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SEVENTH FRAMEWORK PROGRAMME

RISKCYCLE

RISKCYCLE (#226552)

Proceedings of the 2nd RISKCYCLE workshop

(Deliverable 2.1.)

Workshop proceedings

Risk of chemical additives and recycled materials

State of the art, new challenges and future trends

Report on the 2nd workshop of the RISKCYCLE Coordination Action

Shenyang, China, 15th – 19th November 2010

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1. Introduction and Executive summary

The second RISKCYCLE workshop was held from 15 – 18 November 2010 in Shenyang, China. The host of the workshop was partner ICEEE - Institute of Clean Energy and Environmental Engineering from Shenyang Institute of Aeronautical Engineering, who had prepared a tentative programme. This workshop was used to present and summarise the results and achievements of the projects first year and also as a platform for exchange of information, involving scientists, policy-makers and stakeholders related to chemicals and risk assessment. The projects workshop was combined with a one day conference about "Waste Management and Circular Economy", which offered the possibility for all project partners to talk to local scientists and policy-makers, which presented especially local problems, related to the main tasks of RISKCYCLE. An enormous amount of more than 100 participants took part at the workshop.

Scientific waste management not only can solve the environmental problems caused by solid waste pollution, but also reduce the waste of resources and promote sustainable economic development. Circular economy is one of new model of economic development, which core contents include high efficiency of resource utilization and recycling. The main principles of circular economy are reduction, reuse and resource, while it characteristics include low consumption, low discharging, and high efficiency. So scientific waste management is one of most links in the circular economy, and it is very meaningful for economies sustainable development, lower resource waste and ecological environment protection.

1.1 Summary of session 1

The first session of the 2nd workshop was dedicated to welcome all participants to Shenyang Institute of Aeronautical Engineering and to introduce the goal and scope of the project.

After the first day of the workshop, which was organized as an international forum for Waste Management and circular economy, the second day was opened by speeches of the Chinese hosts. They all lined out among others that the technology of waste resource utilization and pollution control in China, comparing with developed country, is relatively lag. So it is very urgent to strengthen the communication with developed countries and import advance technology. Therefore the waste management and circular economy forum has been organized. The objective of this forum has been to improve the level of waste management and circular economy, promote sustainable and healthy development of economy, and reduce the waste of resource and protection the ecological environment. The main topics of the international forum included circular economy and low carbon city, municipal solid waste management and resource utilization and hazardous waste management and environmental risk assessment.

Further on everybody addressed good wishes and that the 2nd RISKCYCLE workshop and the project in general would become very successful!

Among these speeches Veit Grundmann introduced the goal and scope of the project RISKCYCLE to all attendees and highlighted why the project is necessary and what the importance of a global network of information about the risk of chemicals and additives in products is. Further on he introduced the philosophy of a coordinated action, the difference to a research project and introduced the involved parties and project partners.

1.2 Summary of session 2

In this session three case studies were presented concerning with the fate and behaviour of chemicals and products for some industrial sectors covered in the RISKCYCLE project in different countries, namely China, Vietnam and India.

The first presentation was by Professor Jinhui Li from the Department of Environmental Science and Engineering (Tsinghua University, China) who exposed the state of recycling technologies for plastics in China, where there are a large amount of small recycling enterprises. He reviewed some of the most relevant aspects concerned, such as the existing regulatory framework as well as the requirements for plastic waste management throughout the whole process (storage, separation, pre-treatment and recycling steps). Caution should be taken with plastic waste coming from electronic products, since it may contain hazardous compounds like polybromodiphenyl ethers (PBDE) and polybromobiphenyls (PBB). E-waste must be therefore considered and managed as hazardous waste. To the end, some conclusions and suggestions about possible measures to be taken in the future to improve plastic recycling were presented.

The second speaker was Professor Pham Hung Viet from Hanoi University of Science (Vietnam). He presented a case study related to human exposure to brominated flame retardants (BFR), polychlorinated biphenyls (PCB) and dioxin-related compounds (DRC) in Vietnamese people working in E-waste Recycling sites (EWRS). These chemicals qualified as persistent, toxic and bioaccumulative are covered by the Stockholm Convention. In the study presented breast milk samples from workers of two types of recycling plants (i.e., urban and family based recycling plants) were collected and analyzed. The results showed that EWRS workers are directly exposed to these chemicals since E-waste storage and handling conditions are insufficient. Dust was also recognized as an important exposure and intake pathway for the compounds under concern. The study concluded that the exposure levels of these persistent organic pollutants were generally greater in small family operated recycling plants.

Finally, Col. Rakesh Johri and Dr. Suneel Pandei (The Energy and Resources Institute, New Delhi, India) presented a speech about the recovery and valuation of physico-chemical sludge generated in waste water treatment plants of the textile industry in India. After describing the main traits of the industrial sector concerned, research was focused on finding a valuable use for the large quantity of chemical sludge generated in common waste-water effluent treatment plants (CETPs). Sludge collected from 4 areas in India was characterized and subsequently used for manufacturing cement blocks adding appropriate binders and other additives. The so obtained cement-sludge blocks fulfilled the mechanical properties required for most of the materials used for non-structural purposes.

1.3 Summary of session 3

Section 3 of the second RISKCYCLE workshop focuses on alternative methods usable to obtain information on toxicology profile, physic-chemical characterization and environmental fate of chemicals without extensive testing approach. The section includes two presentations made by Diego Baderna (WP4 - IRFMN) and Professor Jingwen Chen from the School of Environmental Sciences and Technology of Dalian University (China).

The first speech was related to the progress done in the first year of the project by WP4 and included a brief introduction on alternative methods and the explanation of the goals already achieved. Alternative methods (AMs) was developed to reduce, replace or refine the use of animal models to obtain toxicological and environmental-related properties because of two main reasons: the ethical aspects and the cost and time consuming aspects linked to animal experimentation. In the recent years, scientific community hardly works on alternative methods in particular for the REACH legislation. AMs can be easily classified into two main categories: testing and non testing methods. Testing methods include in vitro assays, ex vivo tests and reduced/refine in vivo test (mainly on lower classes organisms) while non testing methods are in silico models and PBMK models. The presentation focused on in vitro and QSAR models. Regarding in vitro, the methods was initially developed as tool for risk assessment of drugs but nowadays they can also be successfully applied on environmental studies. An huge number of standardized and validated in vitro models and protocols is already available and usable worldwide. Data from ECVAM validation process was also presented suggesting that some in vitro test is already validated and some others is under evaluation covering the most important eco and toxicological endpoints like aquatic acute toxicity, genotoxicity and developmental toxicity. Despite the big effort done, in vitro assays are not ready to completely replace, at this moment, animal testing but they can be considered as a valid tool to reduce or refine the use of animals. Referring to QSARs, some general slides were shown to describe which are the components of QSAR models and the progress done in the last years by mathematical and computer sciences. The different ideal characteristics of QSARs model for academia, regulators and industries were shown focusing on criteria proposed by regulators due to the nature of RISKCYCLE project. Additionally, the possible validation criteria were described including the ones from REACH legislation and

OECD guidelines. In particular, validation is based on the transparency of the model, the applicability domain, the defined endpoint and the unambiguous algorithm. Moreover, some criteria were recommended basing on the experience of the WP4 partners highlightening the need of models easy to use and able to provide easy to understand results.

The second presentation targeted the application of computational toxicology on environmental field as a tool for risk assessment. Computational toxicology applies mathematical and computer models and molecular biological and chemical approaches to explore both qualitative and quantitative relationships between chemical exposure and adverse health outcomes. Three example of models developed by the Chinese team were shown. The first model is able to estimate the octanol-air partition coefficient (Koa), an important environmental property influencing the long range transport of chemicals. Experimental determination of Koa is costly and laborious. The second model targets the photodegradation. Photodegradation is the main degradation path determining environmental persistence of Persistent Toxic Substances (PTS). Data on photodegradation is scarce and it is difficult to establish predictive models on photodegradation kinetics and pathways, due to the complex of photochemical reactions. The model approach is based on quantum chemical calculation used to extrapolate the algorithm from experimental results. In particular, the developed model was applied on photodegradation of antibiotics and sunscreens in aquatic environment. Third models investigate the toxicological potential on thyroid hormone, in particular the effects of HO-PBDEs compounds. These chemicals have similar molecular structures to T3 and T4 thyroid hormones. Different Quantum Chemical structure parameters were analyzed to characterize the interactions between the chemicals and the thyroid hormone receptor.

The two presentations highlighted the role of QSARs and Computational Toxicology in environmental researches, in particular when there are no information on chemicals toxicity or their environmental properties.

1.4 Summary of session 4

This session consisted of 5 presentations on different topics related to risk assessment. Speakers from RISKCYCLE project and one professor from Nankai University (China) participated in this session.

The first speaker was Dr. Rosa Mari Darbra from the Polytechnic University of Catalonia. Her presentation was about RISKCYCLE WP5: aims achieved and future goals. She introduced the main aim of this workpackage as well as the work done until this moment. She also introduced the revision of methodologies to assess risk of chemicals for human health and environment prepared by all the WP5 partners. A set of criteria were also presented in order to select the most suitable methodologies to be applied to the RISKCYCLE selected substances.

In second place, Dr. Gaël Bellenfant from the BRGM (Geological Survey of France), presented a speech on the “Use of hybrid uncertainty theories to analyze the risk of exposure to Bisphenol A”. This compound is broadly use in the industry and can cause effects on human health and environment. In order to assess the risk of this type of substances, he presented a possibilistic model with which is possible to assess the risk of Bisphenol A for babies and adults.

After him, a presentation from Prof. Qixing ZHOU was held. He talked about the impact of agricultural activities in Shonghua River in China. Since 1949, the agriculture has increased a lot in this area. As a consequence, the overuse of fertilizers and pesticides has raised a lot. The water quality is decreasing continously. At the moment, only monitoring controls are being conducted. Hopefully, measures to improve the situation will arrive soon.

In fourth position, Prof. Marta Schuhmacher from Univesitat Rovira i Virgili presented one of the methodologies for risk assessment commented in the first presentation: USE-tox. This tool comes from a consensus taken at the SETAC conference and includes the point of view of other well-known methodologies used for risk assessment and life cycle assessment. Three factors are necessary to characterize the risk: fate, exposure and effects. Prof. Schuhmacher showed an example on how to use this tool applied to nonylphenol. At the end of the presentation, the advantages and disadvantages were commented.

Finally, Mr. Taku Tanaka introduced another of the aforementioned models: 2-FUN-tool. Mr. Tanaka has been working on the development of this tool in the framework of an EU project called 2-FUN. The idea was to present an integrated approach to assess health risk for toxic chemicals by linking multimedia environmental and PBEK. Mr. Tanaka presented a case study on the benzopyrene found in the river Seine (Paris). The concentration of this substance on lungs and liver was estimated and its risk for the human health was assessed.

1.5 Summary of session 5

This session consisted of 2 presentations on different topics related to life cycle assessment. One speaker from the RiskCycle project and one professor from Tsinghua University (China) participated in this session.

