
Reduce; re-use; recycle – a global necessity

Matthias Kuehle-Weidemeier

Wasteconsult International

Abstract

With regard to the shortage and price increase of resources it is important to break new ground in waste management to support sustainable methods of waste treatment in the future.

The following article gives an overview of the availability and the use of raw materials (fossil fuels, metallic and non-metallic) in some important countries in the world. Also, it is shown how CO₂-emissions can be reduced by recycling and valuable resources can be saved for future generations.

Today's methods of waste treatment (mechanical-biological-treatment or waste incineration) are evaluated concerning their feasibility for sustainable waste management.

Finally recommendations on how to reach a sustainable waste management are presented.

Keywords

waste management, resources, raw materials, waste treatment, MBT, incineration

1 Introduction

The approaching exhaustion of many raw materials and expanding demand for resources due to fast growth of world population and increasing prosperity in many developing countries are a challenge for the world economy and will become a driving factor for enhanced waste treatment / material recovery technology. Quantity and quality of recovered resources from residual waste depend on the kind of waste treatment. Mechanical-biological treatment (MBT) and incineration are the dominant treatment technologies for residual waste and have to prove their feasibility for sustainable waste and resource management.

2 Population growth, consumption of raw materials and available resources

2.1 Population development and consumption of raw materials

The world population will grow from 6.7 billions now (data 2007) to round about 9.1 billion in 2050 (UN, 2009). That corresponds to an average annual growth of 56 millions.

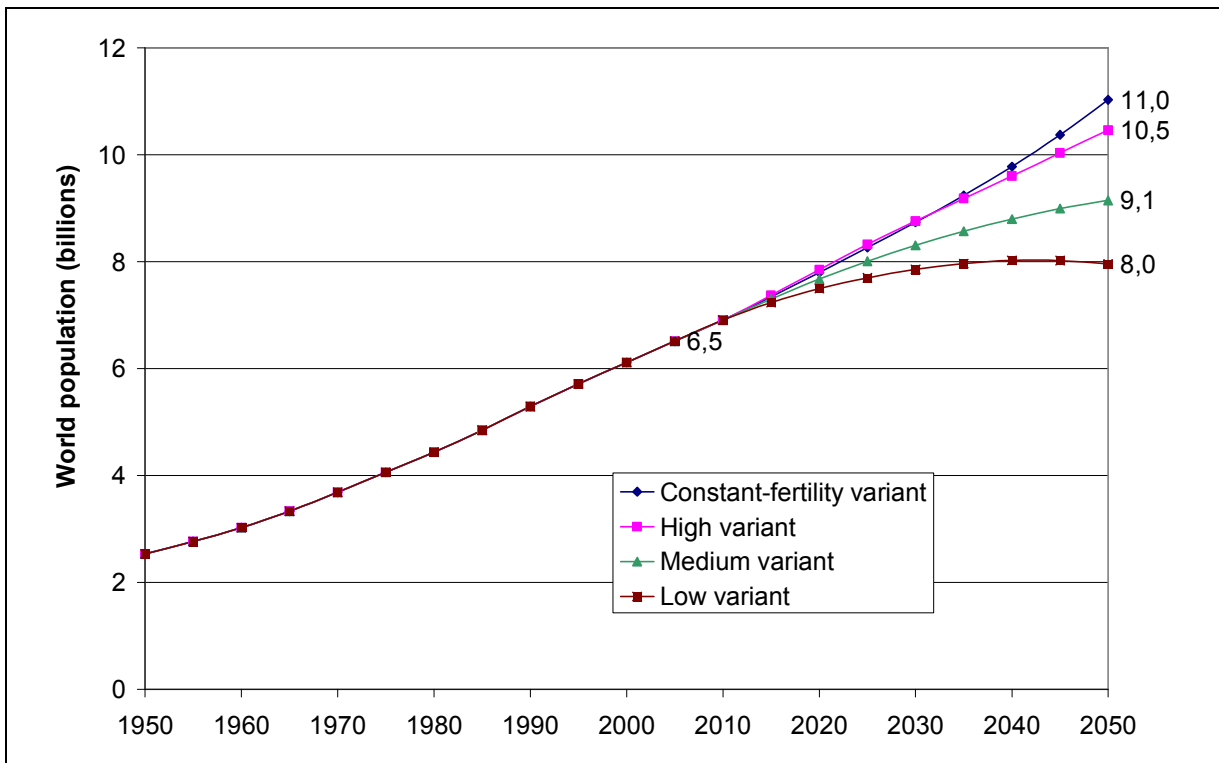


Figure 1: Different scenarios of world population growth (data source: UN, 2009)

The German Foundation for World Population (DSW) reports on their web site a current world population growth of about 81 million people per year. This is nearly as much as the total number of Germany’s inhabitants.

Developing and emerging countries show the highest rates of population growth but there are huge differences between the countries. Figure 2 shows the prediction (medium variant) for China and India compared to Germany. Due to their high number of inhabitants and high economic growth, China and India have a high relevance for the topics discussed in this paper.

