The Methodology of MFA
-
Case Studies

Paul H. Brunner
Vienna University of Technology
Institute for Water Quality, Resources and Waste Management
http://www.iwa.tuwien.ac.at

Content

1. Motivation
2. Definitions and STAN
3. Scale
4. Applications
5. Integration of MFA in governance

Vision and Motivation

1. Sustainable development:

- **long term environmental protection**
- **„best“ resource use**
- **„utility and happiness forever“**

2. How to measure and to achieve SD?

3. MFA as a key method in the tool box for SD

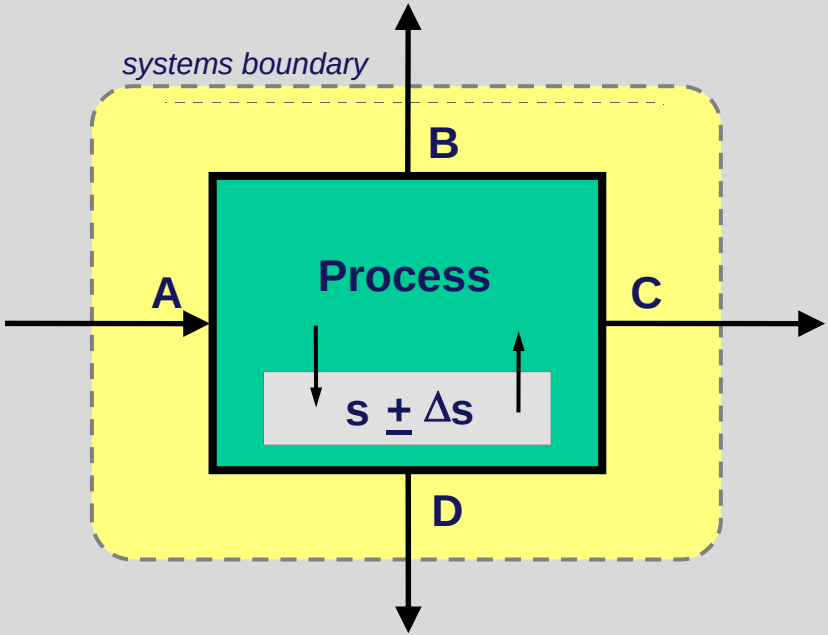
4. The two aspects: goods and substances

- **goods as economic units (*quantity*)**
- **substances determining ecological and resource *qualities***

