1. Publishable summary

Introduction

The project RISKCYCLE ("Risk-based management of chemicals and products in a circular economy at a global scale"), which was funded by the EU Framework Program 7, has started in 2009 and has been accomplished until 2012. Within this coordination action a consortium of international experts investigated and defined the future research needs and gaps of R+D contributions for innovations in the field of risk-based management of chemicals and products.

Various potential hazardous chemicals are used as additives in products worldwide. By developing new chemicals and product management approaches, the risks for human health and the environment should be minimized. As a first step, existing information about usage, risks, chemical properties and labeling chemicals and especially additives in consumer and industrial products were assembled and evaluated. RISKCYCLE focused on the fate and behavior of these additives in six sectors: textile, electronics, plastics, leather, paper and lubricants. Additionally it was aimed at developing alternative testing strategies to minimize animal testing.

Background of the project

The global trade of chemicals and products containing chemical additives such as paint, cosmetics, household cleaners, paper and cardboard, plastic toys, textiles, electronic appliances, petrol, lubricants etc. has resulted in a substantial release of harmful substances to the environment with risk to man and nature on a worldwide scale. Detailed information about the global flows of recycling products are scarce and difficult to investigate.

Figure1 shows a simplified material flow in a circular economy at global scale with its risks for health and the environment in consequence of the worldwide trade of chemicals and products. The new threat is coming from closing the loop in a global scale. Plastic, paper and cardboard, lubricants and other products undergo a recycling process and make their ways into a recovered material with unpredictable and not foreseen health and safety problems.

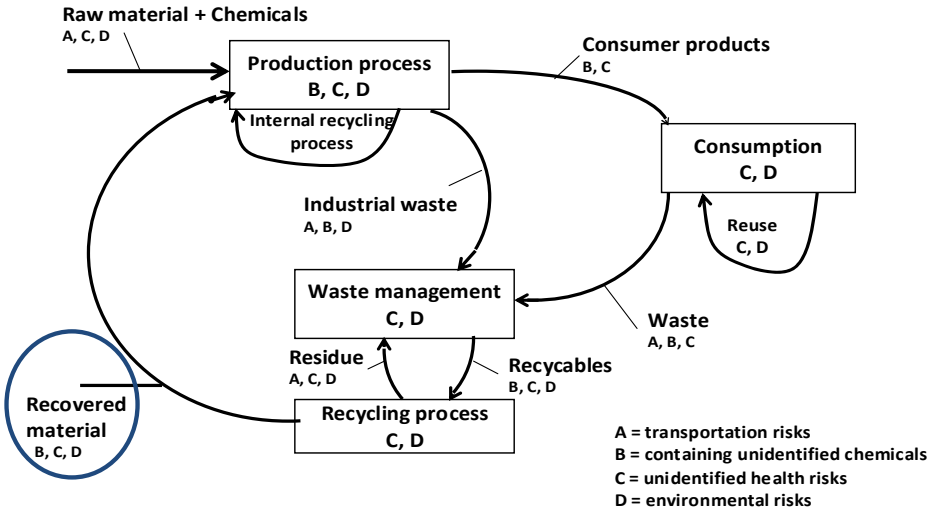


Figure1: Simplified material flow of a circular economy in a global scale with health and environmental risks

The awareness that humans and the environment are exposed to chemical risks on a daily basis, led to the fact that chemicals management and minimizing the risks of using them went into the focus

of politicians in Europe and worldwide. The discussion of the assessment and management of chemicals and products at the 1992 Earth Summit in Rio de Janeiro led for example to the creation of the OECD programme Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Further harmonization of the chemicals legislation in Europe has been done in 2007 by REACH ("Registration, Evaluation, Authorisation of Chemicals") entering into force. Currently there are additional discussions about possible improvements of REACH legislation, which should be decided by the end of 2012. RISKCYCLE aims at contributing to influence the development of REACH, by providing gained results and concluded needs regarding the management and labeling of chemicals.