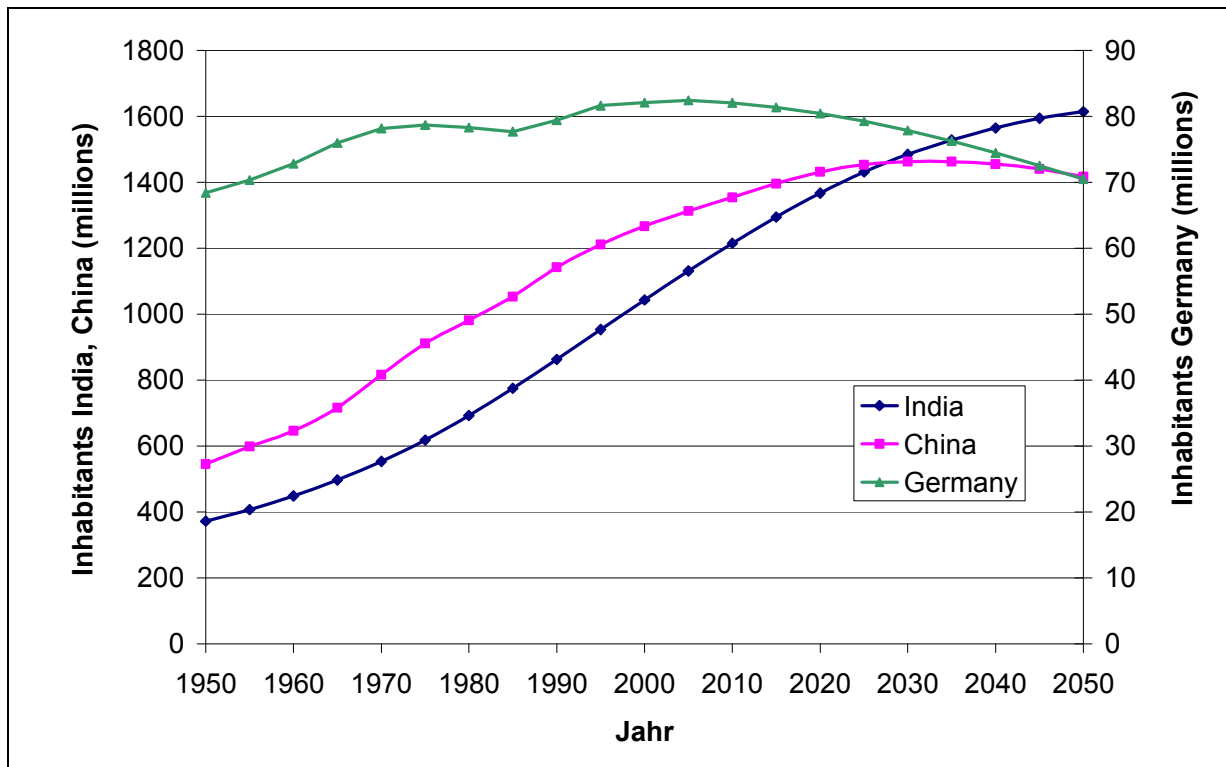


Figure 2: Population development in India, China and Germany, med. variant (data: UN, 2009)

Figure 3 presents the per capita consumption of selected and all resources in different countries. The total includes Biomass. China is already going to approach the average per capita consumption of fossil fuels of the European Union.

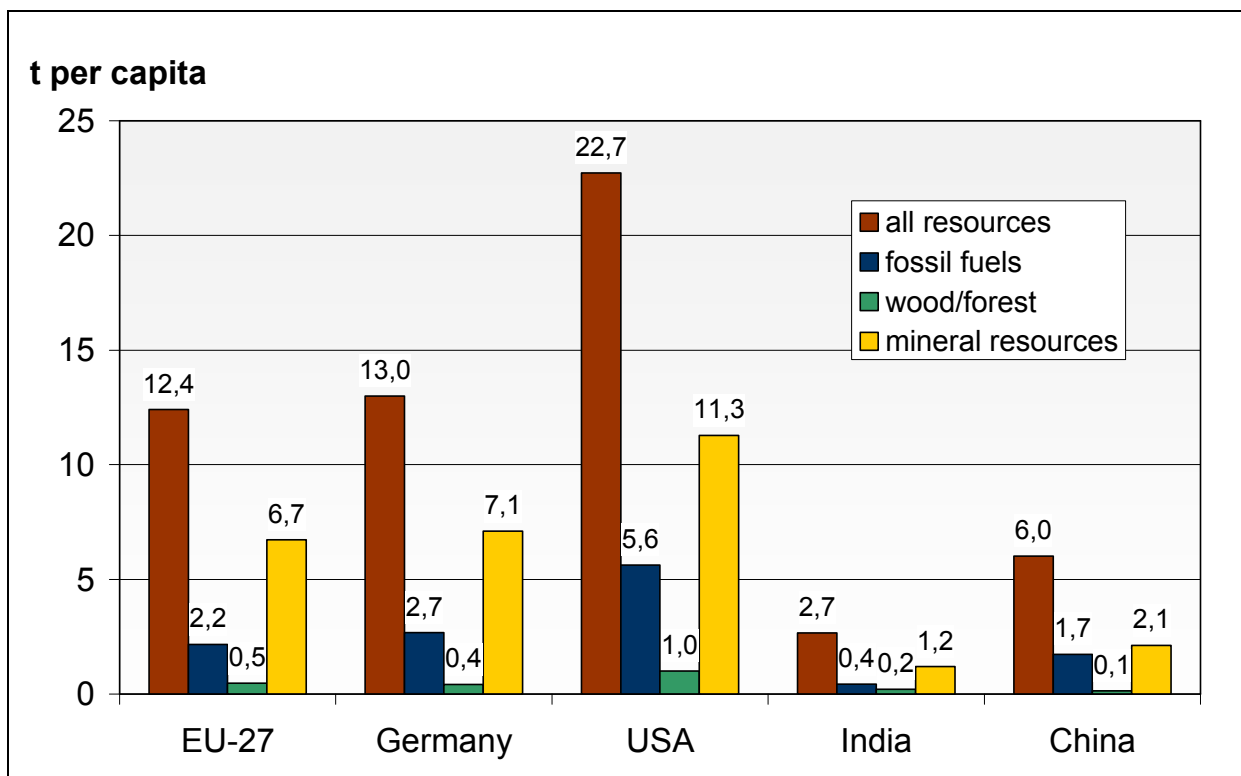


Figure 3: Per capita consumption of resources in different countries (data source: SERI, 2009)

2.2 Important definitions on material reach

For a proper description of the reach of materials (remaining time of availability), some terms need to be defined to avoid misunderstandings due to a different use of these terms in colloquial language. Definitions are according to BARTHEL (1999). These definitions are applied in chapter 2.3 and 2.4 of this article.