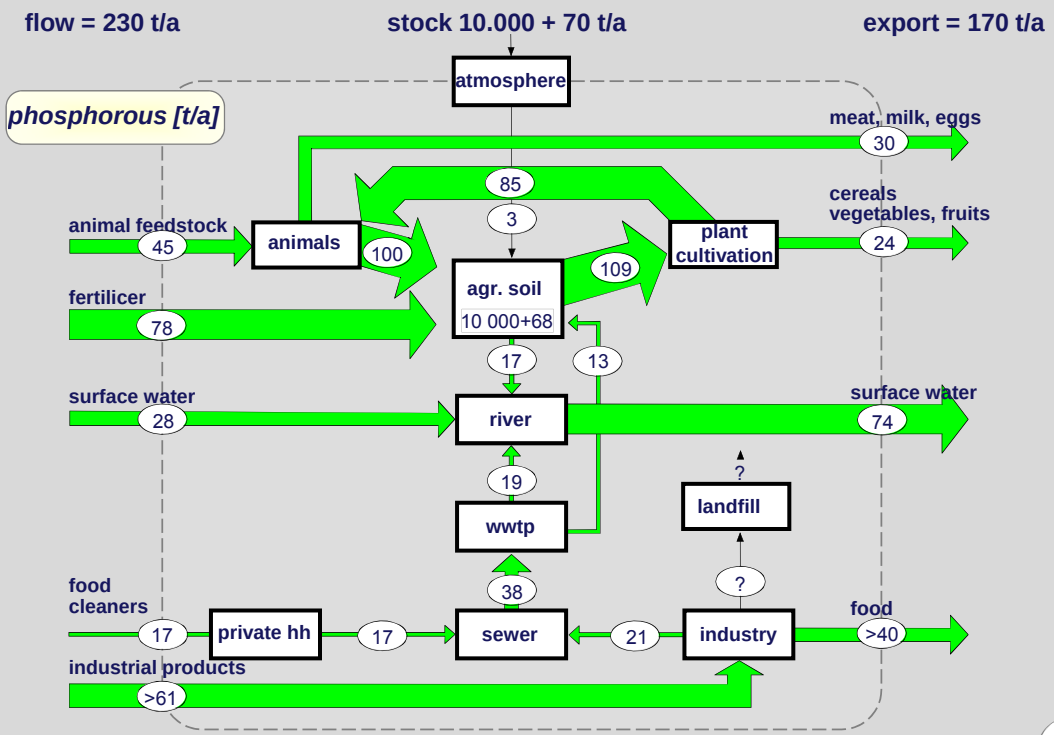
MFA definitions

- Goods and substances
- Processes and stocks
- Flows and fluxes
- Transfer coefficients
- System and system boundaries

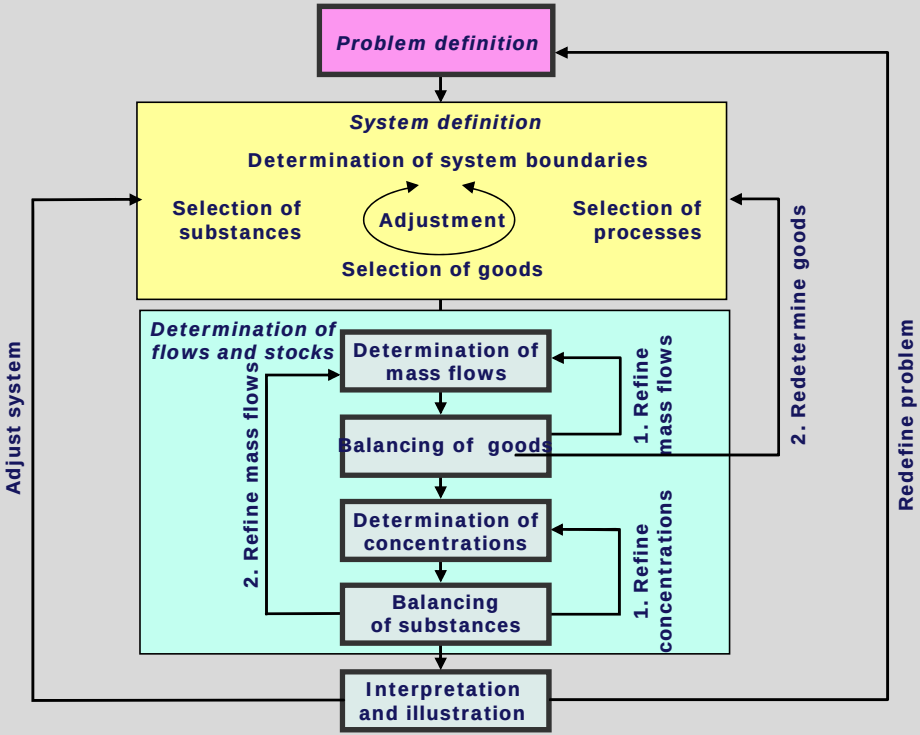
Most simple case of MFA: 1-process system