The first speaker was Dr. Henrik Fred Larsen from the Technical University of Denmark. His presentation was about RiskCycle WP6: “Life cycle assessment and additives: state of knowledge”. He introduced the main aim of this work package as well as the work done until now. Afterwards, he introduced the general principles of life cycle assessment (LCA) including life cycle impact assessment (LCIA) as well as the special LCA-related focus points of RiskCycle. Furthermore, reviews on the state of knowledge regarding LCAs on plastics and printed matter/paper including additives/impurities were presented. Finally, the existing availability of LCIA characterization factors for the proposed additives to be included in RiskCycle was shown.

The second speaker was Professor Jinhui LI from Tsinghua University. The title of his presentation was “Life cycle assessment of chemical hazardous waste in China”. In the first part he presented general principles of LCA and the results of a life cycle assessment study on a Chinese desktop personal computer. This study didn’t include hazardous waste and the results showed dominance of potential impact in the production stage and the use stage whereas the end of life stage showed benefits in the overall impact profile of the computer. The second part of his presentation focused on additives in plastics and e-waste in China. He presented relatively detailed results on total material/chemical content of different “waste types” (refrigerators, air conditioners etc.) based on literature values.

1.6 Summary of session 6

The sixth and final session of the workshop was devoted to societal and spatial aspects of material flows, waste and pollution of chemicals from these flows. In addition, a discussion panel concluding the whole workshop was part of the session.

The first presentation by Dr Tomas Rydberg, from IVL, gave an overview of the socio-economic aspects of additives, with examples relating in particular to the content of hazardous substances present in e-waste. There are positive aspects related to the additives, in terms of, e.g. adding function and value to the product where the additive is used. The negative aspects in focus in Dr Rydberg's presentation covered the damage costs to environment and to human health related to additives emitted from the products during use, or during various reuse, recycling and waste management operations. Through these operations, additives may appear in products and locations where they were not intended.

In the second presentation, Professor Geng Yong, from the Chinese Academy of Sciences, gave an overview and provided insight from studies on the spatial characteristics of the availability of recyclable material on regional level. As the population density differs in different parts of the region, also the amount of collectible material varies accordingly. The presentation highlighted the challenge of collecting recyclable material in a way that makes recycling happen in an economic way, but also pointed at some solutions that are already in place to deal with the challenge.

The panel consisted of Prof Bernd Bilitewski, Professor Damia Barcelo, Professor Li Rundong and Professor Li Jinhui. The panel members first summarised from their individual point of view the impressions of the workshop. The main messages were that the workshop had been very successful, addressed quite important topics, and that the area raises huge challenges, which involves not only scientific aspects, but also political and economic aspects. This complicates the identification of solutions. Furthermore, there is a vast need for further details in describing the amount and nature and waste and contaminants. This underlines the need of initiative like RISKCYCLE.

The panel thanked Professor Li Rundong and his team for arranging a very successful workshop.

2. RISKCYCLE workshop presentations

2.1 Introduction Speeches of Chinese hosts

2.1.1 Speech from Mr. Rui Xiaomiao

Distinguished leaders, guests, and friends from the media, good morning.

Promoting the green economic development is a key step in china's sustainable economic development in the twelfth 'five year' plan and also in a long period of time in the future. Based on the comprehensive in depth analysis of our country's current status, strategic demand and the path for our modernization, the party and the government put forward the development goals of "promoting green economic development and constructing ecosystem and awareness. We believe the break-through would lie in the promotion of the low-carbon circulation concept, and in the development of low-carbon circulation economy. It is for this purpose, the forum is being held today, jointly sponsored by Chinese Academy of Engineering, Chinese Academy of Science, Shenyang Aerospace University and Shenyang University. SAU and SYU jointly hold this international forum of "Circulation Economy and waste management", with the hope to advance the academic communication on the subject between Chinese and overseas scholars, and to make new contributions to the development of the Circulation Economy and waste management of China. Now I declare the international forum for 'circulation economy and waste management' open.

Please allow me to introduce distinguished leaders and guests present today :

- Academician Jin Yong, professor, Tsinghua University,
- Academician Yang Fengtian, president of Shenyang Aerospace University,
- Academician Sun Tieheng, president of Shenyang University,
- Mr. Wang Zhijiang, deputy director of the bureau of Environmental Protection of Liaoning Province,
- Mr. Wang Liyan, deputy inspector, The reform and development committee of Liaoning Province,

- Mr. Taohua, Chief of staff, China association of Urban environmental sanitation,
- Professor Chiyong, Jiejiang University,
- Professor Zhao youcai, Tongji University,
- Professor Bilitewski, Dresden University of Technology, Germany,
- Professor Barceló, Barcelona Institute of Chemistry and Environment, Spain,
- Professor Huang huanzhong, Hongkong Baptist university,
- Professor Wang shaohong, vice president of Shenyang university,
- Now, let's welcome Academician Yang Fengtian, president of Shenyang Aerospace University, to give us a speech,
- Now, let's welcome Mr. Wang Zhijiang, deputy director of the bureau of Environmental Protection of Liaoning Province to give us a speech,

The first part of the opening ceremony is now finished, we will have a 30 minutes tea break, all questes, please go downstairs for a group picture-taking ; At 0:30, Mr. Taohua, researcher from China Association Of Urban Environmental Sanitation, will host the first subject discussion on 'low carbon city and circulation economy'.

2.1.2 Speech from Mr. Yang Fengtion

Honorable Guests, Ladies and Gentlemen:

Good morning.

As we are entering the winter of 2010, International forum "Circular Economy and Waste Management)", hosted by Chinese Academy of Engineering, Chinese Academy of Sciences, Shenyang Aerospace University and Shenyang University, is now open in Shenyang Aerospace University. On behalf of the faculties and students of Shenyang Aerospace University, I would like to extend my warm welcome to our distinguished guests and friends and wish the forum a complete success in advance.

Characterized by aeronautics and astronautics, Shenyang Aerospace University (SAU) is a multi-disciplinary university, which, while focusing on engineering, also covers such areas as science, liberal arts and management. The university now has 44 specialties, among which six are national specialties. SAU is under the administration of China Industry and Information Technology Ministry and Liaoning Provincial Government, and has five leading programs of Liaoning province.

With respect to the research of circular economy and waste management, the key provincial cleaning energy lab of SAU focuses on the application technology of clean energy and solid waste energy. Among which, the researchon the application technology of solid waste of low-level fuel has reached international level. Technology of pollution control and urban solid waste bio-anaerobic fermentation is in leading position of China. In recent years SAU undertakes fifty projects in international cooperation, national and provincial level. SAU gets more than ten awards from provincial government, which produces effective social and economical benefits.

Circular economy is an economical growth pattern, with effective and recycling use of resource as its core, reduction, recycling and resource as its principle, and low cost, low consumption and high efficiency as its feature. Reasonable waste management plays a key role in recycling economics development.

Currently, china has a long way to go to catch up with the developed countries in the technique and development pattern of circular economy and solid waste management. The successful holding of the conference will undoubtedly promote the exchange among scholars from home and abroad and push the circular economic development of China to a higher level.

This conference also offers an invaluable opportunity for us to learn from each other and exchange ideas. SAU will cherish this chance and strive to work with scholars and experts in the field for the development of circular economy and waste management, for building a beautiful resource-conservation society.

Finally, I wish the conference a complete success and may all of you enjoy good health and stay happy.

Thank you.

2.1.3 Speech from Mr. Wang Zhijiang

Fellow leaders, Specialist from home and abroad, teachers and students:

Good morning everyone!

In order to further strengthen environmental protection and resource conservation consciousness, vigorously develop circulation economy and construct a conservative society, China Academy of Engineering, Shenyang Aerospace University, Shenyang University and China Academy of Science jointly sponsor“Waste Management and Circulation Economy International Forum”.

Today, this forum is being held grandly at the Shenyang Aerospace University, this will help Liaoning to implement and solidify scientific development concept, vigorously develops circulation economy, impetus energy conservation reducing platoon and realizes sustainable economic development.

Here, I represent the Shenyang People’s Government to wish the“Waste Management and Circulation Economy International Forum”a complete success in advance! And extends warm welcome and sincere regards to energy expert from home and abroad, and leaders and guests who have visited Shenyang to attend the forum!

Harmony between human and nature are unchanging subjects of an urban sustainable development, Shenyang urban development must makeprotecting ecological environment as foundation for urban construction, and set up the circulation economical idea as its premise.

Liaoning's economy has already entered the fast development period. But we should never forget that constructing a harmonious city or the whole province, is for the purpose of solving ecology problem, repairing ecological environment, developing ecology economy and perfecting the ecosystem.

In recent years, Liaoning urban construction takes the ecology urban construction committed, insisting that environmental protection, environment government and ecological building are as important as socio-economic development, resources conservation and resource development. By implementing the three big structural adjustments and economic growth method transformation as the core, using developing the circulation economy as the master line, the environment infrastructural facilities as support, the environment comprehensive improvement as the method, and pollution source control as a vigorous foundation, finally making the establishment of environment protection plan which is adaptive to our socialist market economy and the unified highly effective coordinated environmental management system as our motivation. Liaoning’s economy has maintained a swift growth, and the appearance has improved enormously.

This forum a is a rare opportunity for advancing Liaoning’s circulation economic development, will certainly continue to promote the healthy development and bring about positive effects to Liaoning’s economy, and will certainly play an important role for making Liaoning an exceptional environmental construction model province.

We shall explore the economical and environment coordinated development topic unceasingly, realizing the economic growth method, resources use method and the ecological protection thinking mode transformation, through the circulation economy and waste management's deliberation and practice, providing a out of the ordinary model for the domestic city's environmental construction.

Finally, I wish this forum a complete success in advance; I also wish fellow experts and friends present here good health and success with all your endeavors.

Thank you!

2.2 Introduction to the project

B. Bilitewski [(1)], V. Grundmann [(1)]

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Products undergo a recycling process and make their ways into a recovered material with unpredictable and not foreseen health and safety problems.

The primary aim of RISKCYCLE is to identify future R&D needs required to establish a risk-based assessment methodology for chemicals and products that will help reduce animal testing while ensuring the development of new chemicals and product management pattern leading to minimized risks for health and the environment. The project is focussing on consequences due to the behaviour of chemicals and their release during recycling of the six fractions: paper, electronics, leather, lubricants, plastics, textiles.

The overall objective of the coordination action RISKCYCLE is to establish and co-ordinate a global network of European and international experts and stakeholders from different programmes to define together future needs of R+D contributions for innovations in the field of risk-based management of chemicals and products of a circular economy in a global perspective making use of alternative strategies to animals test.

2.2.1 SPECIFIC OBJECTIVES OF THE PROJECT RISKCYCLE

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.

Unpredictable and not foreseen health and safety risks due to recycling processes of products, which make their ways into a recovered material, are major issues of today's waste management.

In spite of some common efforts to harmonize the safety assessment of chemicals and products a new problem with Recovered Material, as illustrated in Figure 1, additionally appeared. The figure 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.

