevant mixtures of PAHs and long term effects of a pyrolytic mixture (Vignet et al. 2015)
- A study on time dependent expression and activity of cytochrome P450 1s in early life-stages of the zebrafish (*Danio rerio*) (Bräunig et al. 2015)
- Development of a threshold-screening ANOVA as an algorithm to unmask hidden gene expression patterns in aggregated noisy transcriptome data (Hausen et al. 2015)
- Investigations on the toxicity of sediment cores from Yangtze River estuary to zebrafish (*Danio rerio*) embryos (Wang et al. 2015)
- Investigations on sediment toxicity of German rivers applying a standardized bioassay battery (Hafner et al. 2015)

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