10-process system „regional phosphorous flows and stocks“



Procedure to establish MFA



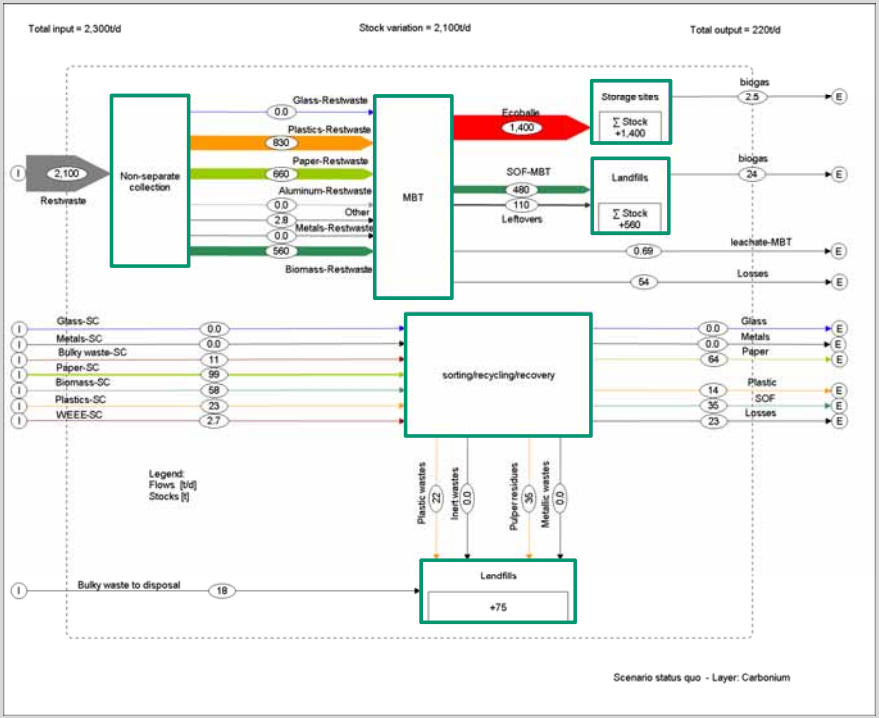
STAN freeware to support MFA including uncertainty

STAN:

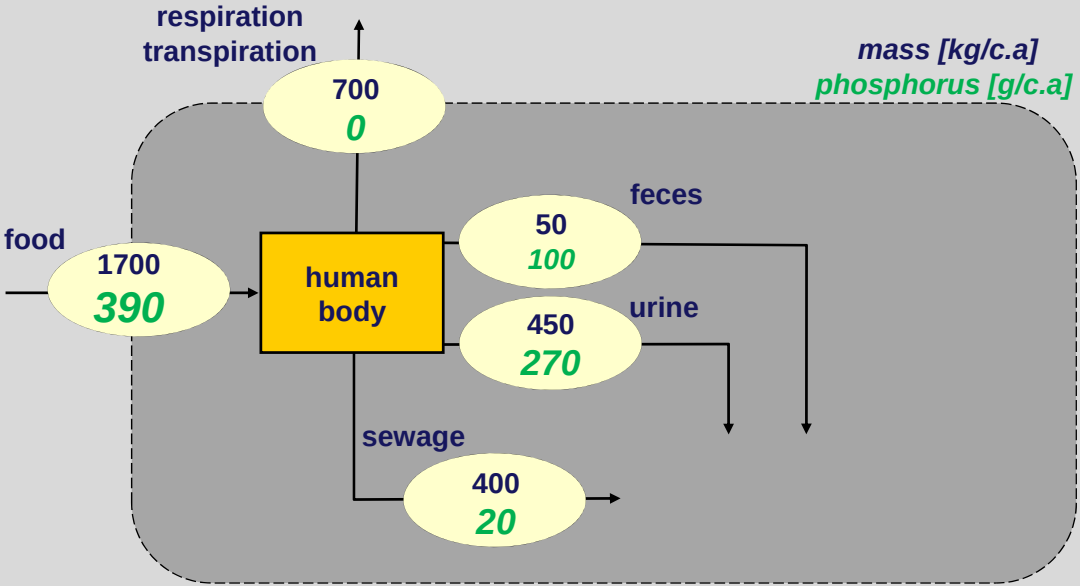
http://www.iwa.tuwien.ac.at/iwa226_english/stan.html