Reserve: Those known raw material sources (e.g. ore) that can be economically produced under current market price conditions.

Resource: Proven (natural) material sources where production effort is too high for an economical material production. When the market price increases or cheaper production technologies are developed, resources can become reserves.

Static reach: Time that reserves last (reach of reserves) at a constant production rate

Reach data in chapter 2.3 and 2.4 is based on a constant production rate. An increase of the production rate would shorten the reach.

2.3 Reach of fossil fuels and Uranium

The reach of the non renewable energy resources is important to consider in long term waste management concepts as it will influence the value of refuse derived fuels (RDF) and recovered plastics because oil is the basic raw material for plastics. Oil reserves just last 42 years even under constant production.

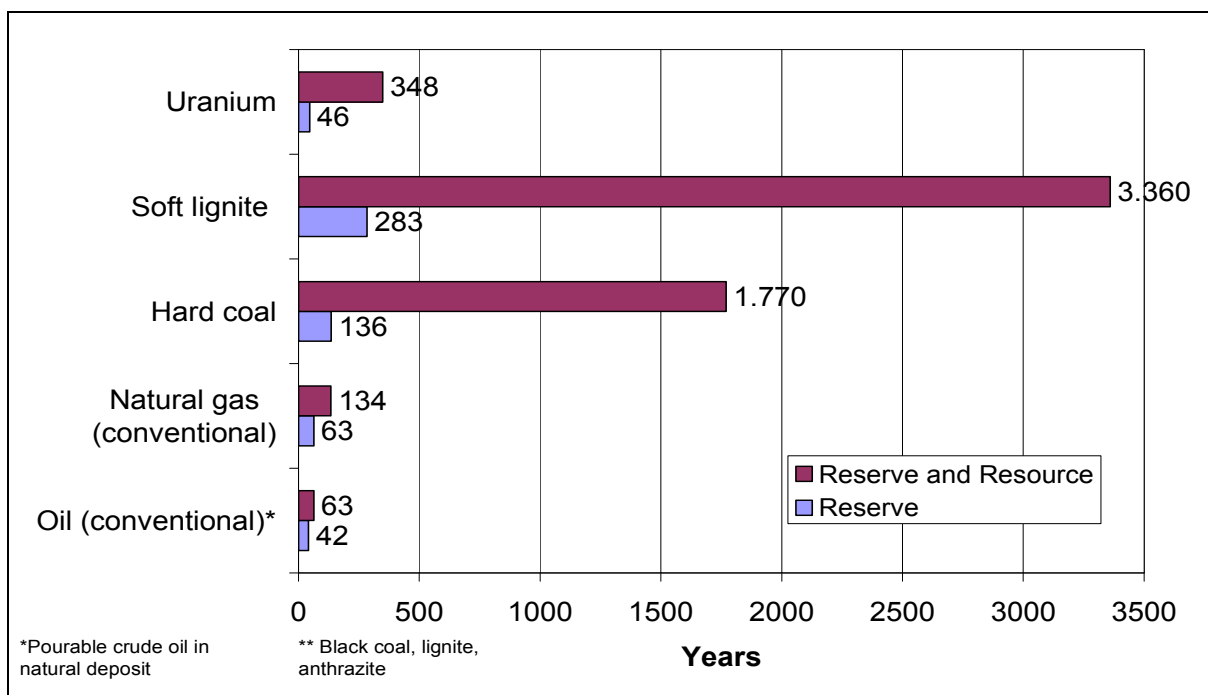


Figure 4: Reach of energy raw materials (data source: BGR 2007)

2.4 Reach of metals and minerals

The reach of metallic and mineral raw materials is not as present as fossil fuels in the public discussion although the reach of many of those irreplaceable materials is even shorter than the reach of oil.

Besides materials that are used for the production of goods, the reach of Phosphate, that is essential for the industrial agriculture and hence for the alimentation of the rapidly growing earth population is only 122 years (BARDT 2008).