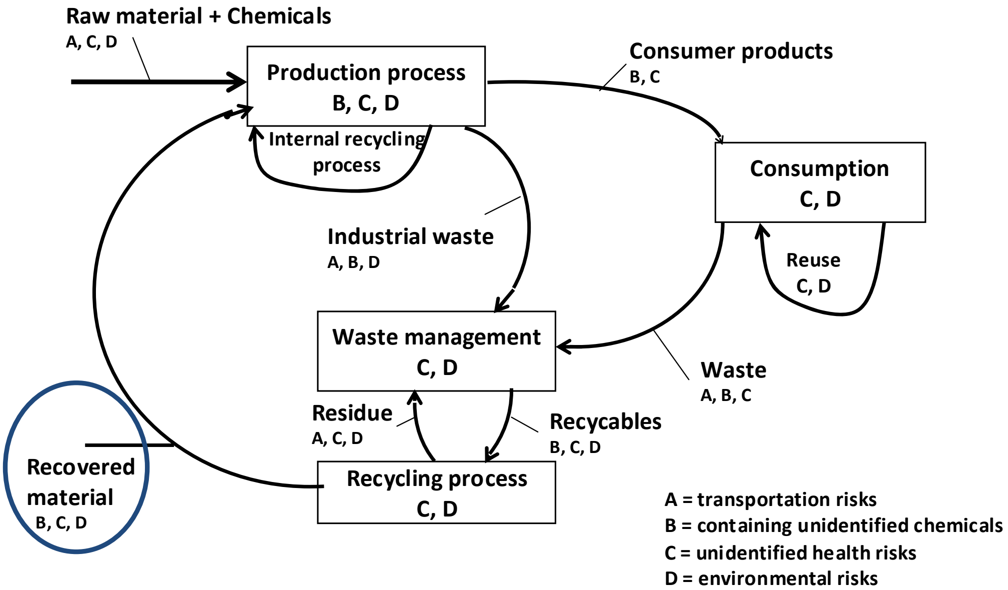

Figure 1: Simplified material flow of a circular economy in a global scale with health and environmental risks

The critical points throughout the products life cycle for the release of chemical substances and the hazardousness of the material set free will be evaluated. Beyond this it is also important to know if the effects caused by the chemicals have a global or only local meaning and if the release of specific substances in the circular economy is an actual risk or a perceived risk.

Within the project the following key pieces of information will be required and collected:

- Where are the critical points throughout the products life cycle for the release of chemical substances? Do methods or defined procedures find “critical points” or is there still the need to develop these methods?
- How hazardous and toxic is the material set free? Has an evaluation and control of the risk of the substances taken place?
- Has a development of strategies for limiting the environmental risks of these substances been done? If yes, for which substances?
- Do the effects caused by the chemicals have a global or only a regional meaning?
- Is the release of specific substances in the circular economy an actual risk or a perceived risk?
- Is the development of new "3R" methods (based on the principles of Refinement, Reduction and Replacement) as a modern alternative approach to the use of animals in safety assessment on a global scale known and supported by regulators? Is there a need to develop new safety assessment methods? Is there a need for 'global harmonisation' (GHS)? Is the 3Rs principle internationally sufficiently known and applied?

The main objective is to establish a global network to explore the synergies of the research carried out within different programmes and countries of the EU, USA, Japan, China, India, Brazil, Vietnam etc. and to facilitate the communication with researchers, institutions and industries and make the information about the risks of hazardous chemicals and additives in products and the risk reduction measures for substances widely available.

The specific objectives of RISKCYCLE are:

- To exploit complementary elements needed with regard to the research objectives, methodologies and data of ongoing as well as recently completed EU and international projects.
- To specify demands for tools for ecological design of consumer products, production, use and reuse of products and waste recycled to secondary material and products. Methods such as LCA, risk assessment and risk reduction strategies, environmental impact analysis, material flow analysis and economics related tools are considered to achieve socio-eco-efficient solutions.
- To create a powerful platform enabling discussion among all stakeholders on usage, risks, chemical properties of consumer products, labelling and the fate of certain chemicals in products traded, used and recycled in a global scale, identify problems and solutions.
- To contribute to the UN Globally Harmonized System (GHS) for chemical substances and mixtures.
- To start with a conceptual development of a global strategy for a risk-based management of chemicals and additives in recycling and trade products.
- To identify alternative testing strategies and methods to avoid the enlargement and the outsource of animal tests to East and Southeast Asia
- To identify knowledge and research gaps for future research activities
- To consider the most effective way of ensuring continuing progress in this field involving EU and other partners at global scale including also international organisations.

The RISKCYCLE network, which consists of international, European and national experts and stakeholders from different programmes and organisations, will closely collaborate with related projects, EU and international bodies and authorities to communicate and agree on standards and to avoid duplication and redundant work. Figure 2 is an illustration of the impact pathway approach showing how the different key-aspects of RISKCYCLE may co-operate and to assess and assist the socioeconomic studies related to chemicals risk as well as the policy instruments including global strategies.

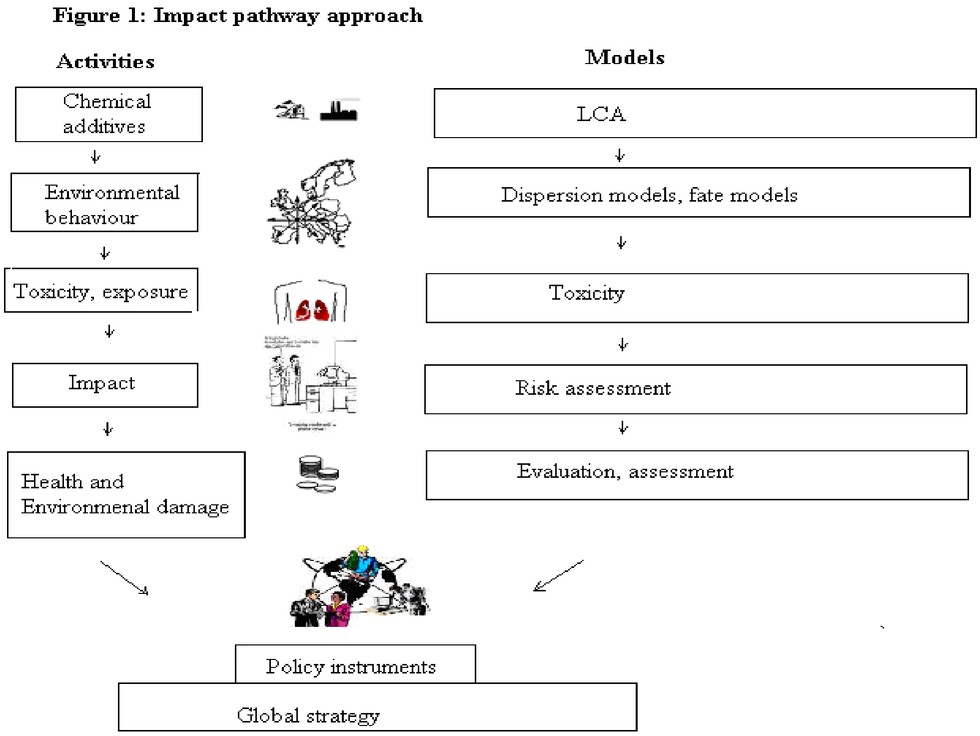

Figure 2: Impact pathway approach

2.2.2 SCIENTIFIC INTERACTION

RISKCYCLE Kick Off meeting

The projects kick off meeting was held from 13 – 15 October 2009 in Barcelona, Spain. It was organised by the coordinator of the project and hosted by partner CSIC. The aim was to align possible different interpretations of the projects tasks from all participating partners and Advisory Board.

During this meeting partners were called to exchange information about their institutions, field of work and culture. It also aimed at putting forward, discussing, determining and organising all future steps related to RISKCYCLE activities: data mining, meetings, web-page establishment, etc. Further discussion on the aims and objectives of the project set the basis for the work to be done and an effective collaboration.

The first RISKCYCLE workshop

The first RISKCYCLE workshop was held from 4th - 5th May 2010 in Hanoi, Vietnam. It was organised by the coordinator of the project and hosted by partner Hanoi University of Science.

This first workshop was used to present and summarise the results and achievements of the first period of the project RISKCYCLE and also as a platform for exchange of information, involving scientists, policy-makers and stakeholders related to chemicals and risk assessment. There was also the possibility for local scientists and policy-makers to present especially local problems, related to the main tasks of RISKCYCLE.

Due to the long-standing very good relationship between HUS and TUD, Hanoi University of Science was chosen to be the host of the first workshop. Nearly 70 invitations have been sent to interested persons, from which a majority took part at the workshop. The results and perceptions of the first workshop will influence all following project workshops and the hosts of future project workshops will benefit.

Information exchange

The RISKCYCLE webpage[1] provides introductory information about the project in several different languages, according to the origin of the participants, to invite contacts with the interested parties in industry, academic institutions, regulators intergovernmental institutions, engineering companies and the public at a global scale.

Further on the results of the research work done within the project (according to the milestones) will be published, as well as newsletters, publications, flyers and the reports from the workshops.

Acknowledgement

The project partners of the project RISKCYCLE would like to thank the European Community for receiving funding from the European Community's Seventh Framework Program under grant agreement n° FP7–226552.

[1] www.wadef.com/projects/riskcycle

2.3 Human Exposure to Brominated Flame Retardants and Dioxin-Related Compounds in Vietnamese E-waste Recycling Sites

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This presentation aims to provide an overview of the on-going research on pollution by persistent organohalogen compounds in Vietnamese e-waste recycling sites (EWRSs). Human exposure to brominated flame retardants (BFRs), including polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs), was investigated using breast milk as bioindicator. Women living in the EWRSs were found to accumulate high levels of PBDEs, up to two orders of magnitude higher than an urban population. The specific accumulation patterns and influences by lifestyle factors suggest that accidental ingestion of dust generated by e-waste recycling as important BFR exposure pathway for EWRS residents. Therefore house dust can be used as exposure indicator of other e-waste related contaminants, and thus was used for evaluation of TCDD toxic equivalents (TEQs) using the Dioxin-Responsive Chemically Activated LUciferase gene eXpression assay (DR-CALUX), combined with chemical determination of PCDD/Fs, DL-PCBs, PBDD/Fs and monobromo PCDD/Fs to determine their TEQ contribution.