Circular economy

The concept of a Circular Economy describes the transformation of traditional patterns of economic growth and production. The conventional perception of economic systems is that they are linear. The linear system is converted to a circular system when the relationship between resource use and waste residuals is taken into consideration.

In the year 1996 the German parliament passed the worldwide first law on Circular Economy and since then a number of comments demanded a revision of the law. In 2012 it has been revised and focuses now even more on the management of waste as valuable resource and its material flow.

The German government has still been guided by the ideas that waste and pollution prevention are the foremost aim of the development of a circular economy. The prevention could be reached by a change of technology of production to cleaner production. Further on the better reuse and recycling of waste and better and more recycling friendly construction of goods are demanded to fulfill higher recycling rates.

Although there are already good examples at national level, but new threats arise from closing global substance cycles. The trade of products of unknown specification and ingredients will cause unsafe consumer and industrial goods arriving on the global market. An exemplary compound with oestrogenic activity, which has already been extensively studied and which is formed as an intermediate in the production of polycarbonate and epoxy resin, is Bisphenol A (BPA).

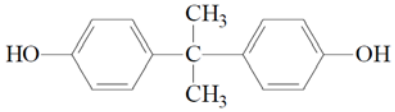


Figure2: 2,2-Bis-(4-hydroxyphenyl)propan (Bisphenol A, BPA) [1]

Toxic substances in WEEE may include for example heavy metals, such as lead, mercury and cadmium or organic halogen compounds, such as polychlorinated biphenyls (PCBs) and brominated flame retardants (BFRs). Currently it is estimated that up to 80% of electronic waste is being transported illegally from developed countries into developing countries in Asian and African, due to lower labor costs and lack of control of environmental rights, where they are recycled and prepared for re-use.

A closer look on paper and cardboard recycling cycles shows that endocrine disruptors are increasingly introduced into the paper cycle, for example the already mentioned BPA by recycling of used thermal papers. BPA may be subsequently detected in recycled paper and within the next product or within waste water (toilet paper). Printing inks used in newspaper printing may result in contamination of cardboard packaging for the food industry and thus enter the food chain of humans. [2]

Using these hazardous substances is partly already banned or restricted in Europe. Due to the international trade of products, also from lower production standards, unforeseeable health and safety problems may occur. All these examples show that in a circular economy, global trade without a globally agreed risk assessment for existing and new chemicals and products is inacceptable.

Collaboration in a coordination action

Under direction of Prof. Bernd Bilitewski (Technische Universität Dresden) and Prof. Damiá Barceló (Spanish National Research Council (CSIC), Barcelona) five international conferences have been organized over the past three years. Among others the main aim of the workshops was to give the 16 project partners and the representatives from the Advisory Board of the project (e.g. OECD, UNEP, SAICM) the possibility to discuss country-specific problems and research results together with international and also local politicians and representatives. The outcomes of these workshops have been included into the main tasks of the single work packages of RISKCYCLE and in the created reports and publications. The presentations, pictures and proceedings of the single RISKCYCLE conferences are available as download on the project website.

Figure3: Group picture of all participants of the 2nd conference in Shenyang

The first two conferences were held in May 2010 in Hanoi (Vietnam) and in November 2010 in Shenyang (China), with an enormous amount of 70 – 100 participants each (see Figure3: group picture from RISKCYCLE conference in Shenyang, China). In 2011the two international conferences were held in May 2011 in Rio de Janeiro (Brazil) and in October 2011 in New Delhi (India). Due to the organization by each of the international partners, an interesting mix of international speakers and topics could be presented. Research results, which are usually written and published in foreign languages and thus difficult to obtain, have been made publicly available to a broad European audience and provided versatile and valuable input to the project.

The final RISKCYCLE conference, titled "Risk-Based Management of Chemicals and Products in a circular economy at a global scale", was held on 8 and 9 May 2012 in Dresden.

Selected results of investigations and case studies have been introduced and presented. The conference was divided into two days. On the first day the aim of the conference was among others to introduce the main aims of the project RISKCYCLE, to present flows and emissions of additives - from production to reuse, recycling and waste, the fate and behaviour of chemical additives in recycling products and alternative toxicity testing for additives in products to reduce animal test in line with the objectives of the REACH directive.