composting plant.mfa

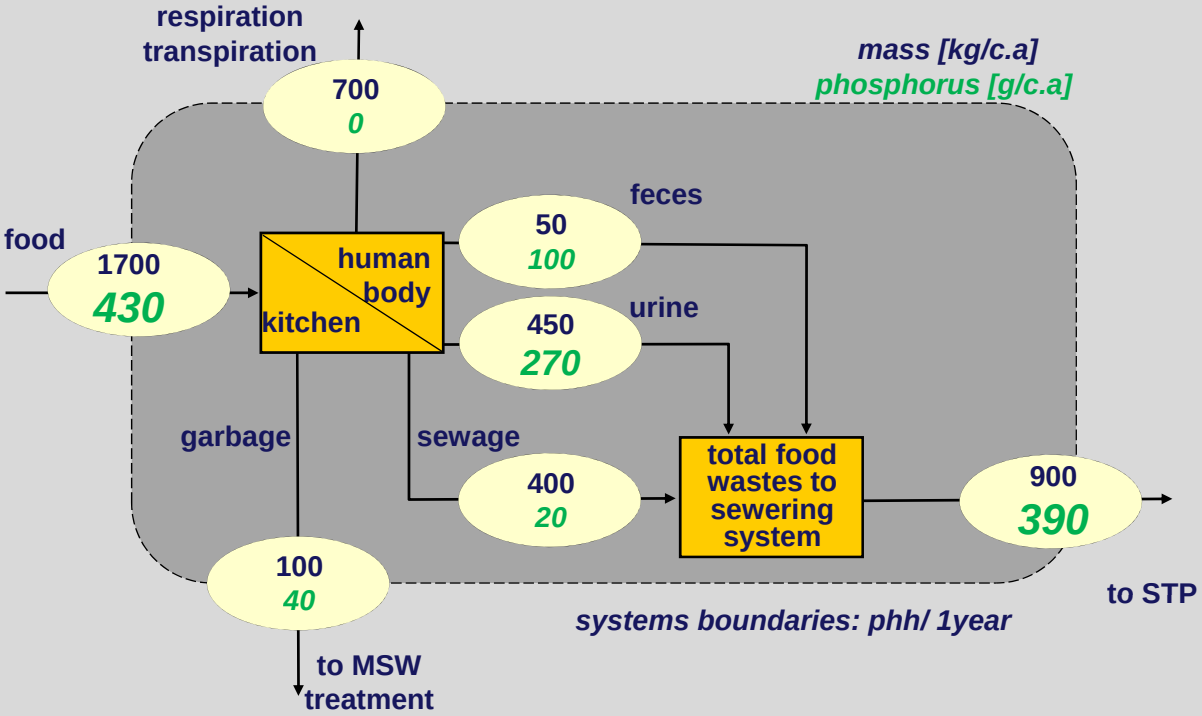
STAN allows modelling more complexe systems such as wm