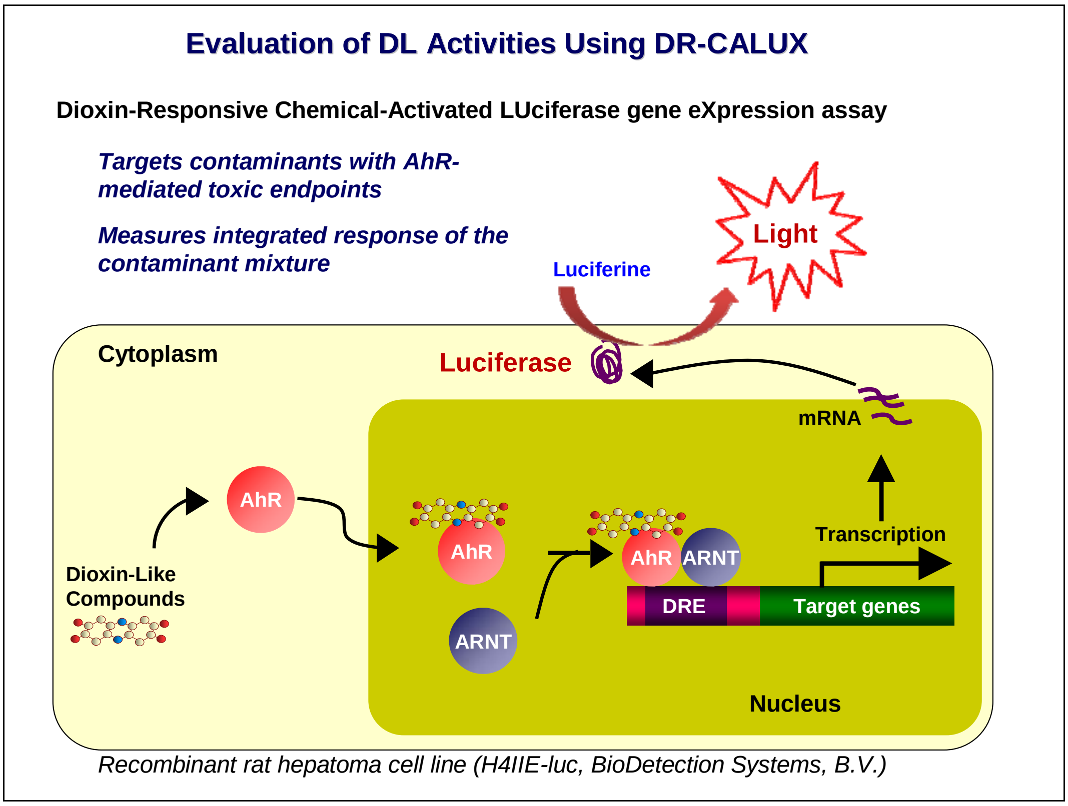

Figure 1: Evaluation of DL Activities Using DR-CALUX

The CALUX-TEQ levels in house dust ranged from 370 to 1000 pg/g in the EWRSs, approximately 3.5-fold higher than in the urban control site. In EWRS house dust, the concentrations of the unregulated PBDFs were 7.7–63 ng/g, an order of magnitude higher than those of regulated DRCs (PCDD/Fs and DL-PCBs), and PBDFs were also principal CALUX-TEQ contributors (4.2–22%), comparable to PCDD/Fs (8.1–29%). However, the percentage of unknown dioxin-like activities was high in all dust samples, indicating large contribution from unidentified DRCs and/or synergy among contaminants. Results of daily intake estimation indicate high exposure levels to PBDEs from breastfeeding for infants of mother actively involved in e-waste recycling and to DRCs from dust for children living in the EWRSs, implying possible adverse health effects.

References

[1] Tue, N. M.; Sudaryanto, A.; Minh, T .B.; Isobe, T.; Takahashi, S.; Viet, P. H.; Tanabe, S. Accumulation of polychlorinated biphenyls and brominated flame retardants in breast milk from women living in Vietnamese e-wastere cycling sites. Sci. Total Environ. 2010, 408, 2155–2162.

[2] Tue, N. M.; Suzuki, G.; Isobe, T.; Takahashi, S.; Viet, P. H.; Tanabe, S. Level sof polychlorinated biphenyls, brominated flame retardants and dioxin-like activities associated with e-waste recycling in Vietnamese house dust. Organohalogen Compd. 2009, 71, 368–371.

[3] Minh, N. H.; Minh, T. B.; Watanabe, M.; Kunisue, T.; Monirith, I.; Tanabe, S.; Sakai, S.; Subramanian, A.; Sasikumar, K.; Viet, P. H.; Tuyen, B. C.; Tana, T. S.; Prudente, M. S. Open dumping site in Asian developing countries: A potential source of polychlorinated dibenzo-p-dioxins and polychlorinated diben-zofurans. Environ. Sci. Technol. 2003, 37, 1493–1502.

[4] Lorber, M.; Patterson, D.; Huwe, J.; Kahn, H. Evaluation of background exposures of Americans to dioxin-like compounds in the 1990s and the 2000s. Chemosphere 2009, 77, 640–651.

[5] Hong, B.; Garabrant, D.; Hedgeman, E.; Demond, A.; Gillespie, B.; Chen, Q.; Chang, C.; Towey, T.; Knutson, K.; Franzblau, A.; Lepkowski, J.; Adriaens, P. Impact of WHO 2005 revised toxic equivalency factors for dioxins on the TEQs in serum, household dust and soil. Chemosphere 2009, 76, 727–733.

2.4 Reuse potential of a chemical sludge – a hazardous waste in textile dyeing process

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Presentation coverage: The presentation would cover the following aspects of waste management in textile dyeing process.

Presentation would summarize importance of textile manufacturing sector in India and prevalence of small scale industrial units engaged in textile dyeing and printing process. This would follow short introduction on textile process and wastewater generation. The wastewater generated from individual units are treated in common effluent treatment plants (CETPs) located in each of these industrial clusters.

The physico-chemical treatment of wastewater leads to generation of chemical sludge in voluminous quantities. This sludge is considered as hazardous waste as per the Indian Hazardous Waste (Management, Handling and Transboundary) Rules of 2008. Presently, the only option available to CETP operators for disposal of this sludge is to send it to a secure landfill which is costly option for small scale industrial clusters.

This case study attempted to find environment friendly ad cost-effective solution for management of this chemical sludge. The sludge samples were collected from various CETPs spread across the country and subjected to characterization for physico-chemical parameters, toxicity and microstructural aspects. Solidification/stabilization (S/S) of chemical sludge was carried out using two binders – ordinary Portland cement (OPC) and pozzolona Portland cement (PPC) to evaluate its suitability as construction material. Evaluation of solidified samples was carried out in terms of its physical engineering properties such as unconfined compressive strength, block density and chemical properties such as leaching of heavy metals. The microstructural examination of solidified samples was also performed using X-ray diffraction (XRD) and scanning electron microscopy (SEM).
The characterization study revealed that the sludge samples were alkaline with high electrical conductivity values. The concentration of heavy metals (Cr, Cu, Ni, Zn,

Cd, and Pb) in the dried sludge as well leachate was found to be less than prescribed limits (Indian Hazardous Waste Rules for sludge samples and UESPA limits for leachate). The oxides such as SiO_2, Al_2O_3, Fe_2O_3, MgO and SO_3 were present in significant amount. The unconfined strength and block density data of solidified blocks indicate that the chemical sludge has a potential to be used as a construction material for different kinds of applications.

2.5 Alternative methods: an updated point of view

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The scope of WP4 is to select alternative methods that will be used to evaluate the toxicity of concerning chemicals selected by the RISKCYCLE project. To do this, in collaboration with the other partners of WP, we have selected databases, possible QSAR models and existing bioassays/biosensors to obtain information on chemicals. Preliminary list of databases and bioassays are already available as deliverables, together with the proposed validation criteria for QSAR models. The oral presentation focus on alternative methods to Replace, Reduce or Refine the use of animal experiments in biomedical research, testing or education as defined by Russell and Burch in 1959. Nowadays, alternative methods can be classified into two main categories: testing methods and non testing methods. The first group includes in vitro assays, ex vivo tests and reduced/refined in vivo methods while in silico methods and biokinetic models are the most important non testing methods. According to ECVAM, the first strategy to avoid animal consuming is to maximize the use of existing data also including occupational and environmental studies, epidemiological investigations and data from post-marketing surveillance. In spite of the great effort made on in vitro testing we are still far to have alternative methods robust enough to cover developmental, neurotoxic, reproductive or carcinogenic potential for the substances evaluated. Scientific community agrees that in vitro methods can be considered as tools to refine or reduce rather than replace animal bioassays.

In vitro assays offer some advantages because they are time-saving and cheap if compared to in vivo experiments. Moreover they require small amount of chemicals and space and they can provide qualitative information on chemical mode of action accounting of the overall effects on cells. Unfortunately, in vitro assays reflect only a part of events induced by chemical on whole organisms, they don't provide info on toxicokinetics and it can be difficult to relate a response to a specific concentration due to the possible interference of evaporation and plastic absorption. An overview of currently validated in silico methods is also shown.

Regarding in silico methods, we include a brief introduction on how to build a QSAR model focusing in particular to chemical databases, one of the main focal “ingredients”. The progresses done in the last years offer the chance to build robust model based on specific descriptors like chemical reactivity and molecular size, leading to an increased availability of more powerful algorithms and, consequently, prediction models.

Regulators, Academia, Scientist and Industries are the most important QSAR users with different starting point and needs. For example, regulators prefer models with low false negative rate and high level of quality control while industries needs low rate of false positive to save money and times. We will show a survey on existing validation criteria for QSAR model including ones suggested from REACH and from OECD. Moreover we suggest additional criteria, like the availability of information on uncertainty and reproducibility of the models but also the simplicity of use and the transparency of the results in order to build an user-friendly model.

2.6 Work pakage 5 - Aims achieved and future goals

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2.6.1 Introduction

Within the framework of the RISKCYCLE project, Work Package 5 (WP5) aims at identifying the different methodologies that can be used to assess the risk of chemicals in products concerning human health and the environment.

Chemicals analysed in the context of the project are additives used in a set of industrial sectors: textile, electronics, plastics, leather, paper and lubricants.

This WP consists of 6 partners from different EU countries and research centers: UCSC (Italy), URV (Spain), CSIC (Spain), TUD (Germany), BRGM (France), UPC (Spain). The work is being done in close collaboration with the all the partners and coordinated by UPC (workpackage leader)

2.6.2 Aims achieved

Since the beginning of the project (September 2009), different tasks have been accomplished in order to attain the aforementioned main objective. For the first six months of the project, WP5 was responsible fordefining and undertaking a work plan to research on textiles. In the same way, each WP team of the RISKCYCLE project was responsible for one of the selected industrial sectors. For the textile sector the following work plan was established:

- Task 1: Collection of general information on textiles and additives used in this sector.
- Task 2: Pre-selection of a limited number of additives (5) used in this sector.
- Task 3: Selection of 2-3 additives according to several criteria.
- Task 4: Presentation of risk scenarios for these substances.

The first task was accomplished in January 2010. It consisted in identifying chemical additives used in the textile sector and their potential human health/environmental impact. In order to carry out this first task, all WP5 partners did a review of the literature (scientific papers, internet sites, databases, etc.) to find this type of information.