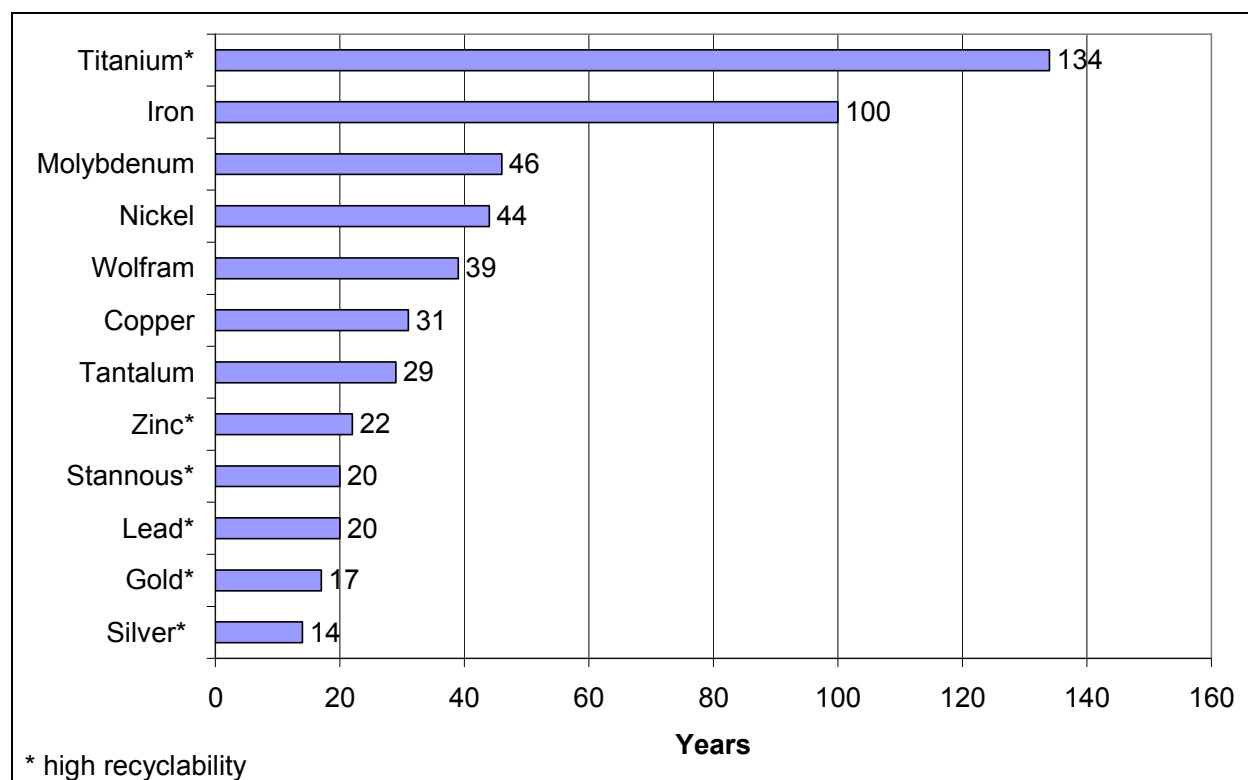


Figure 5: Reach of metallic reserves (DATA SOURCE: BARDT 2008)

The institute of German economy (Institut für Wirtschaft, IW) in Cologne (Köln) published a raw material supply risk list of materials that have a reach of less than 30 years. In spite of their short reach, gold, silver, zinc, stannous and lead do not appear in this list because of their high recyclability. The supply with chrome, molybdenum, columbium (niobium) and metals from the platinum group is classified as very critical in the list. This considers not just the reach but also the situation, that the supply with those metals depends on only 3 countries and 3 companies (BARDT, 2008).

The situation in metal supply is reflected by price development for metallic raw materials that increased by 235% from 2005 to 2008. The price increase of iron ore and steel scrap was even 385% (BARDT 2008). The current massive price drop can be assumed as a temporary event.

2.5 Price development of secondary raw materials

The prices of plastic reclaim (re-granulate) increased significantly in the last years too (50-100% from summer 2003 to summer 2008). With the beginning economical crisis in the second term of 2008 massively declined. This endangers the recycling industry seriously.

The situation of trading prices for used paper is similar:

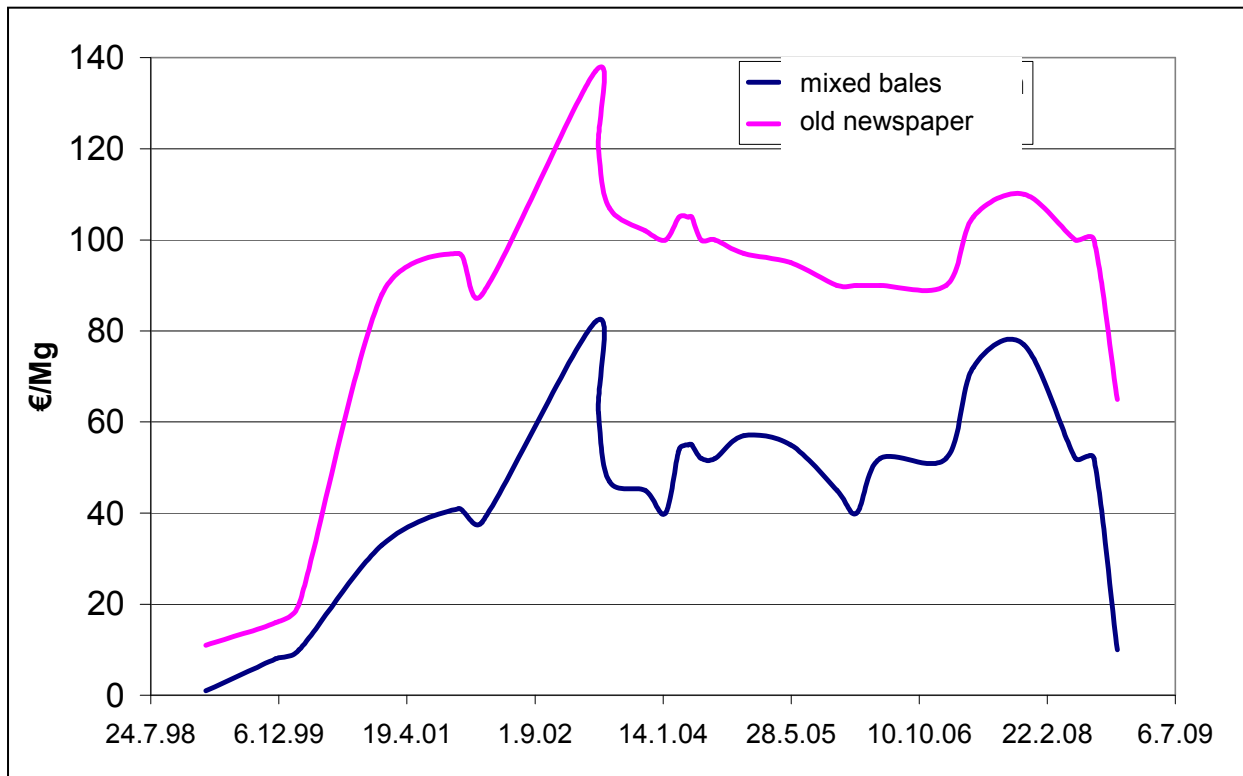


Figure 6: Prices of 2 used paper qualities (data: numerous issues of EUWID Recycling und Entsorgung)

2.6 Reduction of CO₂- emissions by recycling

Recycling is important for climate protection too. By order of INTERSEROH, a German recycling company, Fraunhofer-Institute UMSICHT compared CO₂-emissions caused by the production of primary and secondary materials.

