Environment and Peace: Balancing Development and Environmental Protection

Bernd Bilitewski

(Professor, Technische Universitat Dresden)

| 요약 |

제가 오늘 발표할 주제는 환경과 평화, 그리고 개발과 보호의 균형이 되겠습니다. 물론 쉬운 주제는 아닙니다만 저는 엔지니어의 배경을 가지고 있고, 또 어쨌든 이번 기회를 빌어서 일반적으로 우리가 가르치는 그런 방식에서 조금 벗어나서 다른 시각으로 접근을 해 보도록 하겠습니다. 제가 처음에 이 발표를 수락했을 때 노벨 수상위원회에서 노벨평화상을 알 고어와 정부간 기후변화 패널(IPCC)에 수여하기로 결정을 했다는 내용을 들었습니다. 지구온난화에 대한 업적을 치하하기 위한 것으로 알고 있습니다. 이 상은 세계평화와 환경보호가 얼마나 서로 연결되어 있는가를 잘 보여주고 있습니다. 전 세계 평화와 지속가능한 삶의 질을 유지하는 데에는 긴밀한 상관관계가 있습니다. 환경은 이러한 모든 것들과 서로 연결 되어있습니다. 특히 CO_2가 대기 중에서 증가를 하고 있고, 이러한 것들이 발암율의 증가와 출산율의 저하를 가져오며, 그리고 신경성 장애, 알레르기, 천식 등이 전 유럽에서 봤을 때 연간 5%씩 계속 증가되는 것을 보면 이런 환경이 우리에게 얼마나 영향을 미치는지 알 수 있습니다.

이번 제 발표를 통해서 제가 수질관리 전문가로서, 또 수 년 동안 환경문제를 연구한 연구원으로서, 그리고 또 한 개인 인간으로서 어떻게 이러한 것이 함께 연결될 수 있는지 말하려고 합니다. 노벨평화상 위원회가 이 지구온난화와 환경문제를 심각성을 인정하고 이 분야의 공로자인 개인과 단체에게

수상을 한 것에 대한 배경을 좀 더 잘 이해할 수 있을 것이라 생각합니다. 그래서 이제 급속하게 개발되고 발전되고 있는 여러 경제 국가들이 있는데, 그러한 국가들이 전 세계 환경의 관점에서 좀 더 생각을 해봐야 된다는 것을 말씀드리고자 합니다. 특히 독일의 드레스덴의 도시를 예를 들어서 공공정책들이 어떻게 지역차원에서 효과적으로 해석이 되고 있고, 전 도시에 걸쳐서 성공적인 이니셔티브로 진행되었는지를 말씀드리겠습니다. 드레스덴 프로젝트는 환경 문제에서 전 세계적으로 많이 인용되고 언급되어지고 있습니다.

우선 개발상의 불균형에 대해서 말씀드리겠습니다. 우리가 우선 생각해봐야 될 문제들은 이런 개발상의 불균형과 환경 문제는 어떤 특성을 가지고 있는지 하는 것입니다. 우리가 이 환경문제에 대해 얘기를 할 때, 유럽이나 미국이나 아시아지역의 사람들은 보통 20년 내지 50년, 100년 전의 이야기를 합니다. 그 당시에는 모든 사람이 협동해서 살고 있었고, 환경오염은 전혀 문제가 아니었습니다. 그렇지만 우리가 좀 더 면밀하게 살펴보면 지금 현 사회는 수백 년 이상 되는 여러 가지의 아픔도 가지고 있습니다. 기아와 질병과 전쟁에서 고통을 받아 왔습니다. 그런데 작은 마을에 살고 있는 사람들은 서로 공생하기 위해 서로 돕고 있었고, 그렇게 함으로써 단결이 더욱 더 강화되었습니다. 본인의 안전과 상대방의 안전을 도모하면서 환경을 위해서 나름대로 어떤 기여를 했던 것입니다 .

이제 사회가 계속해서 발전을 하고 있고, 자연과학이나 공학 같은 것이 발전됨에 따라서 우리가 위생에 대해서 좀 더 잘 알게 되었습니다. 또 어떻게 하면 효과적인 보건과 보건을 유지할 수 있는지, 소득증대를 도모하고 전쟁을 예방하는 노력도 기울이게 되었습니다. 이제 사람들 수명도 늘어나게 되었고, 훨씬 더 부유하게 되었습니다. 그렇기 때문에 유럽이나 미국이나 아시아를 보면 개인주의가 더욱더 팽배하고 있는 것을 볼 수 있습니다. 그런데 이렇게 산업이 계속해서 발전을 하고 전 세계 경제가 급속한 성장을 보이고 있음에도 불구하고 환경에 대한 기본적인 인식은 과거 우리가 그냥 시골마을에 살고 있었던 것과 똑같은 것 같습니다. 사람들의 생활양식이 이렇게 변화하고 있고, 또 우리가 무언인가를 생산하고 소비하는 방식들이 달라지고 있

는데 환경이 우리에게 해줄 수 있는 것은 제한되어 있습니다.

이런 개발의 불균형은 자원의 사용과 함께 더욱 더 증가되고 있습니다. 예를 들어서 전쟁의 위협이 원자재를 대상으로 해서 발생하기도 합니다. 전 세계 인구가 60억 곧 이어서 70억 80억 까지 이를 것으로 추정이 되고 있습니다. 사람이 먹고 살아야 할 음식, 즉 식량 생산은 사람들이 먹지 않고 생존할 수 있지 않는 한 여전히 전 세계에서 가장 중요한 이슈가 될 것입니다. 이것 이외에도 사람들의 주거환경 문제도 중요하기 때문에 시멘트나 금속의 생산도 상당히 중요하게 될 것입니다. 때문에 모든 사람을 위한 그런 식량이 완전히 충분히 갖춰야 된다는 것이 우리의 과제이기도 하고, 또 여러 가지 화학물질도 중요한 역할을 서서히 가지게 되었었습니다.

사실 화학물질은 우리주위에 어디든지 다 있습니다. 어떤 화학물질들은 유해한 것으로 알고 있으나 어떤 것은 환경에 어떤 피해를 미치는지 파악되지 않는 경우도 있습니다. 독성이 있는 물질도 있고, 생태계에 독성을 미칠 수 있지만 그런 데이터가 나와 있지 않은 경우도 있습니다. 이런 인공 화학물들이 환경에 들어오게 됨에 따라서 지역적으로 다양한 메커니즘을 통해서 전 세계적으로 퍼져나가고 있습니다. 어떤 화학 물질들은 빛과 함께 반응을 하기도 하고, 좀 더 위험한 분자로 형성이 되기도 하고, 아니면 수 십년 동안 이런 화학물질들이 사라지지 않고 그대로 우리 근처에 존재 하고 있는 경우도 있습니다. 예를 들어 식물이나 또는 살아있는 유기체들이 이런 것을 흡수하고, 그렇게 되면 일부 화학물질들은 체내에 축적이 됩니다. 그런데 이런 물질이 식량 식품으로 계속 식탁에 올라오게 됩니다. 그렇기 때문에 상당히 높은 독성을 가진 것들이 동물이나 사람 몸속에서 계속해서 발견이 되고 있는 것입니다.