The second task was carried out during the month of February. A first selection of additives used in the textile sector was done. The following group of substances was chosen:

- **Flame retardants**: Brominated flame retardants (e.g. PBDE's -polybrominateddiphenylethers- and HBCD -hexabromocyclododecane-). These substances were appointed by more than one of the partners as interesting chemicals to be studied in detail. On a second step, PBDEs were disregarded, the reason being that WP7 team had already selected these chemicals as additives in electronics.
- **Repellent finishers**: Perfluorocarboncompounds (PFOS -perfluoro-octane sulphonate- and PFOA -perfluoro-octanoicacid-). These compounds are persistent organic pollutants used as surfactants in many industries such as the textile ones.
- **Antimicrobial finishers (biocides)**: Antimicrobials for controlled release (e.g. Triclosan). The UCSC partner showed a great interest in the research of these chemicals since antimicrobial and antifungal agents are of great importance when talking about health issues.
- **Easy-care and durable press finishers**: Formaldehyde-containing products (e.g. TMM -trimethylolmelamina- and HMM -hexamethylolmelamina-). Formaldehyde is present in many different textile products. Systemic or local allergic reactions attributed to it have been reported in many studies, from here the importance of its study.
- **Dyestuffs**: Mordants (metals). The use of metals (in particular, chromium) in the process of textile dyeing and their potential damage to the environment, together with their toxicity for human health, make them candidates to be included in the final study. Some metals, such as Pb and Hg, were already selected by WP7 members as possible final additives to be studied within the electronicssector.

The third task was to choose 2-3 substances from the aforementioned ones to carry out several risk scenarios with them. Three substances were selected: HBCD (brominated flame retardant), PFOS and PFOA (repellent finishers) and Triclosan (biocide). Formaldehyde-containing products were excluded since they are mainly used at a local scale and compared with the selected substances, they are not so relevant. Mordants were also disregarded because they were studied in other WPs.

The last task was to define risk scenarios for these three substances. Partners worked on this task practically until May 2010 and this work was included in the first deliverable of the WP5 (Deliverable 5.1). The results were presented at the Vietnam meeting (May 2010) and a discussion on the suitability of these substances to be finally included was hold in this workshop. PFOS and PFOA were excluded since they are not used in textiles anymore in developed countries.

Similarly, each WP team was responsible for exploring the other industrial sectors mentioned in the introduction. Based on the review work carried out by each WP team, an almost definitive selection of substances to be analysed more accurately within all WPs was made at the Vietnam meeting (see Table 1)

Table 1: Preliminary selected substances for the RISKCYCLE project

Industrial sector	Chemicals	CAS number
Lubricants	Perfluorooctanesulfonate (PFOS) Perfluoro-octanoic acid (PFOA)	2795-39-3 335-67-1
	Nonylphenoxyacetic acid (NPAA)	3115-49-9
Textiles	Hexabromocyclododecane (HBCDD)	(several)
	5-chloro-2-(2,4-dichloro-phenoxy)-phenol (triclosan)	3380-34-5
Plastics	Di(2-ethylhexyl) phthalate (DEHP)	117-81-7
	Pb	7439-92-1
	Organotins	(several)
Electronics	PBDEs	(several)
	Pb	7439-92-1
	Triphenyl phosphate (TPP)	115-86-6
Leather; Paper	Nonylphenol*	25154-52-3
	Bisphenol A *	80-05-7
	Biocides (not specifically stated) *	---

* May change.

2.6.3 Present work and future goals

From May 2010 on, WP5 has returned to its original role, namely risk assessment. A preliminary document on several risk assessment methodologies was created by the URV partner and it was circulated among the rest of partners to be completed by the end of September. This document is currently completed and it has been sent to all the partners for a final revision. It includes a thorough review of methodologies used to assess human toxicity and ecotoxicologicalimpacts of chemicals.

From information gathered in this report, it has been observed that several models and methods exist to predict the impact of a chemical released into the environment and that this prediction/evaluation can be carried out in the context of both Risk Assessment (RA) and Life Cycle Impact Assessment (LCIA). These two tools (RA and LCIA) differentiate each other mainly in the orientation given to the problem (e.g. RA is chemical-oriented while LCIA is product-oriented). However, RA and LCIA have in common several methodological steps, i.e. both tools relate environmental emissions to risk factors or impacts, combining multimedia fate and multipathway exposure estimates with effect assessment data. Therefore, models reviewed in the aforementioned report are applicable to both fields (RA and LCIA).
InTable 2, a summary of the main characteristics of the models reviewed in the aforementioned report is presented. Several criteria were set to allow their comparison; these are described in the following list:

- *Impact categories (model outputs):* Ecotoxicity impacts and/or human toxicity impact.
- *Exposure routes:* Ingestion, inhalation, dermal.
- *Fate, exposure and effect:* Are analyses on fate, exposure and effect included in the model? If so, how?
- *Chemicals considered:* Organic pollutants and/or metals.
- *Media considered:* Air, water (fresh, ground, sea...), soil, sediment, vegetation, food chain, etc.
- *Spatial variation:* Regional scale, continental scale, global scale, country and seas boundaries.
- *Source code availability:* Are model statements and equations available?

- *Model availability:* Is the model at users' disposal?
- *Availability for sensitivity and uncertainty analyses*
- *Population category:* Are differences in man/woman and adult/child considered in the model?

According to the WP5 main objective, the next step is to assess the suitability of the reviewed methodologies in the RISKCYCLE context, that is, to evaluate which methodologiesare adequate to conduct risk assessment for the substances of the different industrial sectors selected within the RISKCYCLE framework.

All the methodologies presented in Table 2 have strengths and weaknesses. If the consideration of both human health and ecosystem quality as impact categories is deemed to be a strong point of the methodology, then WMPT, EDIP, Eco-indicator 99, USES-LCA, GLOBOX, IMPACT 2002+, USEtox and RAIDAR could be considered as suitable. Similarly, if the consideration of both types of chemicals (organic and inorganic) is deemed to be another strong point, then most of the models could be judged adequate, except for IMPACT 2002+ and MAFRAM. Since several aspects can be regarded as important during the selection of a model, it has been planned to discuss this question at the China meeting (November 2010).
Once the models have been selected, they will be applied to the RISKCYCLE substances (Table 1). Risk scenarios for all the selected substances will be developed. In this way it will be possible to assess the risk of these additives for the environment and for the human health.

2.6.4 Conclusion

UPC as a work-package leader is satisfied with the development of the work done by the partners. The timing of the deliverables is followed well in advance: the next deliverable should be ready by the 22nd month of the project (June 2011) and it is practically finished at the moment.

The exchange of information among the WP5 partners is working very well, as well as internal meetings and chats to clarify different points related to the project and WP5. We expect that this good collaboration will last until the end of the project.

References

[1] Ahbe S, Braunschweig A, Müller-Wenk R. Methodikfüroekobilanzen auf der basis ökologischeroptimierung. SchriftenreiheUmwelt Nr. 133. BUWAL, Bern (1990).

[2] Webster E, Mackay D, Di Guardo A, Kane D, Woodfine D. Regional differences in chemical fate model outcome. Chemosphere (2004) 55: 1361-1376.

[3] Krewitt W, Trukenmueller A, Mayerhofer P, Friedrich R. ECOSENSE: an integrated tool for environmental impact analysis. In: Kremers H, Pillman W (Eds.) *Space and Time in Environmental Information Systems*. Umwelt-Informatikaktuell, Band 7.Metropolis-Verlag, Marburg (1995).

[4] US EPA. Waste Minimization Prioritization Tool (Beta Version 1.0): User's Guide and System Documentation. EPA530-R-97-019 (1997).

[5] Hauschild, M. and Potting, J.Spatial differentiation in life cycle impact assessment – the EDIP2003 methodology. Guidelines from the Danish Environmental Protection Agency, Copenhagen (2005).

[6] Goedkoop, M. and Spriensma, R. The Eco-indicator 99. A damage oriented method for life cycle Impact assessment. Pré Consultants, Amersfoort (2000).

[7] Van Zelm R, Huijbregts MAJ, Van de Meent D. USES-LCA 2.0: A global nested multi-media fate, exposure and effects model. International Journal of Life Cycle Assessment (2009) 14: 282-284.

[8] McKone TE.CalTOX, a multimedia total exposure model for hazardous-waste sites, Part I: executive summary. A report written for The Office of Scientific Affairs Department of Toxic Substances Control California Environmental Protection Agency Sacramento, California by the Lawrence Livermore National Laboratory, Livermore California (1993).

[9] Sleeswijk AW, Heijungs R. GLOBOX: A spatially differentiated global fate, intake and effect model for toxicity assessment in LCA. Science of The Total Environment (2010) 408: 2817–2832.

[10] Jolliet O, Margni M, Charles R, Humbert S, Payet J, Rebitzer G, Rosenbaum R. IMPACT2002+: A new life cycle impact assessment methodology. International Journal of Life Cycle Assessment (2003) 8: 324-330.

[11] Rosenbaum RK, Bachmann TM, Gold LS, Huijbregts MAJ, Jolliet O, Juraske R, Koehler A, Larsen HF, MacLeod M, Margni M, McKone TE, Payet J, Schuhmacher M, van de Meent D, Hauschild MZ. USEtox-The UNEP-SETAC toxicity model: recommended characterisation factors for human toxicity and freshwater ecotoxicity in Life Cycle Impact Assessment. International Journal of Life Cycle Assessment (2008) 13: 532-546.

[12] Seuntjens P, Steurbaut W, Vangronsveld J. Chain model for the impact analysis of contaminants in primary food products. Study report of the Belgian Science Policy (2006).

[13] Arnot JA, Mackay D, Webster E. Screening level risk assessment model for chemical fate and effects in the environment. Environmental Science and Technology (2006) 40: 2316-2323.

[14] Batiha MA, Kadhum AAH, Mohamad AB, Takriff MS, Fisal Z, Wan Daud WR, Batiha MM. Modeling the fate and transport of non-volatile organic chemicals in the agro-ecosystem: A case study of Cameron Highland, Malaysia. Process Safety and EnvironmentProtection (2009) 87: 121-134.

Table 2: Main char acteristics of the methodologies of risk and impact assessment reviewed

Methodology	*Ecopoints*[1]	*ChemCAN*[2]	*ECOSENSE*[3]	*WMPT model*[4]	*EDIP methodology*[5]	*Eco-indicator 99*[6]	*USES-LCA*[7]
Principal characteristics	No modelling; distance-to-target method using policy standards	Multimedia model with steady-state condition	Mixture of air transport models with impact analysis based on slopes of exposure-response relationship	Screen-level/ risk-based ranking tool	Integrated quantitative models focusing on independent environmental key properties	Multimedia model based on EUSES using the DALY and PAF concepts	Multimedia model based on Simplebox 3.0
Impact categories	No separate categories distinguished; only Ecopoints	Human toxicity	Human toxicity	Human toxicity and ecotoxicity	Human toxicity and ecotoxicity	Human toxicity and ecotoxicity	Human toxicity and ecotoxicity
Exposure routes	Not considered	Not specified	Inhalation	Not specified	Inhalation and ingestion	Inhalation and ingestion	Inhalation and ingestion
Fate, exposure and effect	Only effect through policy standards	Fate	Fate (for air), human exposure and effect are considered	The method is performed by summing scores	All but only partially	All are considered + damage analysis	Fate, human exposure and toxicological effects
Chemical considered	Organic and inorganic chemicals	Organic compounds and non-volatile compounds	Organic and inorganic chemicals	Organic and inorganic compounds	Organic and inorganic chemicals	Organic and inorganic chemicals	Organic and inorganic
Media considered	Not considered	Air, surface water, soil, bottom sediment, groundwater, coastal water, and terrestrial plants	Air, water, and soil	Air, water, soil, sediment	Air, water, natural soil, agricultural soil, industrial soil	Air, water, natural soil, agricultural soil, and industrial soil	Global: air, (sea)water, and soil; Continental: air, fresh water, seawater, natural soil, agricultural soil, industrial soil, fresh water sediment and marine water sediment
Spatial variation	Different sets of ecofactors for different countries	Regional	Local and regional scales	Not considered	Not considered	Regional scale	Distinction between continental and global scale and between three climate zones
Source code availability	Not specified	Yes	No	No	No	Not specified	Yes, as Excel program
Model availability	Not specified	Yes	Yes	Yes	Not specified	Yes	Yes
Dynamic or steady-state	Not considered	Steady-state	Dynamic for air transport model	Steady-state	Not specified	Steady-state	Steady-state
Sensitivity and uncertainty analyses	Not considered	Not considered	Yes	Not considered	Not considered	Uncertainty analysis is available	Uncertainty analysis is available
Population category	Not considered	Not considered	Not considered	Not considered	Not considered	Not considered	Not considered