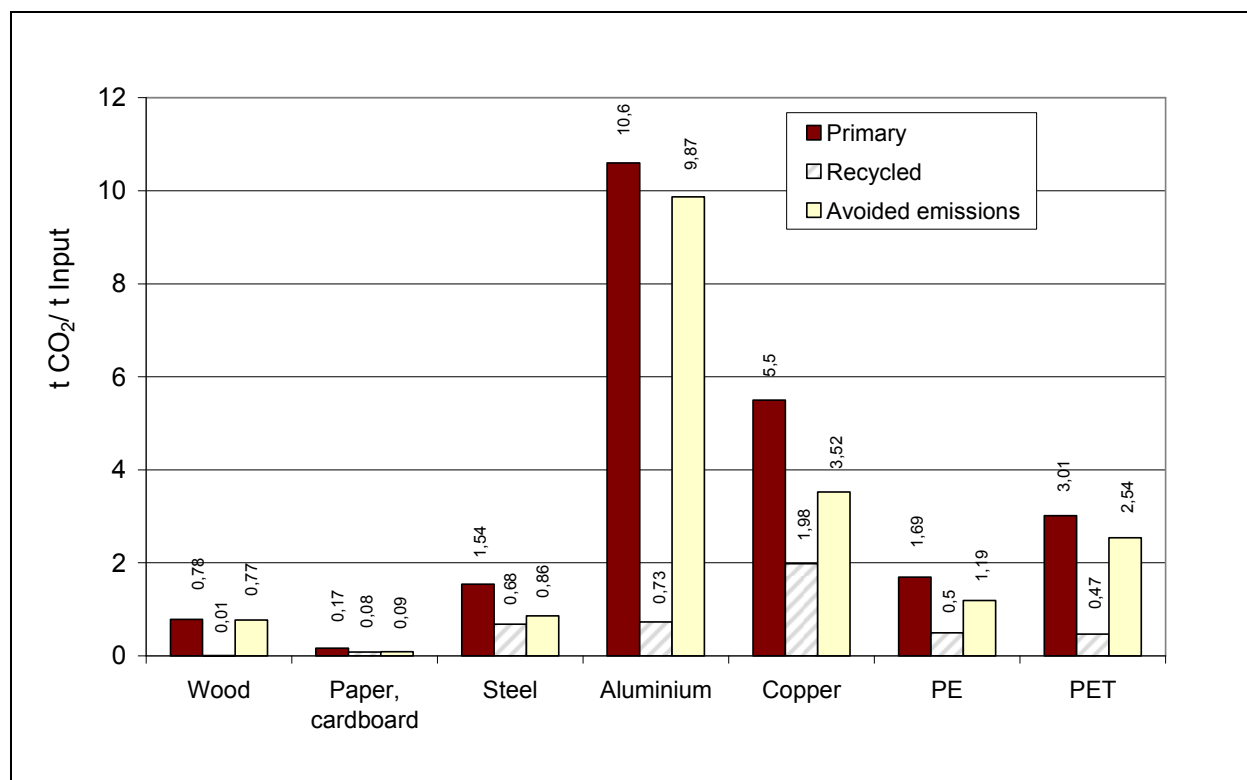


Figure 7: CO₂-emissions by primary and secondary material production and avoided emissions by recycling (data: Interseroh, Umsicht, 2008)

Figure 7 shows that recycling saves an enormous amount of CO₂ emissions and thus energy. For example, copper recycling saves 36%, steel recycling 56%, PE recycling 70%, PET recycling 85% and aluminium recycling even 95% compared to primary material production.

The calculated emissions of the recycling process consider collection, transport and the recycling process itself. Considered transport distances to the recycling facilities are based on the true situation. In case of PET this is the transport to south east Asia. It has to be mentioned, that plastics, paper and wood are only feasible for a small number of recycling cycles. Paper fibres can be re-used 5 - 7 times.

3 Feasibility of waste treatment technologies for the requirements of sustainable waste management

3.1 Treatment of residual waste in Germany

Landfilling of non inert waste is not permitted in Germany. Packages and native organic waste are separately collected and recycled. The remaining residual waste is treated by incineration (about 80%) and about 20% mass-% by mechanical-biological treatment (KÜHLE-WEIDEMEIER, 2005).

3.2 Thermal waste treatment (incineration)

3.2.1 „Classic“ incineration of residual waste

Conventional waste incinerators are an approved and very reliable technology for waste treatment. If they are combined with a state of the art exhaust gas treatment system, there is not much reason to be concerned about their toxic emissions.

Depending on it's quality (leaching test) incinerator bottom ash is used as construction material (mainly for roads) or landfilled. The long term behaviour of incinerator bottom ash is subject of a controversial discussion. The main concern is that possibly a real long term stability (immobilisation of heavy metals) is possibly not given. That is why some opponents call roads constructed with incinerator bottom ash "line landfills".

