Introduction

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Abstract Many potential hazardous compounds are traded worldwide as chemicals or incorporated as additives in consumer and industrial products. Their release to the environment has been a concern of the European Commission, UNO, WHO and OECD. The discussion of the assessment and management of chemicals and products led to the creation of the OECD programme Globally Harmonised System of Classification and Labelling of Chemicals (GHS). The World Summit encouraged countries to implement GHS with a view of having the System operating by 2008. The need to form GHS on a global scale is part of the EU policy. GHS aims to have the same criteria worldwide to classify and harmonise the responsible trade and handling of chemicals and products and at the same time protect human health and the environment. The EU will ensure transition from the current EU Classification and Labelling (C + L) system to the implementation of GHS, which harmonises with REACH registration. However, a complete picture on the global state of implementation is not available. With the growing level of worldwide trade, we however face unsafe consumer products on the market. These examples show that on a global perspective the trade of chemicals and products in a circular economy is not acceptable without globally agreed assessment methods and harmonised C + L (GHS).

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The overall objective of the Coordinating Action RISKCYCLE is to define together with international, European and national experts from different programmes future needs of R + D contributions for innovations in the field of risk-based management of chemicals and products in a global perspective using alternative testing strategies to minimise animal tests.

Keywords Chemicals, Circular economy, Globally Harmonised System, Risk assessment

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 and lubricants has resulted in a substantial release of harmful substances to the environment with risk to man and nature on a worldwide scale.

The discussion of the assessment and management of chemicals and products at the *1992 Earth Summit* in Rio de Janeiro led to the creation of the OECD programme *Globally Harmonised System of Classification and Labelling of Chemicals (GHS)*. The *World Summit on Sustainable Development in Johannesburg 2002* encouraged countries to implement the GHS (adopted by UN ECOSOC in July 2003) as soon as possible, with a view of having the system operating by 2008.

In spite of some common efforts to harmonise the safety assessment of chemicals and products, a new problem with Recovered Material (as illustrated in Fig. 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 due to the worldwide trade of chemicals and products. Circular Economy is a concept that is transforming traditional patterns of economic growth and production. The conventional perception of economic systems is that they are linear. This linear system is converted to a circular system when the relationship between resource use and waste residuals is taken into consideration.

Although the practices of circular economy have been present throughout history, the modern concept of circular economy (now under discussion in Asia and very seriously in China) was only introduced in Germany in 1998. The new threat comes 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. In this way, unsafe consumer and industrial products get onto the global market. Latest reports in the news on tooth paste, toys and drinking cups from Asia releasing hazardous components prove this new problem.

Viet Nam News December 22, 2008 wrote that more than 75% of the country's empty plastic containers carrying all kinds of chemicals are recycled and sold back to the market to produce new plastic products of different type. Bangkok Post on February 8, 2009 noted that the use of substandard fertilisers and agricultural chemicals of unknown origin has badly affected rubber production in the region.

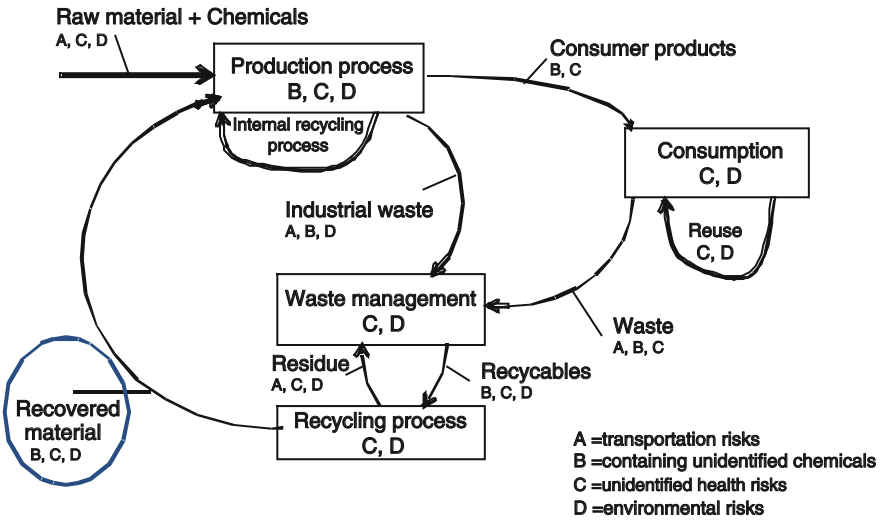

Fig. 1 Simplified material flow of a circular economy in a global scale with health and environmental risks

One compound with estrogenic activity that has been studied extensively as an intermediate in the production of polycarbonate and epoxy resin is Bisphenol A (BPA). The migration of BPA from polycarbonate flask used for baby food is enhanced when sterilisation of flask is carried out at temperatures over 80°C [1]. A recent study carried out in Germany demonstrated that estrogenic activity was detected as a result of migration of endocrine disruptors form bottled mineral water in plastic containers made of polyethylene terephthalate (PET). In contrast to polycarbonate, PET should be free form BPA. Different authors detected several phthalates in PET plastic bottles. So, it is most probably that a migration of DEHP (Di(2-ethylhexyl) phthalate) (see Table 1) occurred from PET to the bottled mineral water and afterwards the estrogenic activity was detected [2].