Table 3: Main characteristics of the methodologies of risk and impact assessment reviewed (continued)

Methodology	*Caltox*[8]	*GLOBOX*[9]	*IMPACT 2002+*[10]	*USEtox*[11]	*XtraFOOD model*[12]	*RAIDAR model*[13]	*2-FUN tool*	*MAFRAM model*[14]
Principal characteristics	Multimedia model for fate analysis and extensive analysis of exposure pathways	Multimedia model based on EUSES 2.0	Multimedia chemical fate model combined with an exposure model for human health and potency/severity based effect analyses for human and ecotoxicological impacts	A scientific consensus model based on comparison of seven models	Multimedia model focused on the primary food chain	Tool coupling fugacity model calculations and food webs data to assess critical emissions based on an unit emission rate	Integrated tool coupling an environmental multimedia model and PBPK models	A fate model (EQC-2V) and a risk assessment model (EcoRR) combined to evaluate risks in agro-ecosystems
Impact categories	Human toxicity	Human toxicity and ecotoxicity	Human toxicity and ecotoxicity	Human toxicity and freshwater ecotoxicity	Human toxicity	Human toxicity and ecotoxicity	Human toxicity	Ecotoxicity
Exposure routes	Inhalation, ingestion, and dermal contact	Inhalation and ingestion	Inhalation and ingestion	Inhalation and ingestion	Ingestion	Ingestion and inhalation	Ingestion, inhalation and dermal intake	---
Fate, exposure and effect	Fate, exposure, and effect	Fate, human exposure and toxicological effects	Fate, human exposure and toxicological effects	All considered	Fate and exposure are considered	All considered	Fate, exposure, and potential effect are considered	All considered
Chemical considered	Organic and inorganic compounds	Organic chemicals and metals	Predominantly for non-polar organics	Organic and inorganic (although interim CFs) chemicals	Organic compounds and heavy metals	Hydrophobic chemicals, more water-soluble chemicals and ionizing compounds	Organic and inorganic chemicals	Non-volatile organic compounds (NVOCS)
Media considered	Air, water, sediments, 3 soil layers, vegetation (2 sub-compartments)	Air, rivers, freshwater lakes, salt lakes, groundwater, sea water, freshwater lake sediment, salt lake sediment, sea sediment, natural soil, agricultural soil, urban soil	Air, water (fresh and oceanic), soil, sediments, plants, and urban regions	Continental scale: urban air, rural air, agricultural soil, industrial soil, freshwater and coastal marine water; Global scale: = continental scale (without urban air)	Air, soil, farm-related crops, animal	Air, water, suspended particle, soil, sediment, aquatic organisms, vegetation, terrestrial organisms	Air, fresh water, soil/ground water, farm-related crops, and animal (cow and milk)	Air, water, soil, sediment, aboveground plant and roots
Spatial variation	Not considered	Distinction between 239 different countries and 50 different seas (global scale)	Regional and global scale	Continental and global scales	Not considered	Regional scale (10^5 km^2)	Not considered (mainly used for regional scale)	Regional scale
Source code availability	Yes, as Excel spreadsheet	For internal use only	Logic and calculation procedure are fully documented	Not specified	Not considered	No	Yes	NA
Model availability	Yes	Yes	Yes	Yes	Not specified	No	Yes in the near future	No
Dynamic or steady-state	Dynamic	Dynamic and steady state	Dynamic	Algorithm estimating the effect of intermittent rain	Steady-state	Steady-state	Dynamic	Steady-state
Sensitivity and uncertainty analyses	Yes	Not specified	Yes	Not considered	Yes	Not considered	Yes	Not considered
Population category	Not considered	Not considered	Not considered	Not considered	Age and gender considered	Not considered	Age and gender considered	Not considered

2.7 An integrated approach to assess health risks for toxic chemicals by linking multimedia environmental and PBPK models

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In this study, an integrated modelling approach to predict health risks for toxic chemicals was performed by linking a multi-media environmental model and a physiologically based pharmacokinetic (PBPK) model. The multi-media environmental model is used to simulate the partitions and reactions of target chemicals between and in several environmental media (i.e. air, fresh water, soil/ground water, plants, and animal). The PBPK model is used to simulate to estimate the body burden of toxic chemicals throughout the entire human lifespan, integrating the evolution of the physiology and anatomy from childhood to advanced aged. In this study, these two models were linked on a common platform called Ecolego, taking into account multi-pathways of chemical exposure, i.e., inhalation, ingestion, and dermal intake.

The aims of this study are to demonstrate full-chain risk assessment for a chemical by implementing the integrated model based on a case-study, and to identify the model inputs and exposure pathways sensitive to model outputs as health risks, taking into account parametric uncertainties contained in input parameters. The case-study was designed for a region situated on the Seine river watershed, downstream of the Paris megacity and for benzo(a)pyrene (BaP) emitted from industrial zones in the region.

2.8 Life cycle assessment and additives: state of knowledge

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2.8.1 Introduction

Concerns about possible effects on human health and the environment from additives/impurities accumulated in globally recycled waste/resources like paper and plastics was one of the main reasons for starting up the EU FP7 Coordination Action project RiskCycle (www.wadef.com/projects/riskcycle). A key aim of the project is to identify research needs within this area focusing on both risk assessment (RA) and life cycle assessment (LCA). Besides the sectors on paper and plastics (being the focus here) also lubricants, textiles, electronics and leather are included in RiskCycle. In Figure 1 the life cycle of printed matter (paper) is illustrated showing the recycling step which is in special focus in RiskCycle.

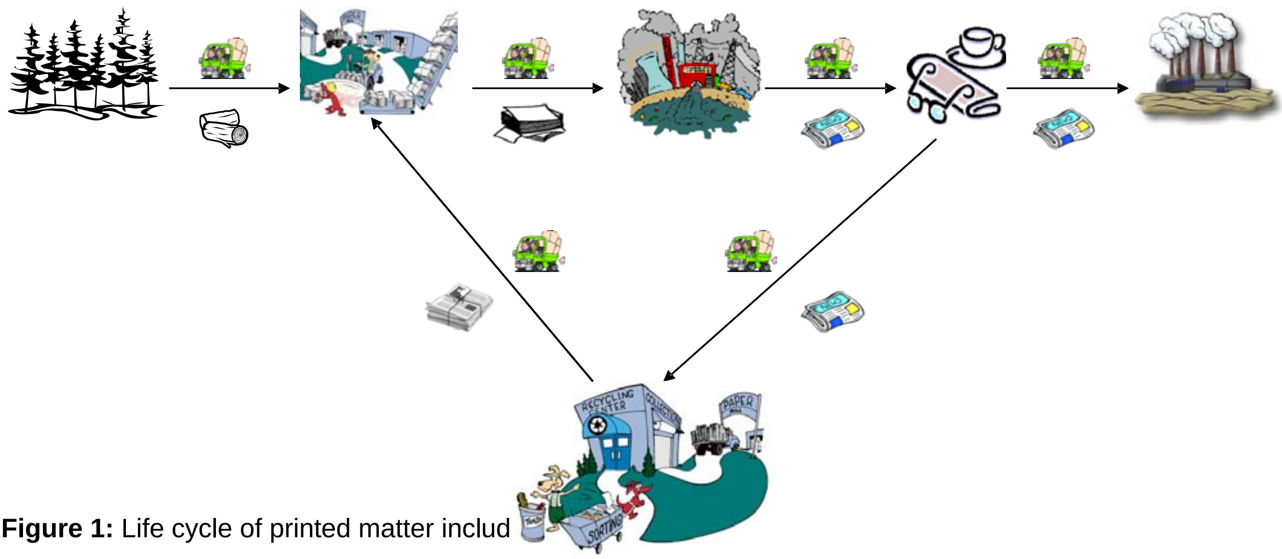

Figure 1: Life cycle of printed matter includ

Work package 6 of RiskCycle "Life cycle assessment (LCA) of additives" addresses the issue on how to include additives (including accumulation of additives/impurities in globally recycled waste/resources) in life cycle assessment. Case studies on plastics and paper are going to be performed including the provision of relevant inventory data (process-related resource consumptions and emissions) and life cycle impact assessment (LCIA) characterization factors for specific additives/impurities. Until now reviews on the state of knowledge regarding additives and LCA have been performed on plastics and printed matter/paper. Furthermore, the degree to which LCIA characterization factors already exists for the proposed additives have been investigated.

2.8.2 Results

Plastics

On plastics a literature review regarding the state of knowledge on additives/impurities in LCA has been performed within RiskCycle [2]. Based on overviews from JRC-IES and the UNEP-SETAC Life-Cycle Initiative several inventory databases (LCI data) have been investigated and the result shows that most LCI databases use PlasticsEurope data for plastics production. Most of these data are aggregated and do not include additives, although this is not obvious. Furthermore, there is no data on use and recycling, and data on incineration are not specific for additives. Regarding the production of additives only data on metals and DEHP was identified. As regards LCAs on plastics 110 papers has been reviewed. Only 25 of these mention additives but they are not included in the emissions list. Many of the papers are on waste management and additives may be mentioned as a problem for recycling, but no numbers are given. Only a few studies include additives in the impact assessment and additives are never mentioned as important for the outcome. A way to approach this lack of inventory data may be to use Material Flow Analysis and emission factors as in a recent Swedish study on emissions of additives from plastic materials [3].