Figure4: Group picture of all participants of the final RISKCYCLE conference in May 2012 in Dresden

The second day of the conference dealt with several risk assessment methodologies and mitigation strategies for human health and environment related to additives, the importance of additives in life cycle assessment of textiles, electronics, plastics, leather, paper and lubricants and also attempts to bridge research needs with policy in the field of Risk-Based Management of Chemicals and Products.

The final RISKCYCLE conference has been concluded every day with a final discussion led by the work package leaders and speakers. Together with the audience the contents of the presentations and further on the needs of future research activities in the field of risk-based management of chemicals and additives have been discussed. The papers about the presentations and also to the poster presentations are included in the proceedings [5] of the conference, which are available via the website of the conference organizers.

Results and conclusions

In the beginning of the project the most dangerous substances and additives for each of the six considered fractions were set by means of literature researches. Then they were examined further in the ongoing course of the project and the intensive individual work packages.

Within the paper, leather and textile industries, different additives, dyes and tannins, influencing the properties, were object of observation. The chemicals Nonylphenol, Bisphenol-A and various biocides were determined as pernicious and significant additives within these six sectors and should therefore be considered more detailed. Within the leather industry also heavy metals, such as Chromium, have been investigated more in detail. In addition the use of flame retardants, particularly brominated flame retardants, has been analyzed within the electronic and textile industry. The use of PFOS, PFOA and NPAA in the lubricants industry and the use of phthalates (DEHP), lead and organotin are also in the focus of the project activities.

The cooperation of international experts within the various work packages, targets at using different approaches when dealing with the core issues of RISKCYCLE to develop a common strategy using the gained knowledge. The individual work packages of the project include for example identifying alternative testing methods for chemicals and additives in products, to avoide the enlargement of animal testing; risk assessment methodologies, as well as the consideration of life cycle assessment of and socio-economic aspects, occurring due to unintended appearance of additives.

Future Impact of the project RISKCYCLE

The aim of the coordination with a consortium of European and overseas experts is to investigate and define the future research needs and gaps in this field. The following bullets show some of the current research needs and gaps, which have been considered to be important by the work package responsible persons:

- Lack of data about chemicals in products
- Risk of chemical mixtures
- Release of chemicals from materials and goods
- Scarce information on characteristics related to the use of chemicals
- Associated uncertainty is missing for in vivo experiments
- Necessity to increase the acceptability on alternative methods
- Missing common database for additives in the WEEE
- Limited specific data about informal recycling processes (efficiency,emis-sions)
  Lack of information about additives in products in LCA databases
- More detailed emission models for products need to be developed
- Necessity to establish the link between emissions and impacts of a substance

RISKCYCLE - Future outlook

What will be the outcome of the RISKCYCLE project and how is the influence on research policy and legislation? Different ways for implementation are conceivable: the Ecodesign Directive, European Waste Legislation (RoHS, WEEE, and REACH).

The Ecodesign Directive is the regulation that sets the standards for products in principle for the pre-consume phase, so that only those chemical additives may be added that do not cause problems in a sustainable closed material and substance cycle. Currently the Directive is being discussed to expand its scope, and not only to products related to energy consumption.

Since the implementation of the RoHS Directive many problems have already been addressed and hazardous components have been limited or banned. The outcome of the RISKCYCLE project and further research initiatives could be a reason to extend the scope of the Directive either by a broader scope (not only electrical and electronic equipment) or by extending the catalog of restricted substances (Annex II of the Directive).