A part of the exhaust gas cleaning residues is highly toxic and gets stored in subsurface hazardous waste landfills.

Ferrous metals are removed from incinerator residues by magnetic separation. These metals are heavily oxidised. Non-ferrous metals are irrecoverably lost in the bottom ash.

Another product of incineration is energy. That is why incinerators are sometimes called waste to energy plants (sounds nicer). Municipal solid waste [MSW] (with or without source separated collection) has many components with a low calorific value like water (humidity) soil and much more. Hence, the yield of energy is low. Some incinerators are badly located in areas without demand for the produced heat. In some countries the calorific value of the waste is so low that oil is needed to support the combustion process. In this case, waste to energy converts to energy to waste.

3.2.2 Co-generation plants for refuse derived fuel (RDF)

Co-generation plants that are operated with (pre-treated) high calorific waste (RDF) are real power stations that can be truly called waste to energy plants. They are usually connected to industrial plants that allow using the produced heat (steam) and the electricity too.

3.2.3 Evaluation and future relevance for sustainable waste management

Concerning the conservation of resources, waste incinerators are energy and resource destruction plants. Table 1 reveals how much energy is lost if only the energy represented by the calorific value is recovered.

Table 1: Calorific value and energy equivalent (cal. value + energy effort for production) of some plastic materials (Reimann 1988)

Material	Calorific value [kJ/kg]	Energy equivalent [kJ/kg]
Polyethylen (PE)	43,000	70,000
Polypropylen (PP)	44,000	73,000
Polystrol (PS)	40,000	80,000
PVC hard	18,000	53,000

Only ferrous metals can be recovered from the incineration process. Hence, in a sustainable waste and resource management concept, incineration is feasible only for the treatment of those waste components that can not be recycled or when recycling effort (e.g. energy consumption) exceeds the benefit of recycling. That has been the case with the majority of the MSW in the past. That is why incineration as an expensive but reliable technique is so widespread in Germany.

Innovations and significant cost reductions in waste processing and sensor based waste sorting has changed this situation as well as the approaching shortage of raw materials. After the current economical and raw material price crisis more and more waste components will be picked out by sorting machines. Besides the ecological benefit, this saves cost for expensive treatment like incineration and often even creates a positive income. Some waste management societies have already voluntarily installed sensor based sorting units because they it pays off. Step by step there will be less waste that will be incinerated in Germany, resulting in increasing incinerator over capacities. This development might be delayed by price dumping of incinerator operators.

3.3 Mechanical-biological treatment (MBT)

3.3.1 Current situation

Figure 9 shows the average mass-balance of the German MBTs. The amount of material recovery in these plants is not very high. From the total of 4.9 million Mg (tons) per year 127,000 Mg ferrous metal and 9,000 Mg non ferrous metals are recycled. The vast majority (2 million Mg) of MBT output goes to energy recovery (incineration) and 1 million Mg are landfilled.

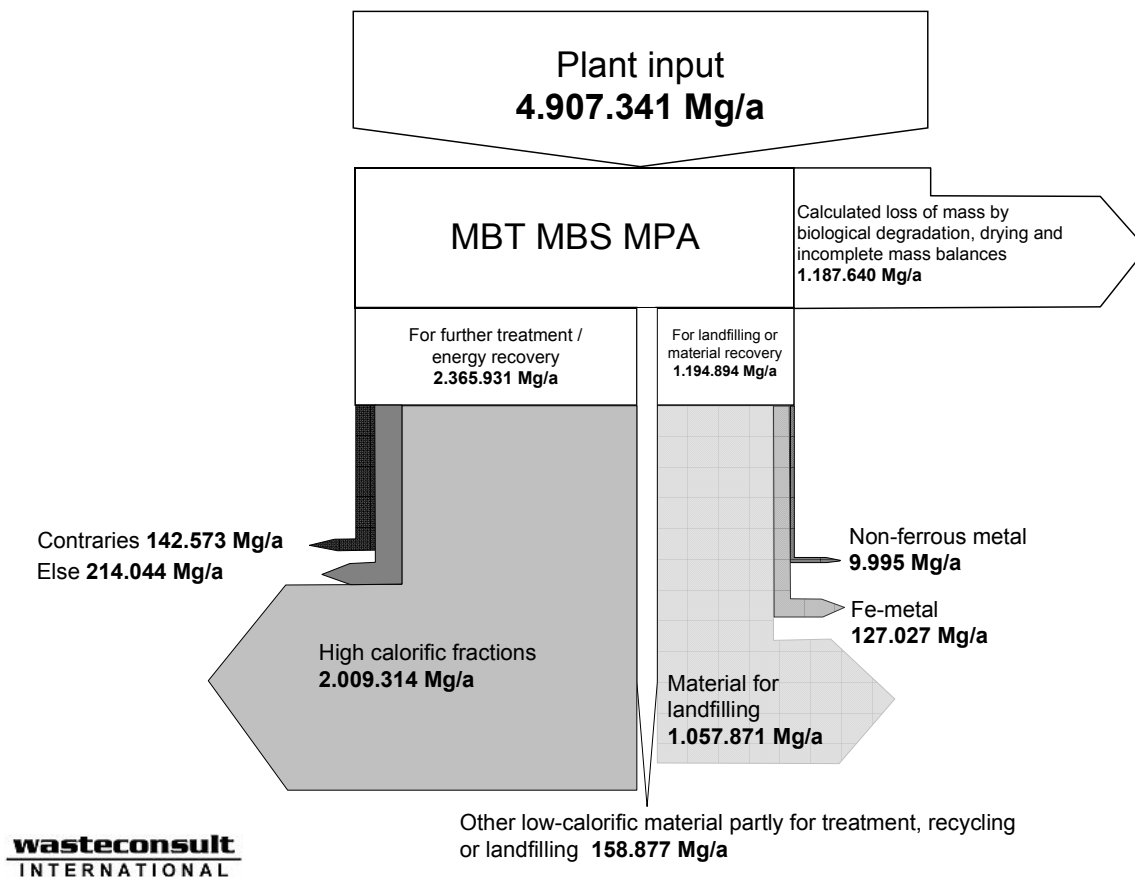


Figure 8: Mass-balance of the German MBTs (Kühle-Weidemeier et al., 2007)

Only anaerobic MBT processes produce energy that covers at least their own energy demand. The other MBT processes just consume energy.