중국의 경제가 발전하게 됨에 따라서 개발 불균형이 어떻게 진행되고 있는지를 좀 더 잘 알 수가 있습니다. 부상하고 있는 브라질, 인도, 중국 등과 같은 국가를 도와서 기술과 환경문제를 잘 알려줘야 된다고 생각합니다. 특히 미국이나 일본, 유럽 이러한 국가들은 이제 비용을 서로 부담을 해야 되는 역할을 해야 된다고 보고 있습니다. 그래서 다른 사람이 사용할 수 있는 환경을 좀 더 잘 조성할 수 있어야 합니다. 이 폐기물 관리를 연구하는 과학자들

은 여러 기술, 경제적 및 사회적인 장치를 사용해서 이 산업에서 야기하는 문제를 해결하기 위해서 노력을 기르고 있습니다. 그런데 이 순환경제에서 가장 중요한 그런 접근 방법 중에 하나를 제안하고 싶습니다. 첫 번째가 바로 이런 잠재성이라고 할 수 있습니다. 환경이라고 하는 것은 사실 기본적인 인간의 보건 문제라고 할 수 있습니다. 복지의 시각에서 본다면 네 가지의 경제적인 기능을 하고 있습니다. 두 번째가 편의시설의 가치를 제공해 주고 있고 또 경제에 대한 자원을 제공해 주고 있고, 또 여러 가지 이성적 흐름에서 틀을 제공을 하고 있고, 삶을 지지하는 시스템을 제공해주고 있습니다.

그러면 이제 우리가 갖고 있는 제한 상황에 대해서 말씀을 드릴 차례입니다. 특히 드레스덴 같은 경우는 가능하면 재활용을 많이 실천하도록 시민들을 계도하였습니다. 도표에서 볼수 있는 것처럼 파랑색으로 표시된 부분 그리고 약간 어두운 파랑색으로 표시된 부분이 바로 전체 1인당 재사용을 계산한 연간 수치입니다. 오른쪽에 나와 있는 것이 그 가격입니다. 많은 요소들이 이러한 가능성에 영향을 미치고 있습니다. 그래서 전체 폐기물을 줄일 수 있는 방안들이 많이 나오고 있는데 그 중에 하나가 바로 그 비용이라고 할 수 있습니다. 세금문제가 있을 수 있습니다. 원천과세라고 하는 것입니다. 버리는 만큼 과세하는 쓰레기 종량제라고 할 수 있습니다. 많이 버리면 세금을 더 많이 내는 그런 제도입니다. 그래서 지금 보시는 것은 이제 사람들이 지불해야 될 그 금액이고, 그 다음에 노란색으로 표시된 것이 평균값입니다. 지금 현재 드레스덴의 개인들은 각각 55내지는 60유로 정도를 일 년에 폐기물 관리를 위해서 지불을 하고 있는 것입니다. 그 규모가 도표에서 확인할 수 있듯이 92% 정도라고 할 수 있습니다. 다음은 우리가 갖고 있는 한계에 대해서 말씀드리겠습니다. 가장 중요한 것은 그 물질의 순환고리를 이제 완전히 닫는다는 것입니다. 솔직히 거의 불가능 합니다. 이제 그 각각 그 순서를 보여드리도록 하겠습니다.

예를 들어서 여러분들이 이제 자동입출금 기계에 가서 입금을 하면 감열지가 나오게 됩니다. 그게 바로 비페놀입니다. 이러한 것이 다시 사용이 되기도 하고, 이것이 하수구로 들어갈 수도 있습니다. 화장지에도 이러한 것이 좀 들어가 있습니다. 그런데 이제 그것이 정화수로 넘어가 나중에 다시 슬러시

로 들어가게 됩니다. 이것도 저희가 당면하고 있는 한 문제 중의 하나라고 볼 수가 있겠습니다. 이러한 것도 결국은 우리 전체의 순환을 체크하는데 한계가 됩니다. 그래서 많은 연구가 아직도 미래에 시행이 되어야 된다고 보고 있습니다. 각각 서로가 도와야 되는 것입니다. 왜냐하면 경제 수준이 상당히 높은 그러한 국가들도 공정 무역이 없이는 살아남을 수가 없습니다. 그래서 순환경제를 우리가 확립시키는 것이 바로 전 세계 사회에 도움이 된다고 생각됩니다.

그리고 여기 보시면 코펜하겐과 독일의 뮌헨이 나와 있습니다. 여기 보면 상당히 적은 다른 유럽도시와 비해서도 그 전체 양이 상당히 적게 나타나는 것을 알 수가 있습니다. 재활용률이 상당히 높은 셈입니다. 여러 가지 노력을 통해서 생산자 책임 제도를 확립해야 할 것이고, 지속가능한 발전을 위해서 이렇게 해야 될 것입니다. 자연과학이나 공학에 있어서 리서치나 연구 같은 것들이 매우 중요합니다. 이러한 것이 150년 동안 많은 발전을 이루었기는 하지만, 무기경쟁과 같은 것에 대해서 돈을 더 이상 낭비하지 않고 우리는 정말 진정으로 평화가 필요하다는 것을 다시 한번 알 수 있을 것입니다. 민주주의는 정부와 권력과 복지에서 사람들의 진정한 참여를 필요로 합니다. 이런 지식 이전도 환경 문제를 좀 더 잘 이해하기 위해서 필수적이라고 생각하고 있습니다.

I. Introduction

The Nobel Prize Committee decided in 2007 to award the Nobel Peace Prize to Al Gore and the working group against "Global Warming". This award demonstrated that world peace and the protection of the environment are interconnected. It also showed that there is a growing awareness of the relationship between world peace and the environment for maintaining sustainable quality of life.

Opinion polls show that a great number of people on all continents have increasing concerns about the influence of environmental factors such as noise, air, water or waste pollution that can have an adverse impact on human health and well-being. The links between our way of life and the environment is obvious as we can see from the rise of CO_2 in the atmosphere as well as our growing understanding of the links with increasing cancer rates, declining fertility rates, neurodevelopmental disorders, allergies and asthma, all of which are rising by up to 5% a year across Europe.

In this paper I want to share with you my conviction, as professor of Waste Management, a researcher into environmental issues of many years, and also as a human being, that we must all make the connections that the Nobel committee has made we must all realise and accept that world peace can only be achieved if our resources are shared, saved and managed successfully.

Following a brief overview, I will make some remarks about

the need to support rapidly developing economies in their efforts to encourage efficient resource use, in the interest of the whole planet. I will use the example of the People's Republic of China.

Secondly, I will take the example of Germany, and particularly the city of Dresden, to explain how public policy has been effectively translated a local level into a very successful citywide initiative. The Dresden project has been copied widely and is a model that can have an enormous impact in many parts of the world.

II. Developmental Imbalance

The question we need to address is: what characterises imbalanced development and environmental problems world wide?

When we talk about modern environmental problems many people in Europe, America and Asia tend to state that in the past, 20, 50 or 100 years ago depending on of the country or the region, everybody lived together in solidarity and co-operation, and the pollution of the environment was not a problem.

But if we look closer we will find that societies were formed over hundreds of years as the result of "hunger, disease and war". People lived in small villages helping each other to survive. The result was that the individual was part of a group and gained the solidarity und support of a social community, but had to pay for his security as a group member with his autonomy.