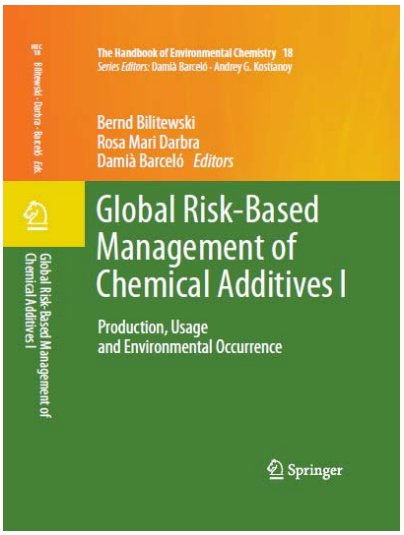
According to the European Chemicals Legislation (REACH) manufacturer and importer have to register chemicals they are bringing on the European market, if the sold volume exceeds more than 1 Mg/a. The REACH regulation has the item that after a five years period there should be an evaluation of the regulation itself – this is where the results of the project RISKCYCLE and follow-up research could give more information to the European legislation As soon as a material or a waste ‘ceases to be waste’, it becomes instead a product and is falling under the REACH regulation. Actually the Commission is working on establishing end-of-waste criteria for a number of specific recyclable materials. With regard to the outcome of RISKCYCLE, the obligations for products containing hazardous substances are of great concern, a risk characterisation is mandatory.

Publication of the results

The homepage of the project RISKCYCLE (www.wadef.com) provides published reports and latest results, for example:

- Overview of environmental factor influence over additive exposure and release into the environment
- Review of models for predicting the concentration of chemicals in air, water and soil to human exposure, including mathematical and functional specification of the multimedia software
- Report containing a discussion on the identified criteria and their scores for alternative methods
- List of databases and meta-databases
- Report on the review of bioassays and biosensors and (Q)SAR models as candidate for the intended use
- Definition of risk scenarios and historical analysis
- Life Cycle Assessment of additives
- Meta-analysis of damage costs related to health, the built environment and the ecosystem

For each of the considered six fractions a list with five main additives, which have been studied in detail, has been compiled. Using these selected additives, exemplary investigations have been carried out within the single work packages, such as Life cycle assessment of additives in the plastics and paper industries, or the use of different risk assessment methodologies to investigate the effects of using these additives and their behavior in various recycling processes. The results of these investigations and the first project outcomes are published in the book *"Global Risk-Based Management of Chemical Additives I (Production, Usage and Environmental Occurrence)"*. [3]



Additional results of the second project period will be published at the end of 2012 as part of the book, *"Global Risk-Based Management of Chemical Additives II: (Risk-Based Assessment and Management Strategies)"*.

References:

[1] Gehring, M. (2004): Verhalten der endokrin wirksamen Substanz Bisphenol A bei der kommunalen Abwasserentsorgung. Beiträge zu Abfallwirtschaft und Altlasten, Schriftenreihe des Institutes für Abfallwirtschaft und Altlasten der TU Dresden, Bd. 34, Pirna: Forum für Abfallwirtschaft und Altlasten.

[2] A. Kersten; U. Hamm; H.-J. Putz; S . Schnabel; Wochenblatt für Papierfabrikation 1/2011 S.14-21

[3] B. Bilitewski; R.M. Darbra; D. Barceló; Global Risk-Based Management of Chemical Additives I (Production, Usage and Environmental Occurrence); The Handbook of Environmental Chemistry, Vol. 18; Springer Verlag, Heidelberg

[4] B. Bilitewski; R.M. Darbra; D. Barceló; Global Risk-Based Management of Chemical Additives II: (Risk-Based Assessment and Management Strategies); The Handbook of Environmental Chemistry, Vol. 23; Springer Verlag, Heidelberg

[5] Bilitewski, B.; Grundmann, V.; Barcelo, D.; Ginebreda, A.; Casal, J.; Darbra, R.M.; v.d.Voet, E.; Rydberg, T.; Benfenati, E.; Risk-Based Management of Chemicals and Products in a Circular Economy at a Global Scale, Conference proceedings, 8-9 May 2012 Dresden, Germany; Beiträge zu Abfallwirtschaft und Altlasten, Schriftenreihe des Institutes für Abfallwirtschaft und Altlasten der TU Dresden, Bd. 87, Pirna: Forum für Abfallwirtschaft und Altlasten