3.3.2 Evaluation

Currently, MBT wastes energy and resources although the material and energy recovery potential is already higher than with conventional incinerators. Even the input of the biological treatment step contains valuable resources that could be picked out (paper, wood, plastics, minerals ...), like it is already done in a very few plants.

3.3.3 Enhancement and future potential of MBT

Big progresses in sensor based sorting makes installation of such units in MBT plants attractive. They are applicable to the coarse fraction as well as to the fine fraction. Best conditions for such applications exist at plants with wet mechanical treatment steps or biological / physical drying. MBT will develop to MRFs with integrated biological treatment.

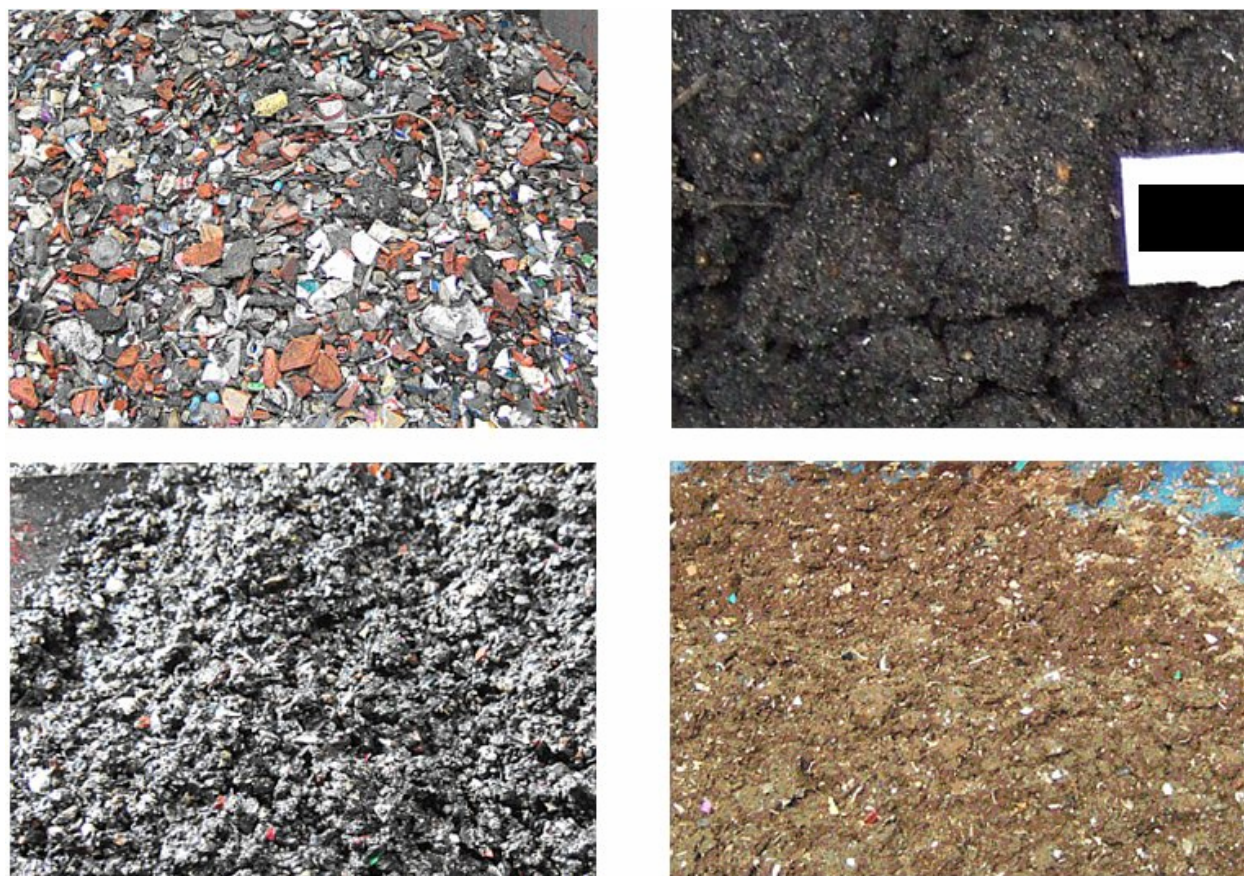


Figure 9: Various fractions from a biological and wet mechanical treatment step of an MBT

The (former) landfill fraction of MBTs with wet mechanical treatment steps of wet anaerobic treatment does not necessarily have to be landfilled. Figure 9 shows that useable mineral and organic fractions could easily be extracted.

The conception of MBT as a material specific waste treatment technology offers best requirements for a sustainable, resource optimised waste management but it needs to be consequently improved with the focus on material separation and recovery.

4 Resource recovery from landfills

Concepts for material recovery from landfills have come back on the agenda, for example VISVANATHAN ET AL., 2007.