Society as we know it today could only develop with a sound education in natural and engineering science, which resulted in better hygiene knowledge, effective health care, higher incomes, and more recently fewer wars, at least in many parts of the world.

Individually, we started to live lives which we more secure overall. We live longer, in better health, and we are much richer, and these are the basic reasons for growing individualization in Europe and America in the past and Asia today.

In spite of the phenomenal development of industry and rapid growth of the world economy, we should realize that the basic knowledge of the environment is like living in the village, nobody initially understood that with the change of lifestyle and the way we produce and consume, the carrying capacity of the environment is limited.

The imbalanced development is growing with rising resource use, as is the threat of wars over resources, resulting in increased instability in the world.

The greatest challenge for mankind is to feed 6 billion, soon 7 and 8 billion, people. The production of food is the single largest product category in the world, followed by cement and metals of all kinds.

To ensure the availability of food for everyone, man has asked chemicals to play an important role.

Chemicals are ubiquitous. Everything in our world is made of chemicals, including all living organisms, our food, the water we drink and the air we breathe. In addition to interactive mixture

of natural chemicals, human activity has added more than 100,000 different new chemicals, of which about 30,000 are used regularly in industrial processes. Some are known to be harmful to humans, wildlife and to the environment, but for others toxicity and eco-toxicity data are not available.

Once man made chemicals enter the environment they can move around regionally and worldwide through a variety of mechanisms. Some react with light or other chemicals, some are degraded and form new dangerous molecules, and others persist for many decades. Following ingestion by living organisms or uptake by plants, some chemicals can become bio-accumulated and become more concentrated as they move up the food chain. High toxic concentrations can be found in predator species and human beings.

The growth of the Chinese economy, for example, shows how imbalanced development can be:

- In China four times more fertilizer and double the amount of pesticides are used in agriculture compared with the USA, a country of about the some geographical size.
- China produces almost 50% of the world's cement, and cement works are energy intensive and pollute the air with dust and gases.
- More than half of the big cities in the world with severe smog problems are in China.
- China is the biggest producer of coal and steel and is going to become the country to emit the largest amount of CO_2 per year in the world.

- Deforestation and the pollution of rivers and coastal areas with fertilizer and hazardous chemicals from industry are the greatest threat to agriculture, drinking water and fishing.

But China is definitely not to blame for pushing forward with its development. We do have to help China and also other emerging countries like Brazil and India by providing information and technology. Secondly, rich parts of the world like the USA, Japan and Europe have to lead with a form of burden sharing in order to make room for economic development and use of the environment by others. But how can this turn around be achieved in practice?

III. Balanced Development - The Potential and The Limitations

Waste management scientists have proposed a countless number of technologies, techniques, economic and social tools to solve problems created by industry, trade, consumption and the aftercare of what is left behind. One of the most important approaches the Circular Economy was proposed by us.

1. The Potential

The environment has four economic functions for the basic human welfare (4):

1. Amenity values
2. A resource base for the economy
3. A sink for the residual flows and
4. A life support system

The objective for the future is to ensure that consumption of renewable and non-renewable resources does not exceed carrying capacity of the environment.

Circular Economy (CE) is a model for future economic development that aims to deliver environmental protection, pollution prevention and sustainable development through conversion, reusing and recycling of resources, in order to minimize pollution from the source and reduce overall waste per unit of output. Germany introduce this concept through a law on "Kreislaufwirtschaft" in 1996, and this is already a step forward towards Circular Economy, although much more is implied than is covered in this German law.

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. The linear system is converted to a circular system when the relationship between resource use and waste residuals is taken into consideration (3). 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 from Germany in 1998. Due to severe resource scarcity, waste reuse in China was common everywhere; still, a well-defined concept of circular

economy was lacking until 1998. It is fair to say that before 1998 China had practices of circular economy but without theories to underpin them. The practices were in reality a kind of spontaneous development mainly targeting wastes having market values for reuse and recycling. In this latest phase the Circular Economy has taken on the traditional feature that aims at resource saving. The wastes without direct market value had previously been directly discharged into the environment causing severe environmental pollution.

The pattern of the circular economy

In this chapter I would like to show the possibilities and chances given by the concept of circular economy. We started in China to establish CE in 2004 and produced a priority list what to do in the next 25 years to change to a sustainable society. Examples from the experiences in Germany are given for plastic and paper how to close the loop of production und consumption.

The State Environmental Protection Administration (SEPA) in China has been paying increasing attention to effective patterns of environmental protection, as shown in figure 1.

The discussions on circular economy we mainly focused on three aspects:

- The first concerns the material contents of circular economy, with primary emphasis on 3R (Reuse, Reduction and Recycling) features of circular economy.
- The second focuses on the link between circular economy and cleaner production, suggesting that cleaner production

relates to activities of individual enterprises.

- The third aspect is the link between circular economy and economic development.

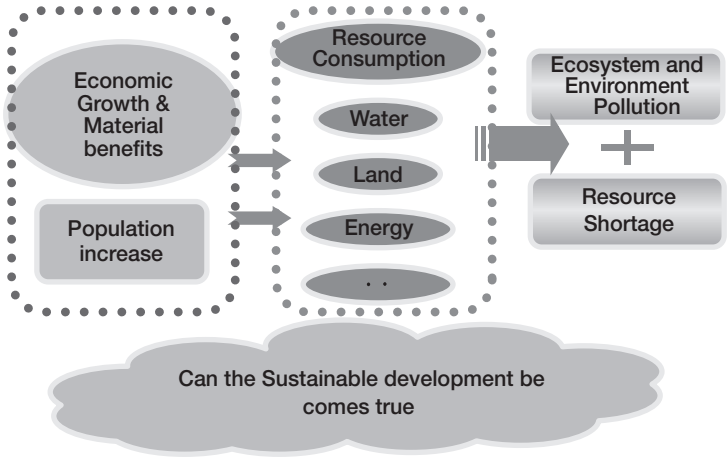


Figure 1: Why China is developing circular economy (1)

In the 11th Five-Year Outline Plan of Economic and Social Development of the PRC the development of circular economy was given very important status. It was put forward as being an important approach to establishing a resource saving and an environmentally friendly society.

In 1996 the German parliament passed the law on Kreislaufwirtschaft (Circular Economy), and since then a number of criticisms created a demand for a revision of the law. The conventional linear perception of the economic system is converted to a circular system with a number of regulations and laws, as shown in figure 2.

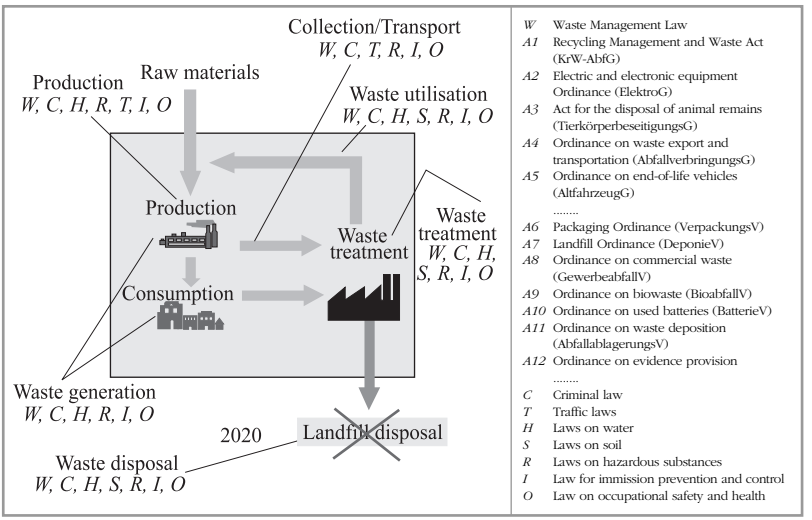


Figure 2: Schematic figure of target areas of balanced material flow of a circular economy (2)

The German government was guided by the following principles:

- Waste and pollution prevention is the primary objective of the development of a circular economy. Prevention can be achieved by a change of technology to achieve cleaner production.
- Better reuse and recycling of waste. Better and more recycling friendly construction of goods are demanded to fulfil higher recycling rates.
- Gradual introduction of a new economic pattern of production, reuse and recycling has to be established. Economic tools like producer responsibility, tax and charging policies, tax deductions etc. are established.