Printed matter/paper

Regarding LCAs on printed matter (including paper) only a few studies has been done – mostly focusing on the energy part [4;5]. However, one of the most recent and comprehensive studies [4;5] actually include toxic impacts from chemical emissions – mostly printing chemicals like printing ink of which some components may accumulate in recycled paper. Even though recycling is included in this study there is no special focus on the additives/impurities in the recycled paper. However, the study shows that potential toxic impacts from the production and use of chemicals like pigments, solvents, metals, AOX and biocides may play a very significant role in the impact profile of printed matter as shown below (in brackets: percentage of total normalized and weighted impact potential, EDIP97 methodology):

- Emissions of ink residues (tetradecane) and cleaning agents (hexane, tetradecane) during the printing process and cleaning (35%)
- Emissions (dichlorobenzidine, chloroaniline, cuprous chloride) during pigment production (17-20%)
- Emissions of heavy metals and AOX (as dichloro benzene) during paper production (>3%)
- Emissions of fountain chemicals (i.e. isopropyl alcohol, IPA) during the printing process (6%)
- Emissions of biocides and hydroquinone from the repro- and plate making process (3%)

Anyway, the study only considered a few generic chemical recipes (one printing ink, few cleaning agents etc.) and at least the following shortcomings in need of further research may be identified:

- Ink components (and their precursors) production: siccatives, antioxidants, pigments, dyes etc.
- Water emissions from paper production: softeners (BPA), other phenolic compounds (NPE, APE), other surfactants (LAS), biocides (benzothiazoler, dibromo-compounds), wood extractions (terpenoids, resin acids) and more
- Recycling of paper: Fate of paper chemicals, ink chemicals, glue chemicals etc.
- Treatment of chemical waste: Fate of (hazardous) waste from printing (ink waste, used cleaning agents, used rinsing water etc.) and from recycling of paper (sludge from repulping)

Characterisation factors

Regarding the life cycle impact assessment (LCIA) part an investigation of the availability of characterisation factors (aquatic ecotox) for the about 17 additives/impurities belonging to 15 chemical groups/chemicals (PFOS, PFOA, NPAA, HBCDD, triclosan, DEHP, lead, organotins, pentabromodiphenylethers, decabromodiphenylether, TPP, mercury, NPE, BPA, biocides) to be included in RiskCycle has been performed. The best practice LCIA "consensus" model USEtox [6] was chosen. This model has the highest number of toxicity related characterisation factors among existing LCIA models. For only nine of the 17 substances characterisation factors exists and four of these are preliminary (interim). Regarding the rest, factors have to be calculated based on physical/chemical property data and effect data compiled in the RiskCycle database - if possible. The proposed additives/impurities are shown in Table 1 together with their corresponding existing characterisation factors (CFs) regarding fresh water ecotoxicity after emissions to fresh water. The unit of the CFs in Table 1 is expressed per kilogram (kg) emitted substance. It takes into account the potentially affected fraction of species PAF (species in the freshwater ecosystem potentially affected above EC50chronic), the volume of water polluted (m3) and the duration/time (day).

Table 1: Existing USEtox life cycle impact assessment (LCIA) characterisation factors (CFs) for the proposed additives/impurities to be included in RiskCycle

Sector	Chemical group	Substance/synonym	CAS No.	CF (fresh water ecotox – emission to fresh water) (PAF*m3*day/kg)[a]	Quality
Lubricants	Perfluoro octane sulfonate	PFOS	2795-39-3	-	-
	Perfluoro octanic acid	PFOA	335-67-1	-	-
	Nonyl phenoxy acetic acid	NPAA	3115-49-9	-	-
Textiles	Hexabromo cyclododecane	HBCDD	25637-99-4	6,4E+04	Preliminary*
	5-Chloro-2-(2,4-dichloro-phenoxy)-phenol (biocide)	Triclosan	3380-34-5	9,9E+04	Preliminary*
Plastics	Di-(2-ethylhexyl)-phthalate	DEHP	117-81-7	3,2E+02	Recommended #
	Lead	Pb(II)	7439-92-1	3,7E+02	Preliminary*
	Organotins				
Electronics	Pentabromodiphenylethers	2,2',4,4',5-Pentabromo-diphenyl ether (BDE 99)	60348-60-9	-	-
		2,2',4,4',6-Pentabromo-diphenyl ether (BDE 100)	189084-64-8	-	-
	Decabromodiphenylether	Decabromodiphenylether	1163-19-5	-	-
	Triphenylphosphate	TPP	115-86-6	2,2E+04	
	Mercury	Hg(II)		2,2E+04	Preliminary*
Leather; paper	Nonylphenol	NPE	25154-52-3	1,5E+04	Recommended #
	Bisphenol A	BPA	80-05-7	5,2E+03	Recommended #
	Isothiazolinones (biocides)	5-chloro-2-methyl-isothiazolin-3-one (CMI)	26172-55-4	5,4E+04	Recommended #
		2-methyl-2-isothiazolin-3-one (MI)	2682-20-4	1,8E+05	Recommended #

* Interim according to USEtox team # Recommended by USEtox team [a] www.usetox.org

2.8.3 Conclusions and discussion

Based on the results obtained until now within RiskCycle it may be concluded that in order to perform LCAs on waste/resources recycled globally both new inventory data and new characterisation factors have to be provided. A preliminary solution to the lack of inventory data may be to use Material Flow Analysis and emission factors. One of the main reasons for this lack of useable data on additives for LCA is probably the general focus on energy which has dominated LCA until recently and the lack of consensus on how to include toxicity. Impact categories related to toxicity (and chemicals) are more difficult to handle than e.g. acidification and global warming for which a much higher degree of consensus have existed among method developers for several years. Anyway, consensus on how to deal with human toxicity and ecotoxicity in LCIA is approaching and the USEtox model is probably the best candidate.

References

[1] Larsen HF (2004). Assessment of chemical emissions in life cycle impact assessment- focus on low substance data availability and ecotoxicity effect indicators. Ph.D. Thesis, October 2004. Department of Manufacturing, Engineering and Management. Technical University of Denmark.

[2] Van Oers L, van der Voet E (2010). Life Cycle Assessment of additives. RiskCycle WP 6; D6.1. Version November 2010.

[3] Westerdahl J, Andersson P, Fuhrman F, Haglund P, Hallberg E, Holmgren T, Molander S, Rydberg T, Tivander J, Öman A (2010). National inventory of emissions of additives from plastic materials. Chemitecs report P4-D4. IVL, Gothenburg, Sweden.

[4] Larsen HF, Hansen MS, Hauschild M (2009). Life-cycle assessment of offset printed matter with EDIP97 – how important are emissions of chemicals? J Clean Prod 17, 115 – 128.

[5] Larsen, H.F., Hansen, M.S. and Hauschild, M. (2006). Ecolabelling of printed matter. Part II: Life cycle assessment of model sheet fed offset printed matter. Working Report No. 24. Danish Ministry of the Environment. Environmental Protection Agency. (peer reviewed). http://www.mst.dk/udgiv/publications/2006/87-7052-173-5/pdf/87-7052-174-3.pdf

[6] Rosenbaum RK, Bachmann TM, Gold LS, Huijbregts MAJ, Jolliet O, Juraske R, Köhler A, Larsen HF, MacLeod M, Margni M, McKone TE, Payet J, Schuhmacher M, van de Meent D, Hauschild MZ (2008). USEtox - The UNEP/SETAC toxicity model: recommended characterisation factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment. Int J LCA 13(7) 532-546.

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2.9 Recycling of WEEE

Susanne Heise, Rosa-Mari Darbra, Mohammed Belhaj, Tomas Rydberg

2.9.1 Introduction

Generation of electronic and electric waste (WEEE) is growing at a very fast speed both in developed (DC) and less developed countries (LDC) where its negative impact on human health and the ecosystem is significant. In order to remove the external effects of WEEE and to avoid high abatement costs, substitution costs as well as recycling costs export of this waste to LDC has been taking place since the 70s. In order to solve this problem of removing externalities from DC to LDC the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal was put into effect in 1992 (Shinkuma (2009)). After the Basel Convention came into force, the trade in waste has undergone enormous changes. As a result of the Convention, there has been an uncertain decrease in the export of waste for final disposal from DC to LDC. Yet, there has been an increase in the export of used products for reuse, as well as scrap (piece, bit, and fragment) for recycling (Shinkuma (2009)).

2.9.2 WEEE, Production and flows

The production of WEEE at the global scale is estimated to range between 20 and 50 million tonnes per year (UNEP 2006). The uncertainty in the estimations is large, and a product of both the use of different methods and lack of data related to different WEEE items, especially in LDC. Table 1 brings together some flows of WEEE at the global level.

Table 1: Global WEEE (million tonnes (2005))

	Household production	Landfill, storage & incineration	Domestic recycling	Export	Import
USA	6.6	5.2	0.13	1.3	
EU-25	7	1.6	3.5	1.9	
Japan	3.1	0.6	1.9	0.62	
China	3.1	3.6	1.5		2
India[2]	0.386	0.337	0.049	-[3]	0.05
Vietnam					
Brazil	0.25				
South Africa	0.048				
West Africa	0.05	0.45	0.17		0.57
Total	20.51				

As show in the figure the estimated figure of 20 million tonnes does not include several regions e.g. most countries in Latin America, Canada, Australia, New Zeeland and other African countries. Including these regions would amplify the estimates.

2.9.3 Global flows of computers, cellular phones and monitors

Once EEE products reach the end of their useful life, they become WEEE. The life cycle of used EEE comprises several stages (Thangtongtawi, (no date):

- Repair for re-use
- Dismantling (for metal recovery, parts for re-use, materials for recycle)
- Disposal

To start with the lower life spans of different items such as computers and cellular phones as well as monitors (CRT) which has drastically diminished during the last twenty years, has led to generation of huge quantities of obsolete EEE both in DC and in LDC. Furthermore, all stages before disposal are capital intensive (human or other) and are associated with higher costs. In addition, to cope with WEEE, what

[2] These are base figures for year 2007 and include desktops and notebooks used by the household sector; TVs – colour and black and white; mobile phones; and refrigerators. For refrigerators it is assumed that 30 percent of e-waste generated is recycled. Source: United Nations Environment Programme & United Nations University, 2009. “Sustainable Innovation and Technology Transfer Industrial Sector Studies - Recycling – from e-waste to resources”.Source: GTZ-ASEM & MAIT. 2007. “Electronic waste Assessment in India”.

[3] Precise data not available

ever the method used i.e. proper or non proper, the procedure leads to different external effects i.e. negative externalities both on human health and the ecosystem. To deal with these external effects according, for instance, to Directive 75/442/ EEC is also associated with high costs. Hence, the consequences being the result of these conditions may/are leading to the following:

- Export in a legal or illegal form of used EEE or its waste to LCD,
- Improper recycling methods leading to negative effects on humans and the ecosystem.

The figure below illustrates WEEE flows in 2005 (Schwarzer et al. (2005)).