Currently, landfill mining is still too expensive in Europe but with increasing prices of raw materials this might change in a medium range of time. Faulstich (2008) compiled data about recoverable resources in German landfills:

Table 2: Resources in German landfills (Data from Faulstich, 2008)

Deutschland	Deponierte Siedlungsabfälle	Deponierte Massenabfälle	Deponierter Klärschlamm	
Gesamtmenge	960	50	>> 10	Mio. Mg
Fe- + NE-Metalle	32			
Zink		70.000		Mg
Blei		25.000		Mg
Phosphat			1	Mio. Mg

5 Summary and recommendations

Shrinking natural resources, fast growth of the world population and increasing prosperity in emerging and developing countries requires consequently resource optimised acting in general and especially in waste management. A massive increase of the share of materials recovered from waste is necessary. This would enhance material supply and save lots of energy (CO₂-emissions) too. Resource recovery means climate protection.

Enhanced MBTs and sensor based waste sorting plants must become the heart of a sustainable, material specific waste management system. Current MBTs are the first step on this very promising way. MBT will develop to MRF with integrated biological treatment or pure material separation.

Incineration does not meet the requirements of a sustainable, resource optimised waste management concept, because the energy that was spent for the production of the materials that are used as fuels is completely lost in the incineration process. Precious waste components like non-ferrous metals are irrecoverably lost in the incinerator ash. A significant share of the waste that is expensively incinerated at the moment will be cheaper recovered in the future. Hence, there will be less input for incinerators. Incineration will step by step lose its importance, although there will always be demand for some incineration capacity because total recovery and recycling is not possible. Countries that are going to design their waste treatment concept should consider this development.

6 Literature

- | | | |
|--|------|---|
| ASA-Beirat | 2006 | MBA und das Ziel 2020. Arbeitsgemeinschaft Stoffspezifische Abfallbehandlung (ASA e.V.), pdf-Dokument. |
| Bardt, H. | 2008 | Sichere Energie- und Rohstoffversorgung. Herausforderung für Politik und Wirtschaft? Deutscher Instituts-Verlag, Köln, ISBN 978-3-602-24133-0. |
| Barthel, F. | 1999 | See the world from a wider perspective. Commodity top news. Fakten, Analysen, wirtschaftliche Hintergrundinformationen. No. 6. Bundesanstalt für Geowissenschaften und Rohstoffe (BGR). |
| Biebeler, H., Mahammadzadeh, M. und Selke, J.-W. | 2008 | Globaler Wandel aus Sicht der Wirtschaft. Chancen und Risiken, Forschungsbedarf und Innovationshemmnisse. Deutscher Instituts-Verlag, Köln, ISBN 978-3-602-14791-5 |
| Brammer, F. | 1997 | Rückbau von Siedlungsabfalldeponien. Schrittfolge und Entscheidungskriterien bei Planung und Ausführung. Dissertation am Fachbereich für Bauingenieur- und Vermessungswesen der TU Braunschweig. |
| Bundesanstalt für Geowissenschaften und Rohstoffe (Hrsg.); | 2008 | Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 2007. Jahresbericht 2007. pdf-Dokument, www.bgr-bund.de |
| Deutsche Stiftung Weltbevölkerung | 2009 | http://www.weltbevoelkerung.de/info-service/weltbevoelkerungsuhr.php?navanchor=1010037 |
| Faulstich, M. | 2008 | Abfallwirtschaft und Ressourcenschutz. Welchen Beitrag leistet Recycling zur Nachhaltigkeit? Präsentation zum Rohstoffkongress 2008, Berlin. |
| Fraunhofer Institut UMSICHT, INTERSEROH AG (Hrsg.) | 2008 | Recycling für den Klimaschutz. Ergebnisse der Studie von Fraunhofer UMSICHT und INTERSEROH zur CO ₂ -Einsparung durch den Einsatz von Sekundärrohstoffen, Broschüre. |
| Kühle-Weidemeier, M. | 2005 | Bedarf, Konstruktionsgrundlagen und Betrieb von Deponien für mechanisch-biologisch behandelte Restabfälle in Deutschland. Veröffentlichungen des Institutes für Siedlungswasserwirtschaft und Abfalltechnik der Universität Hannover, Heft 127. ISBN 3-921-421-57-8 |

- | | | |
|--|------|--|
| Kühle-Weidemeier, M.; Langer, U.; Hohmann, F. | 2007 | Anlagen zur mechanisch-biologischen Restabfallbehandlung. Schlussbericht. By order of the German Environment Agency (Umweltbundesamt) UFOPLAN 206 33 301 |
| SERI (Sustainable Europe Research Institute) | 2009 | http://www.materialflows.net/mfa/
Visited 10.03.2009 |
| UN (United Nations) | 2009 | World Population Prospects: The 2008 Revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, http://esa.un.org/unpp |
| Visvanathan, C.; Norbu, T.; Chiemchaisri, C.; Charnnok, B. | 2007 | Applying Mechanical Pre-Treatment and Landfill Mining. Approach in Recovering Refuse Derived Fuel (RDF) from Dumpsite Waste: Thailand Case Study. In: Kühle-Weidemeier, M. (Hrsg.): International Symposium MBT 2009. Proceedings. |
| Wuttke, J. Dr. | 2005 | Grundzüge der Abfallwirtschaft in Deutschland. In: Hösel, Bilitewski, Schenkel and Schnurer (Hrsg.) Müllhandbuch, Bd. 1, 0169, Erich Schmidt Verlag, Berlin. |

Author's address:

Dr.-Ing. Dipl.-Geogr. Matthias Kühle-Weidemeier
 Wasteconsult international
 Robert-Koch-Str. 48 b
 D-30853 Langenhagen
 Telefon +49 511 23 59 383
 E-Mail: info { at } wasteconsult . de
 Website: www.wasteconsult.de