- Mobilization of the whole of society to establish a new pattern of consumption, reuse, recycling and avoidance of waste.
- Development of a legal framework to promote circular economy.
- Complete ban on the use of landfills - everything has to be recycled

Example: Plastics

Waste can be collected and converted back into new products as shown in simplified form in figure 2. But in reality, so far not all the waste is recycled, as shown in figure 3 for plastic packaging in Germany, some of it because of missed technical opportunities, high expenditures and some of it because of the second law of thermodynamics.

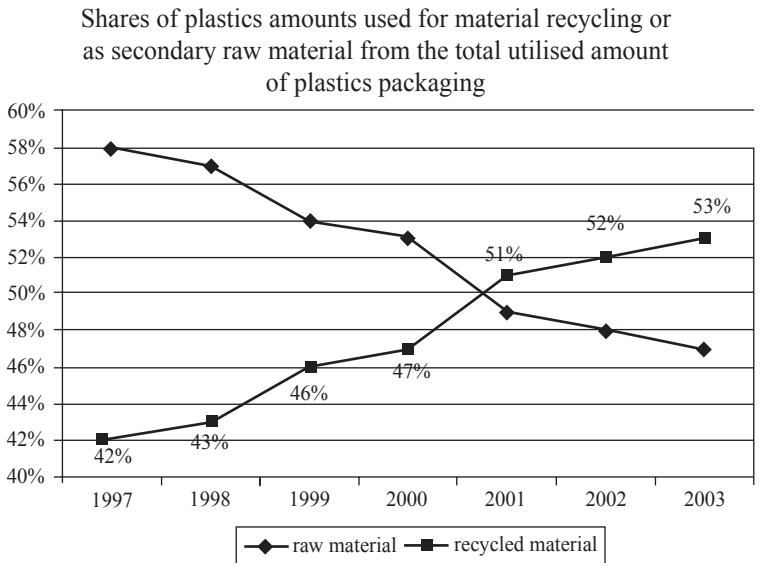


Figure 3: Material flow of virgin and secondary plastics in packaging (2)

Example: Paper

The paper chain is a second good example from Germany. From a total production of 12,941 million Mg of paper and cardboard in 1992, German paper production rose to 19,310 million Mg in 2003. In comparing the two totals certain trends can be noted. The market supply of paper and cardboard in the year 1992 came to 15,739 million Mg because of surplus imports amounting to 2.798 million Mg or 21.6% of total domestic production. 2003, Germany had for the second time after 2002 an export surplus of 0.484 million Mg. This means that over the two years, the domestic market became independent of foreign supplies of paper and cardboard.

Examination of the entire paper flow shows that the successful exploitation of the used paper potential from German households and commerce is one of the main reasons for this achievement, as shown in Fig.4. While 6,785 million Mg or 55.3% of the paper available at from end users had been collected in 1992, this amount increased to 12,174 million Mg or 79.1% of the used paper potential in 2003.

Waste disposal in 1992 still included 5.483 million Mg of used paper, an amount that decreased to 3.208 million Mg in 2003, as shown in Fig.4. In relation to the total quantity from end users this means a reduction of the paper disposed of as waste from 44.7% to 20.9% within the period 1992 to 2003.

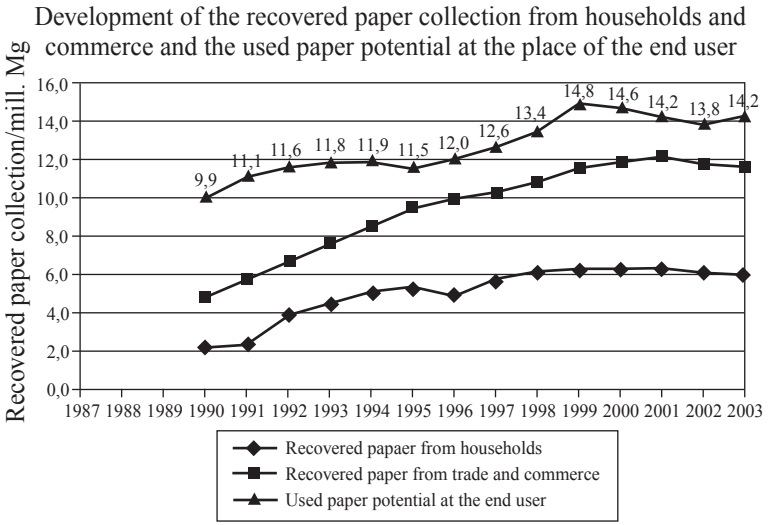


Figure 4: Development of recovered paper collection in a cumulative illustration of the shares from household and commercial sources in relation to the total used paper potential

In Fig. 4 the development of the collected recovered paper quantity from households and commercial sources is summarised and related to the total used paper potential at the location of the end users. These figures demonstrate the importance of recovered paper collection as a raw material source for the paper industry, but it is also evident from the diagram that since 1995 the potential for recycling has remained constant, with the gap between potential and actual recycling volume remaining at 2 to 3 Mg. One reason for this is the quality of the collected recycling paper, which deteriorates the nearer to closure the loop of the material flow.

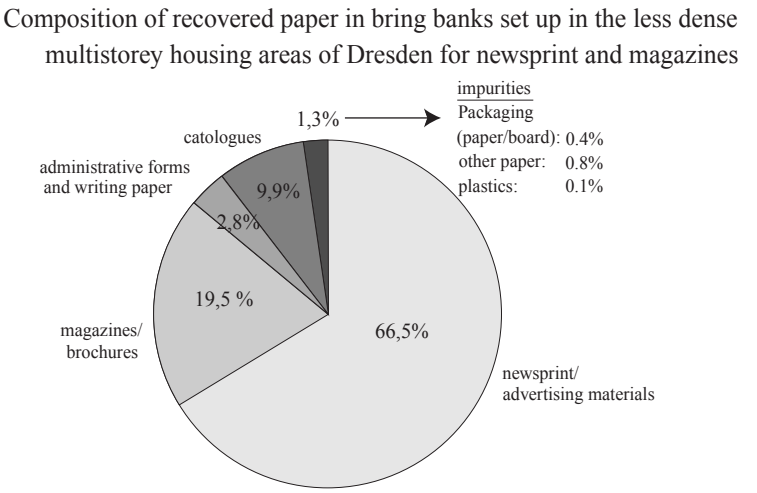


Figure 5: Composition of the collected graphical paper in one study area

Investigations in Dresden (3) revealed that in selected areas the quality of the separately collected graphical paper is good enough to principally meet the requirements the paper industry has established for de-inking material without further processing steps. Such an example can be seen in Fig. 5. The results shown are achieved by means of a drop-off arrangement (bring bank) in the city of Dresden.