Waste electrical and electronic equipment, also known as e-waste, refers to the end-of-life products encompassing consumer electronics, information communication and household devices. Many of them have a short lifetime like computers, television, printers and cell phones. Therefore, e-waste is generated in large quantities with an annual volume about 20–50 million tonnes worldwide with an estimated increase of 3–5% per year [3]. Toxic substances present in e-waste are indicated in the enclosed table (Table 1). Among them, it can be found heavy metals such as lead, mercury and cadmium and persistent organ halogen compounds such as polychlorinated biphenyls (PCBs) and brominated flame retardants (BFRs). Uncontrolled e-waste recycling has become a topic of serious concern in recent years. It is estimated that up to 80% of e-waste from industrialised countries is exported to Asian developing countries, such as Vietnam for recycling and

Table 1 List of the main chemicals present in the different industrial products that will be studied in the following chapters of this book

Industrial sector	Chemical	Synonym/Substance/Acronym	CAS No.
Lubricants	Perfluoro octane sulfonate	PFOS	2795-39-3
	Perfluoro octanoic acid	PFOA	335-67-1
	Nonylphenoxy acetic acid	NPAA	3115-49-9
Textiles	Hexabromocyclododecane	HBCDD	25637-99-4
	5-Chloro-2-(2,4-dichloro-phenoxy)-phenol	Triclosan	3380-34-5
Plastics	Di(2-ethylhexyl) phthalate	DEHP	117-81-7
	Lead	Pb(II)	–
	Tri-*n*-butyltin hydride	Tributylstannane	688-73-3
Electronics	Tetrabromodiphenyl ethers	2,2',4,4'-Tetrabromodiphenyl ether (BDE 47)	5436-43-1
	Pentabromodiphenyl ethers	2,2',4,4',5-Pentabromodiphenyl ether (BDE 99)	60348-60-9
		2,2',4,4',6-Pentabromodiphenyl ether (BDE 100)	189084-64-8
	Decabromodiphenyl ether	BDE 209	1163-19-5
	Lead	Pb(II)	–
	Triphenyl phosphate	TPP	115-86-6
	Mercury	Hg(II)	–
Leather	Pentachlorophenol	PCP	87-86-5
	(Benzothiazol-2-ylthio) methyl thiocyanate	TCMTB	21564-17-0
Paper	Bisphenol A	4,4'-Isopropylidenediphenol (BPA)	80-05-7
	Dibutyl phthalate	DBP	84-74-2
	Isothiazolinones	5-Chloro-2-methyl-isothiazolin-3-one (CMI)	26172-55-4
		2-Methyl-2-isothiazolin-3-one (MI)	2682-20-4

exploiting the inexpensive labour costs and weak enforcement of environmental laws.

The paper chain is a very good example for successful recycling in Europe. However, if a deeper analysis is made, the recycling of paper and cardboard, especially for graphical paper, can introduce chemicals (from the original paper) into recovered material with unpredictable and not foreseen health and safety problems. This is the case for the thermal paper, used in cash machines and as copy paper. It has a colour developing layer with the chemical BPA. BPA is introduced into the paper cycle through the recovery of used thermal paper. BPA is found in the wastewater and detected in the next paper product. Toilet paper has a high concentration of BPA, which can be found in the wastewater after use. Printing ink used in newspaper is contaminating the cardboard for packaging and entering into the packed food exceeding the threshold values for Polycyclic Aromatics in the food by up to more than ten times [4]. All these examples show that in a circular economy the trade in a global dimension is not acceptable without a globally agreed

risk assessment for existing and newly developed chemicals and products without using additional test animals.

Within this situation, the overall objective of the introduced co-ordination action RISKCYCLE aims to establish and co-ordinate a global network of European and international experts and stakeholders from different programmes and countries of the EU, USA, Japan, China, India, Brazil, Vietnam etc. to explore the synergies of the research carried out within different programmes and countries, and to facilitate the communication among 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. As a result of this, RISKCYCLE has 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.

When addressing how this objective will be achieved, it is relevant to consider what information on present activities in this area is available and what is still unknown.

The key pieces of information that will be required and collected are:

- Where are the critical points throughout the product's life cycle for the release of chemical substances?
- How potent 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 risks of these substances been done? If yes, for which substances?
- Do the effects caused by the chemicals have a global or only local 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?

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 (Life Cycle Assessment), 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 different topics: usage, risks and chemical properties of consumer products; labelling; fate of certain chemicals in products traded, used and recycled in a

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