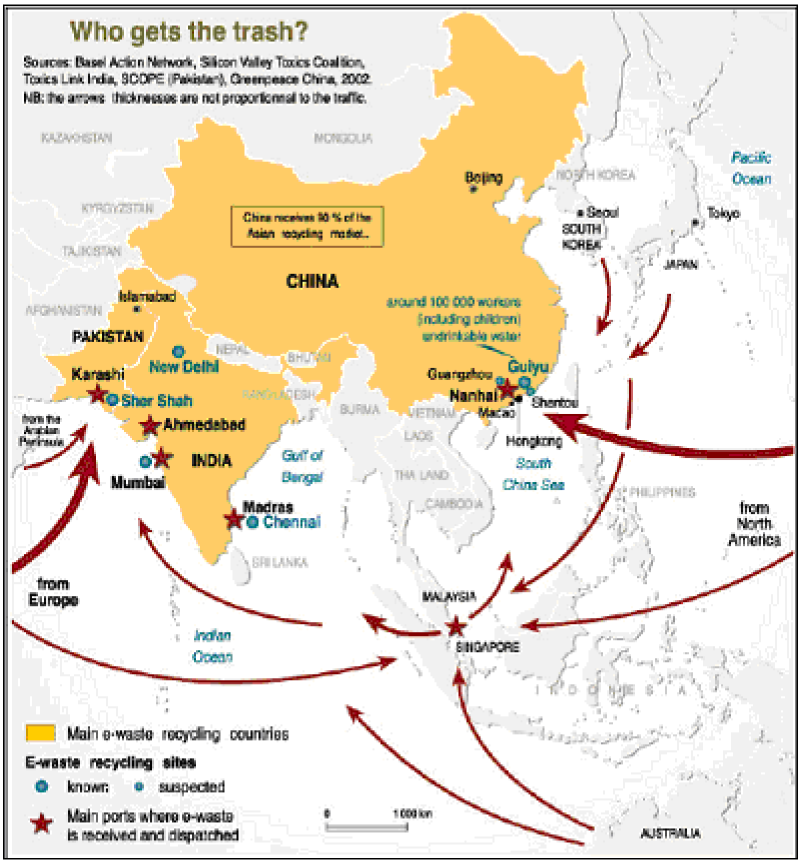

Figure 1: Major exporters and receivers of WEEE in 2005

2.9.4 SFA and external effects of WEEE

To construct a substance flow analysis figure related to computers, monitors and cellular phones is not an easy task depending on the one hand on how the WEEE is taken care of and on the other hand on the variety and properties of the substances (a detailed SFA will be put together in a later stage of the project).

2.9.5 Risk and perceived risk

Although there is no commonly accepted definition of the term risk, all concepts have one element in common: the distinction between reality and possibility. Renn (1998) proposes as a general definition: *"Risks refer to the possibility that human actions or events lead to consequences that affect aspects of what humans value".*
This definition has some important implications: First, a risk can theoretically have adverse or desirable outcomes. Second: it is strongly connected with a value for humans. The risk of extinction of a population of worms in estuarine sediment will concern less people than the reduction of the whales.

- Health effects of Pb:
    - Effects on the nervous system of children
    - Changes in behaviour of children
    - Effects on gastrointestinal system in adults
    - Reduced number of red blood cells
    - Growth retardation in children
    - Depression on thyroid activity in workers
- Health effects of TPP:
    - Information on human health is only derived from animal testing
    - Significance of results to humans is not fully clear
- Animal testing:
    - No mutagenicity, no carcinogenicity
    - Low toxicity, skin sensitization, eye irritation

- Health effects of PBDE:
  - Information on human health only derived from animal testing
  - most sensitive effects in animals: thyroid hormone disruption and neurobehavioral toxicity.
  - Lack of reliable information on carcinogenicity and chronic toxicity

On the other hand risk perception is always a selection (Wiedemann 1996). How much of the given information is considered, what risks finally influence the personal attitude towards an environmental issue, depends on former prejudices and experiences, and on the extent that personal life is effected. The best physical risk predictor seems to be (personal) exposure rather than any other indicator of harm (Renn 1998). The trustworthiness of the source of information is thereby considered highly important. Also the cultural or societal background influences the attitude as it directs the attention people give to different pieces of information and the value that is assigned to different aspects (de Haan 1996).

2.9.6 Damage cost

A negative externality being a damage hitting others can be evaluated in economic terms defined as external or damage costs. In general there are different methods to make the economic evaluation.

The impact pathway of the emissions

To illustrate the concept of external or damage costs, we first look at emissions from WEEE to the air. The different point leading to the evaluation of emission's impacts are the following[4]:

1. Emissions: The determination of emission factors of different substances in WEEE road transport is often the product of national, EU and international research.
2. Dispersion: The pollutants dispersed to the atmosphere are in general modelled using dispersion models.

[4] adapted from http://www.its.leeds.ac.uk/projects/spectrum/downloads/D6.pdf

3. Exposure: the impacts of WEEE substances on health and the environment are location specific and based on conditions discussed above e.g. the way the WEEE is taken care of. Hence the exposure assessment relates to population and the ecosystem being exposed to the externalities.

4. Impact: The exposure response relations are based on epidemiological studies

5. Evaluation of impacts on both the humans and the ecosystem is based on valuation studies in order to monetise the external effects.[5]

Various methods are available to evaluate the monetary value of environmental and health impacts, of which the EPS method will be presented below.

The EPS method

A first version was developed in 1991-2, and the basic concept is still the same: Impacts are expressed in terms of socio-economic costs (or values) occurring by unit effects of damage to five safeguard subjects: Human health, Biological diversity, Ecosystem production, Natural resources and Aesthetic values.

The present version was published in 1999 (Steen, 1999 a and b). Table 4 lists the basic values used in the system.

[5] Emission-factors, dispersion, exposure and impact are discussed in other parts of this project

Table 2: Basic unit effect values in the EPS system

Safeguard subject	Impact category	Category indicator	Indicator unit	Weighting factor (ELU/ indicator unit)	Uncer- tainty factor
Human health	Life expectancy	YOLL	Person-years	85000	3
	Severe morbidity	Severe morbidity	Person-years	100000	3
	Morbidity	Morbidity	Person-years	10000	3
	Severe nuisance	Severe nuisance	Person-years	1000	3
	Nuisance	Nuisance	Person-years	100	3
Ecosystem production capacity	Crop growth cap.	Crop	kg	0.15	2
	Wood growth cap.	Wood	kg	0.04	1.4
	Fish and meat production capacity	Fish and meat	kg	1	2
	Soil acidification	Base cat-ion capacity of soil	mole H+ - equivalents	0.01	2
	Production capacity for irrigation water	Irrigation water	kg	0.003	4
	Production capacity for drinking water	Drinking water	kg	0.03	6
Biodiversity	Species extinction	NEX	dimensionless	1.10E+11	3

For abiotic stock resources, the resource value is set as equal to the production and environmental cost for a sustainable alternative. For fossil oil, gas and coal, these alternatives are rapeseed oil, biogas and charcoal, respectively. For metal (metal ores), the production and environmental costs to upgrade low-quality ores (sustainable supplies), such as silicate minerals, to a quality similar to present day ores, using a bioenergy-driven process (near-sustainable process), is used as the resource value.

The example Lead as evaluated in the EPS system - Emission of Pb to air anywhere in the world

Definition of flow group

The flow group characterised is emissions of Pb to air, in any chemical and physicalstate, at anyplace in the world and at source strengths not giving local acute toxic effects.

Assignment to impact categories

Lead is perhaps the most studied toxic metal in the environment. The main reason is itseffects on the central nerve system and its extensive use as additive in gasoline. Childrenare most sensitive. Too high lead doses cause brain retardation. The doses present inambient air are not high enough to give the most severe effects, but a loss of IQ has beenseen in American studies. This effect is here classified as severe nuisance. The use oflead in gasoline sometimes gives high lead doses to people living in heavy traffickedareas. Lead also show effects on soil micro-organisms and soil invertebrates.

Characterisation of Pb to air with respect to severe nuisance

Definition of environmental system in which the impact is estimated

The system considered is anywhere in the world during 1990.

Model

The characterisation factor is determined by the empirical method.

Category indicator value in system considered

About 17% of the population in USA is estimated to have a decrease in IQ of three unitsin the beginning of the 90ies (Grant et al., 1993). Heavy car exhaust has mainly been aproblem for OECD countries and some megacities outside OECD. This indicates that theproblem is in the order of 100 million persons-years per year.

Contribution to category indicators value from a flow unit

The global lead emission was 344000 tons/year 1983 as estimated by Pacyna. (UNEP1992)

Calculation of characterisation factor

This will result in a characterisation factor of 1·108/3.44·108= 0.291 person-years/kg Pb.

Uncertainty

Lead is being phased out as an additive to petrol in many countries, but the process hasproceeded with different speed in different countries. It is therefore difficult to combineeffects and emissions and to know the status in various countries. Trend investigationshow decreasing lead levels in most countries but a few have no efficient abatementpolicy and is expected to contribute to the impact. USEPA (1996) states that "Between1987 and 1996, ambient lead concentrations decreased 75 percent, and lead emissionsdecreased 50 percent. Lead emissions from highway vehicles have decreased 99 percentsince 1987 as a result of the increased use of unleaded gasoline and the reduction of thelead content in leaded gasoline. Between 1995 and 1996, lead concentrations remainedunchanged, total lead emissions decreased 2 percent, and lead emissions fromtransportation sources did not change. While lead emissions from industrial sources havedropped more than 90 percent since the late 1970s, some serious point-source leadproblems remain."

The number of persons affected were estimated roughly and the dose-effect is difficult to assess correctly and therefore subjectto much debate, the uncertainty is assumed to be rather high.

2.9.7 Discussion

In spite of several attempts to ban export (Basel convention) and import (different laws in LDC) of WEEE these obsolete products are still arriving in several LDCs leading to negative health and environmental problems. The problem will be much worse in LDCs when the WEEE quantities generated in these countries are expected to increase at a higher rate than in DCs when driven by rapid economic and population growth.

The problem is that most of the LDCs particularly in Asia and the Pacific as well as in Africa lack proper recycling and disposal capacity, legal frameworks, enforcement capacity, political will and financial resources to properly manage the waste[6]. So the lack of consistent actions to deal with the flows of WEEE from DC to LDC archaic recycling is certain to increase. One proposal to deal with this problem is to pay backyard recyclers not to recycle.

References

[1] de Haan G. 1996. Die Kommunikation über ökologische Gesundheitsrisiken. in G. d. Haan, Ed, Ökologie - Gesundheit - Risiko. Perspektiven ökologischer Kommunikation, Akademie Verlag GmbH, Berlin.

[2] Renn O. (1998): The role of risk perception for risk management. in P. E. T. Douben, Ed, Pollution risk assessment and management, John Wiley & sons Ltd., Chichester.

[3] Shinkuma Takayoshi &Thi Minh Huong Nguyen (2009): The flow of E-waste material in the Asian region and a reconsideration of international trade policies on E-waste. Environmental Impact Assessment Review 29, 25–31

[4] Schwarzer et al. (2005):E-waste, the hidden side of IT equipment's manufacturing and use http://www.grid.unep.ch/product/publication/download/ew_ewaste.pdf (2005).

[5] Steen, B., 1999 a, CPM Report 1999:4, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS), Version 2000 - General System Characteristics

[6] Steen, B., 1999 b, CPM Report 1999:5, A Systematic Approach to Environmental Priority Strategies in Product Development (EPS), Version 2000 - Models and data of the default method.

[7] Thangtongtawi, Piyanee (no date):E-waste Issues in Thailand. Competent Authority for Basel Convention Government of Thailand

[8] Wiedemann P. M. 1996. Industrieansiedlungen - Risiko, Risikokommunikation und Risikomanagement. in G. d. Haan, Ed, Ökologie-Gesundheit - Risiko. Perspektiven ökologischer Kommunikation, Akademie Verlag GmbH, Berlin.

[6] http://esciencenews.com/articles/2010/03/22/e.waste.trade.ban.wont.end.environmental.threat

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