Tab. 1 shows the utilisation of recovered paper for the main product groups of paper production by comparison of the years 1992 and 2003. The utilisation rate rose from 52.1% in the year 1992 to 64.5% in 2003. A deeper analysis of the data in reveals that the desired growth basically took place within the product groups where already in the year 1992 the highest rates of recovered paper utilisation could be observed. Recovered paper

utilisation in the packaging-grade product segment has, for example, increased by approximately 2.6 million Mg. The use of recovered paper in the largest product group, graphical papers, rose by nearly 2.8 million Mg, an increase which also underlines that the growth potential in this segment is still one of the largest in comparison to the other product segments. The possibility for a continued increase of recovered paper utilisation exists only in the graphical sector, given the fact that in the other entire product segments technical limits of recovered paper utilisation have almost been reached.

Main product groups	Recovered paper utilisation [Mg/a]		Total production [Mg/a]		Rate of recovered paper utilisation in paper production [%]	
	1992	2003	1992	2003	1992	2003
Packaging paper/board	4,353,000	6,969,000	4,166,000	7,481,000	92.3	93.2
Graphical papers	1,300,000	4,092,000	5,784,000	9,450,000	18.1	43.3
Hygiene papers	575,000	795,000	828,000	1,053,000	54.9	75.5
Technical papers	515,000	593,000	1,095,000	1,318,000	38.6	45.0
Total	6,743,000	12,449,000	11,873,000	19,302,000	48.6	64.5

Tab. 1: Development of distribution of the utilised recovered paper across the different segments of paper production (in 1992 and 2003)

For graphical papers an increase of the utilised amounts of recovered paper will also be possible in the longer term.

Example: Metal

Metal is different to paper and glass. Metal is of inorganic nature and could be as often as possible recycled. But metal is important to built up an infrastructure and therefore considered more in a long term perspective, than newspaper or packaging from paper and plastic.

As metal resources are extracted, for example, from ores, and used and circulated for the production of goods, their entropy increases. This is evidenced by gaseous losses in the atmosphere, but also applies to all metals as such. Gold is very good example because everybody expects gold to be recycled without loss, but this is not the case. It is estimated that in the past 6000 years over 152,000 Mg of above-ground stocks have been accumulated. About 15% of this amount has been lost in dissipative uses or is not accounted for (5).

The phases of industrial development must be also taken into account, and this applies equally for emerging countries. Germany consumes 0.36 Mg metal/capita. In the 1970s during its material-intensive infrastructure development phase it consumed around 0.8 Mg / capita (4). During the last two decades domestic extraction of metal ores and industrial minerals in the EU has decreased continuously from about 240 to 150 million Mg, while imports have increased from about 250 to almost 400 million Mg (4). A closer look at the composition of the EU`s 1995 total material requirement (TMR) shows that 72% of the flows were made of non-renewable resources, of these non-renewable flows, 21% were metal flows, and 95% of these

metals were imported (5).

Waste avoidance and sustainable development

To minimise waste it is important to reduce the input of resources to the economy. To keep and increase the level of welfare of a society by reducing the scale of material circulation it is necessary to raise efficiency in industry and consumption.

This development lies with the second law of thermodynamics and the concept of entropy. In industry benchmarking was establish in Germany to evaluate and measure processes, products and services by comparison with best-in-class companies.

In particular, benchmarking can be used to achieve the following goals (6):

- increase in economic efficiency,
- analysis of cost structures,
- realisation of motivating effects,
- realisation of learning effects and
- analysis of material flows (in-/output).

To assess possible compliance with these obligations, programmes aiming to investigate the yet existing potentials in respect of utilisation and avoidance of industrial waste have been launched by some of the Federal States.

In regard to consumption this is more difficult.

Example of the City of Dresden

The City of Dresden, capital city of the State of Saxony, provides a very good example of the developments of waste generation, water and energy consumption in the wake of the transition from a socialistic type of economy to the market oriented economy of the West. I take the example of Dresden, to explain how public policy has been effectively translated a local level into a very successful citywide initiative, based on ideas from the Institute of Waste Management at the University of Dresden. The Dresden project, especially the experiences on "pay-as-you-throw" (PAYT), has been copied widely and is a model that can have an enormous impact in many parts of the world.

The City of Dresden, which now has approx. 470,000 registered inhabitants, was one of the largest cities of the former German Democratic Republic, the socialist part of the divided Germany from 1949-1989.

The peaceful revolution which also had important roots in Dresden heralded the end of the socialist GDR and finally led to the re-unification of Germany. In 1990, Dresden regained its former status as capital of the re-established Free State of Saxony. After the collapse of the self-contained East German economy, which caused the closure of many unprofitable enterprises, western economic structures have been quickly established with the help of extensive financial investment from the West German Lander (States) and support from the EU.

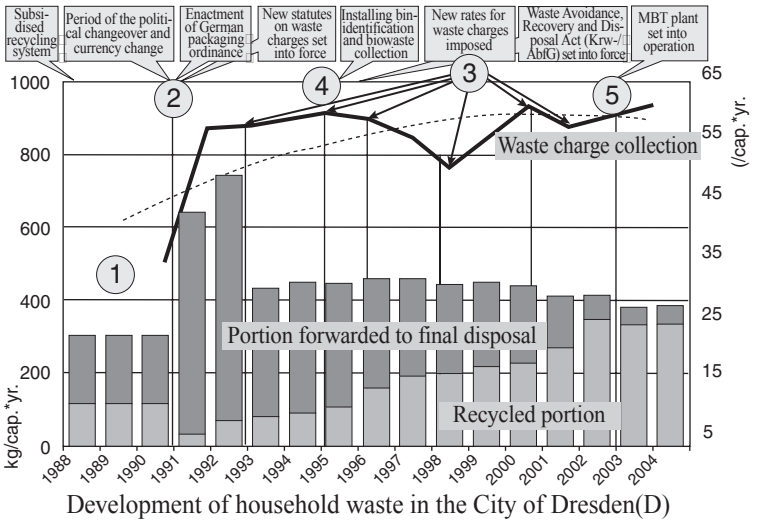


Figure 6: Household Waste in the City of Dresden from 1988 to 2004, from socialistic economy to capitalist economy model (2)

For 1988 to 1990, still at the time of the GDR, Fig 6 shows that the total household waste generation in the City of Dresden was approximately 320 kg/(cap*yr) No 1.

Recycling made up 110 kg/(cap*yr) and was heavily subsidised by the socialist government in order to cope with the shortage of raw materials in their own country. Citizens were encouraged to carry their recyclables to special collection centres, where they received payment. The payments made for paper, glass; metals, etc. were generally higher than the corresponding price for these commodities on the world market. This could only work because the East German currency was not freely convertible and the government had to save their

reserves of convertible money. Due to the shortage of goods, people were also very careful in using their private items, and instead of throwing them away, they preferred to refurbish them or have they repaired once they became obsolete or got broken. At this time, citizens paid a low and rather symbolic amount for the collection of their waste as an element of their monthly housing rent.

In October 1990, (No 2) the switch to a free market economy took place with the monetary union and exchange of the East German currency into Deutsche Mark. During this phase the former recycling system broke down almost completely while citizens started to spend their time shopping with the new currency in their hands. Consequently they produced great deal of over the next two years. The city tried to re-establish a recycling system for large items by setting up four recycling stations, but this could not cope with the vast amounts of different items discarded.

However, by 1991 (No 3) a new waste charging system was introduced and gradually extended in the following years. With the rising waste charges (broken yellow line) people started to become more aware of the charges they had pay for their waste and consequently re-engaged more enthusiastically in recycling. This time they did not receive direct payments for their recyclables but were able to reduce their waste charges and avoid double payments for discarded packaging. The latter followed from the Packaging Ordinance (No 2) enacted in 1992, and the introduction of the green-dot system, which required

people to pay already for the recycling of packaging material at the point of purchase. With the economic instruments applied and a certain saturation level in the fitting out of households with new, western-style products the overall collected waste amount again dropped sharply, although remaining above pre-1990 levels.

To facilitate the recycling efforts of its citizens, the city gradually enlarged its network of recycling stations and increased its offered schemes for separate waste collection. To make the recycling-oriented waste charge system work fully and particularly to give residents in multi-storey apartment buildings the same opportunity to benefit from the incentives arising from it, a system of differentiated waste charges based on an electronic bin identification system was introduced in 1994/1995. With this system in place, a turning point in the overall waste generation and intensity of waste recycling was finally achieved (No 4).

A further significant increase in the overall recycling rate was achieved when a mechanical biological waste treatment plant (No 5) went into operation end of 2002. The plant is able to sort most of the recyclable material from the collected waste and produce combustible pellets out of the remaining stream, which can be used for methanol production.

2. Limitations

In chapter 3.1 about potentials some of the limitations were

already mentioned. The most important of these is the limitation of closing a material loop technically by 100%. Only very few materials such as glass and metal and other inorganic components could possibly make a complete loop become reality. Organic matter like paper, plastic or all other organic molecules undergo a degradation process over time and during a recycling process, so that the quality is going deteriorate (down recycling).

Figures 7a and 7b show the influence of recycling on energy consumption or costs of a new product. In figure 7a the resulting slope shows that recycling effectively can replace virgin material up to more than 50%. In picture 7b the costs of waste management are added. The resulting curve of all three cost curves in figure 7b show that the waste management costs have a significant influence on the amount of recycled material. The higher the waste management costs the greater will be the volume of material recycling, which is also a positive indicator for introduction of a landfill tax. The limitation of this system is also quiet clear. As soon as the resulting curve will leave its optimal point and reach the level of the virgin material costs, then recycling is no longer preferable at the given circumstances.

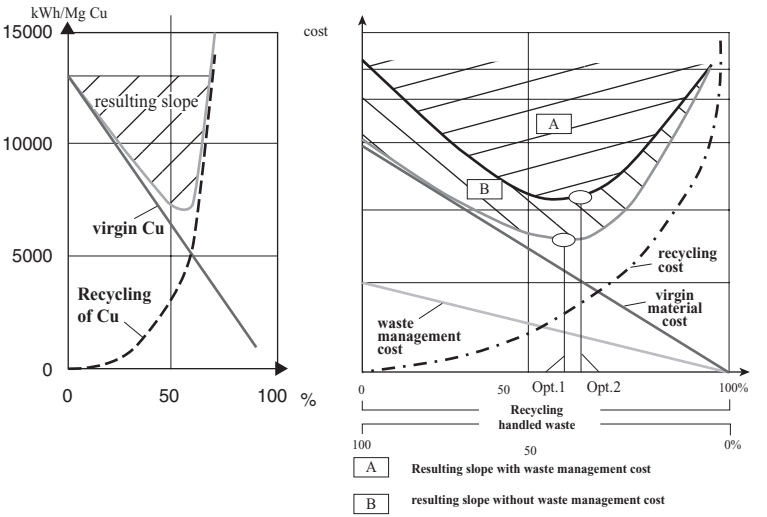


Figure7: The influence of recycling (7a) plus waste management (7b) on the use of virgin material

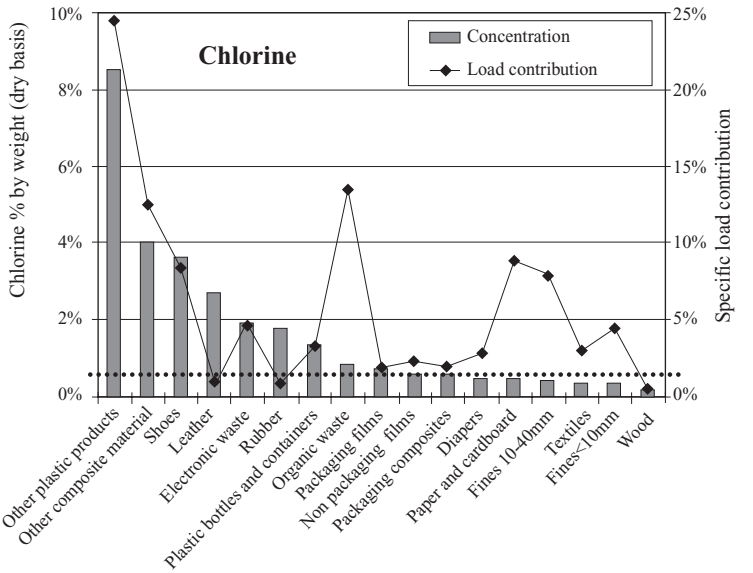
I would like to introduce a second severe problem affecting worldwide material flow of recyclables pollutant in waste fractions.

Sources of Pollutants in Waste

At the Institute of Waste and Site Management in Dresden an action research program has been established with the aim of categorising the chemical-physical properties of household waste. A substantial part of the investigation is the determination of fraction-specific pollutant concentrations. With this data,

pollutant distributions in mixed household waste and in fractions of recyclables can be calculated from its composition.

For the elements chlorine, lead and cadmium which are introduced in Figure 8, similar waste groups are the main carriers of pollutants. These in particular are long-lived products such as plastics from the non-packaging sector, electronic waste, shoes and other composite products. However the load differs substantially as shown in the distribution. In the case of chlorine, all waste fractions carry a basic load. Therefore, fractions such as paper, organics and fine waste add significantly to the total load due to their high mass proportion. To some extent this is also valid for lead. On the contrary, the cadmium load is dominated by the load from other plastics (non-films).



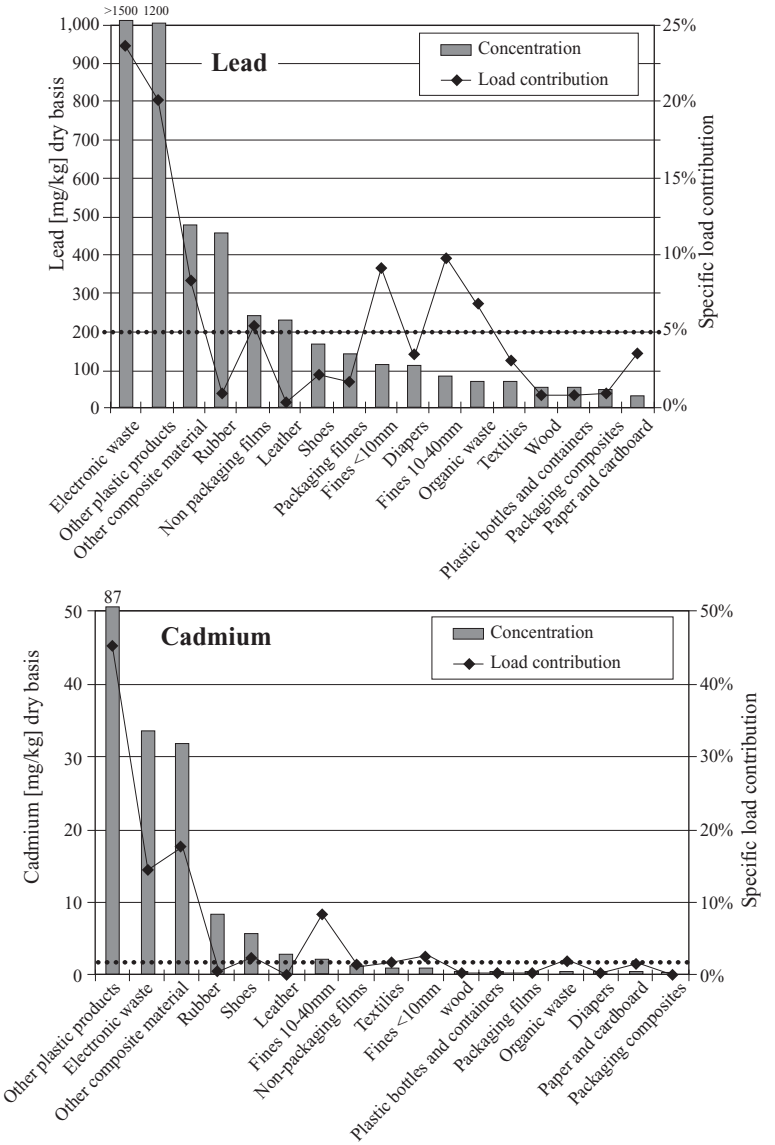


Figure 8: Concentration of chlorine, lead and cadmium in waste fractions and their specific load contribution referred to model household waste from urban areas (without metals) (7)

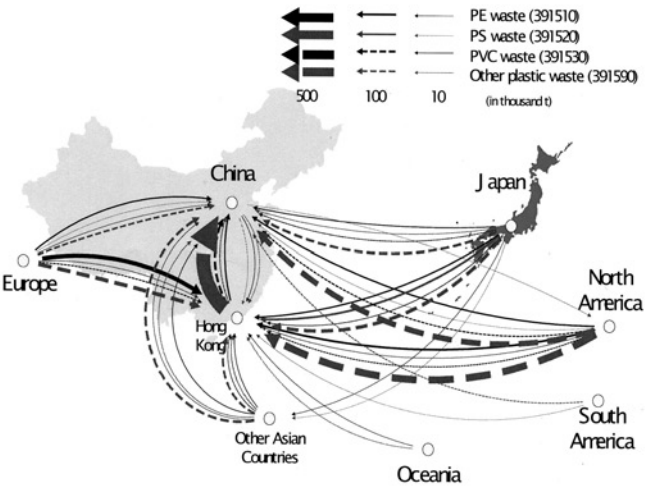


Figure 9: Material flow of used plastic into China (9)

The problem now is worldwide trade and use of recycled material, something that under normal conditions we desire. But our knowledge of hazardous components contained in the material is far from perfect

With the background information of figure 8 it is clear that plastic highly contaminated with heavy metals and chlorine will be processed into new products, which also have this contamination. But plastic also contains organic compounds, which can be released into the environment during the recycling process, and if recycling is not undertaken properly also when the recycled product is in use. Severe damage to health might be the result.

Also the recycling of electric and electronic poisons the workers engaged in recycling and the environment, especially the water sources and the air. For example, there are whole villages in India which specialize in recycling circuit boards to extract gold with mercury, or as it are shown in Fig.10 recycling of copper from cables. To burn the wire and extract copper from the ash is an easy process, and the copper price is right now ten times higher than a couple of years ago.

Figure 10: Village people in China recycle electronic scrap - copper wires

The incineration of PVC wires (thick wires often contain PCB as a cooling agent) in the open produces a considerable amount

of dioxin. The dioxin formation in an open pit incineration process is 10,000 fold higher than in a modern thermal treatment facility

CEPI EXports of Recovered Paper to Other Regions 1999~2003

	1999	2000	2001	2002	2003	Change 2003/2002
	'000Tonnes	'000Tonnes	'000Tonnes	'000Tonnes	'000Tonnes	%
Other Europe	256	387	365	448	366	-18.3
North America	27	48	48	19	24	26.3
Latin America	0	7	6	13	6	-53.8
Asia	3.270	2.921	3.577	3.652	4.124	12.9
Rest of the World	196	129	66	87	68	-21.8
Total	**3.749**	**3.492**	**4.062**	**4.129**	**4.588**	**8.7**

Tab. 2: Export of recycling paper from Europe to other regions of the world (10)

The second example I would like to present is that of paper recycling. Recovered paper collected from households and shops and offices is traded all over the world and save resources like virgin fibre from wood.

Table 2 and in Figure 11 show the importance of the paper trade. Asia has the fastest growing market and demand for recovered paper from Europe and USA.

Thermal paper used in cash machines and as copy paper has a colour developing layer with the chemical Biphenyl A (BPA). BPA is introduced into the paper cycle through the recovery of used thermal paper. Roughly 500 Mg of BPA enters every year

the German paper recycling cycle alone and is also shipped abroad. 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.

BPA is aerobically degradable and therefore considered not harmful. But BPA is an endocrine disrupter like more than 300 other chemicals in use and is able to affect the hormone system of human and vertebrates and other species. In Europe we have found evidence that BPA is dangerous and is one of many chemicals that will affect life today and into the future. The path of BPA from the paper product to the surface and ground water and the soil of farmland are shown.

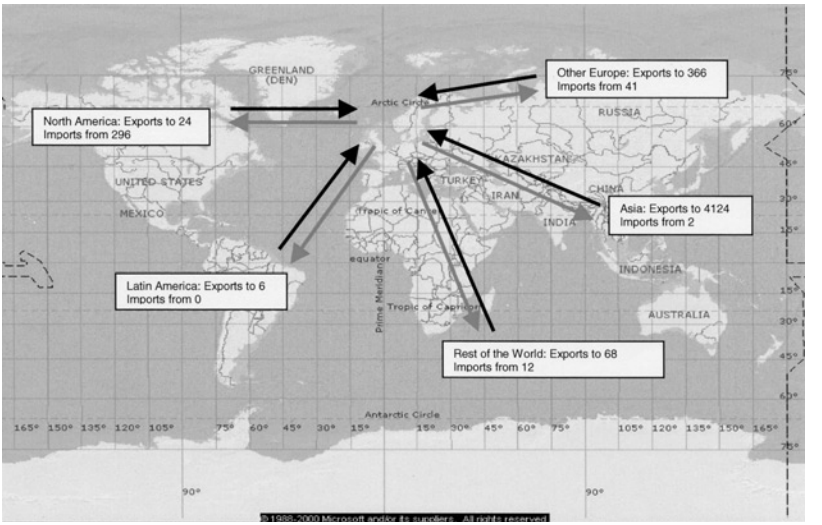


Figure11: Trade Flows of Recovered Paper to and from CEPI Countries 2003 - All figures are '000 Tonnes (10)

The production of sludge from wastewater treatment plants is increasing rapidly in Europe. The wastewater treatment plant produces in a combined process sludge and clarified water shown in figure 12.

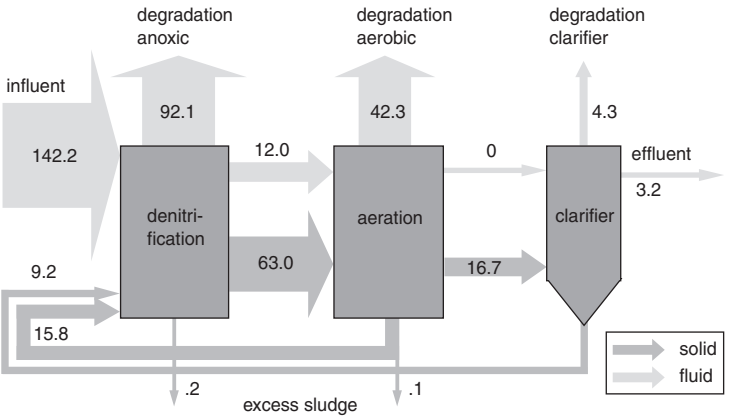


Figure 12: Mass balance of Biphenyl A of a lab scale waste water treatment plant with Biphenyl A as endocrine disrupting compound in effluent and excess sludge (11)

Heavy metals, different kinds of medicine discarded from households and hospitals, endocrine-disrupting compounds like BPA are part of toilet paper and therefore everything is also part of the waste water. They and get unchanged or chemically coverted either in the sludge treatment or/and in the surface water (Figure 12). While surface water has always been a major environmental issue, sludge was not. As in many countries the European Commission has also proposed in a directive to direct sludge from wastewater treatment preferable to agriculture to

use sludge as fertiliser because of its high content of phosphor, which is a scare chemical and essential for life..

Sludge in agriculture has a long term effect as indicated in Fig.13. Taking endocrine disrupting compounds as an example, it will take approx. 100 to 200 years for these chemicals to reach the ground water.

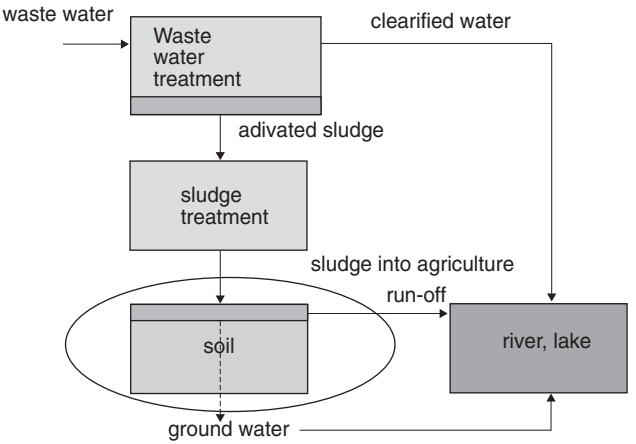


Figure 13: Waste water and sludge treatment facilities and their influence on ground, ground-and surface water (11)

Surface water can be affected much faster. During heavy rainfall chemicals are washed out into lakes and streams. We found sludge recycling for agricultural use in Europe is not sustainable anymore, therefore we have started in Germany to develop technologies to extract phosphorous from sludge to be used directly as fertiliser.

BPA is a good example of the complexity and the limited knowledge we have of recycling processes. But with better understanding, better strategies and technologies we are able to solve such problems.

IV. Conclusion

The limitations and possibilities show that a lot of research remains to be done in the future. The different nations of the world need each other. Nobody can succeed at a high economic level without fair trade. The establishment of Circular Economy can be beneficial to society and the world as whole.

Circular Economy has its conceptual roots in industrial ecology. Germany started with a law "Kreislaufwirtschaft" in 1996. This is already a step forward towards Circular Economy, which gives priority to making full use of waste as raw materials or fuel and to protecting non-renewable and renewable resources.

There has already been discussion on changing the "Kreislaufwirtschaft" law into a law on "Material Flow". But so far this approach has been thought to be too complex, requiring as it does description of every substance and material and their flow through the economy and the consuming society. But nevertheless the existing tools, like MFA, LCA, and the concepts of extended producer responsibility, minimisation, and dematerialisation as well as the techniques to account for

external costs will be needed to provide sustainable developments for future generations.

Environmental problems have an impact on each single person. Nobody in the world can ignore this; it is therefore reasonable to demand that all citizens should have a democratic voice to influence their own and their children's future.

Research and education in natural and engineering sciences its great development about 150 years ago, and science and education will show us the way out of the environmental dilemma and imbalanced development.

For this we need peace and no wasting of money on an arms race. We need democracy and a genuine participation of people in governmental power and welfare. Education and knowledge transfer is a prerequisite for understanding environmental issues as well as the options to solve the existing and upcoming problems.

References

Qi Jianguo : The development of circular economy in China - Progresses and policies, Workshop on Circular Economy at the National University of Science Hanoi, 12 Oct. 2006

Bilitewski, B.: From waste management to circular economy, Workshop on Circular Economy at the National University of Science Hanoi,12 Oct. 2006

INTECUS by order of VDP: Elaboration of a fibre flow balance for the years from 1992 till 2003. (in German)

Andersen, M. S. (1997). Evaluation of the cleaner technology programme. Environmental Review No. 14, Copenhagen: EPA

Estrada Calvo, I.A.: Resource efficiency strategies for developing countries - An analysis based on South America and its mining industry, published in Beitrage zu Abfallwirt- schaft/ Altlasten Volume 47, Schriftenreihe des Instituts fur Abfallwirtschaft und Altlasten der Technischen Universitat Dresden, 2007

Bilitewski, B.; Hardtle, G.; Marek, K.; Weissbach, A.; Boeddicker, H (1996). Waste Management, Springer 1996, p. 564-571

Kost, T.; Rotter, S.; Bilitewski, B. (2000): Einfluss der Aufbereitung auf die Qualitat der Ersatzbrennstoffe am Beispiel von Chlor. In: Urban et al. [Hrsg.] Thermische Abfallbehandlung (Tagungsband), Kassel 2000

Shin-ichi Sakai (NIES, Japan), personal information The China Council for International Cooperaton on Environment and Development, Peking 2004/2005

Bernd Bocking (GesPaRec), (2005)Bedeutung Chinas im Globalen Altpapiermarkt ENTSORGA - CONGRESS Altpapier, Nationale Reglementierung - Globale Markte Koln, 23. Mai 2005

Gehring, M.,Tennhardt,L., Vogel.D., Bilitewski,B. (2003): Waste paper as a Source for Xenoestrogenic Compounds. In: Pullammanappallil, Pr., McComb,A., Diaz, L. F., Bidlingmaier, W. (eds.): Proc. 4 th Int. Conference ORBIT Ass. On Biol. Proc. Organics: Adv. Sustain. Soc., April 30 - May 02, 2003 Perth, Australia, Vol. 2, P53 - p63.