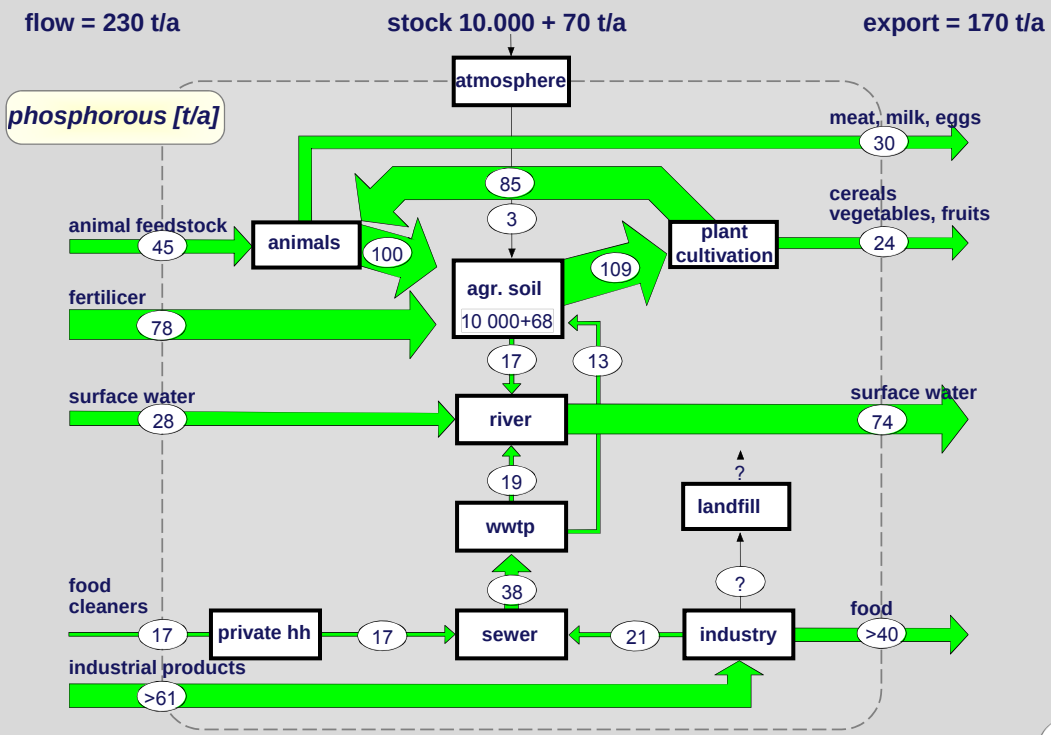
Scale: from human to …



Scale: from human to household to …



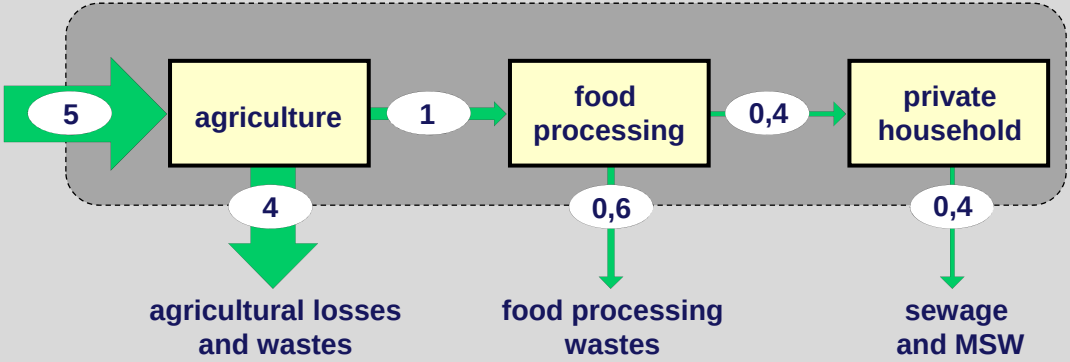
Scale: from human to household to regional to…



Scale: from human to household to regional to national to…

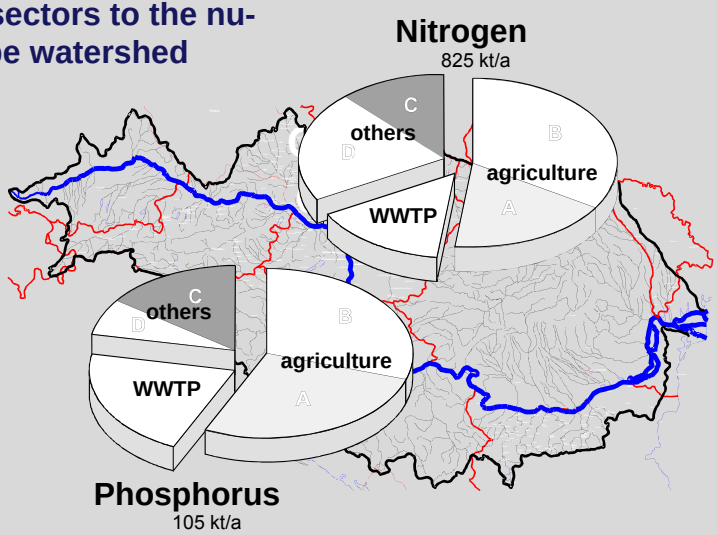
[kg/c.a]

systems boundaries: region/1year



Scale: from human to household to regional to national to watershed…

Contribution of various sectors to the nutrients in the river Danube watershed



A: direct and indirect inputs of animal waste products,
B: erosion and leaching
C: direct flows from private households and industry
D: diffuse inputs from forestry (erosion, percolation),

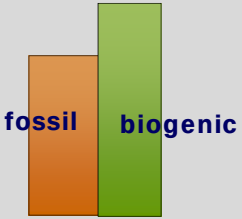
MFA for environmental protection and resources management

1st generation MFA: Environmental protection

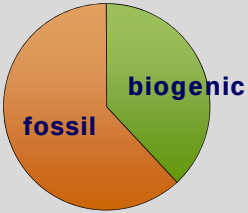
- **DDT**
- **CFCs**
- **PCBs, NP etc.**
- **C -> CO_2 and CH_4**

MFA for greenhouse gas emission assessment

CO_2 from .... sources



Energy from .... sources



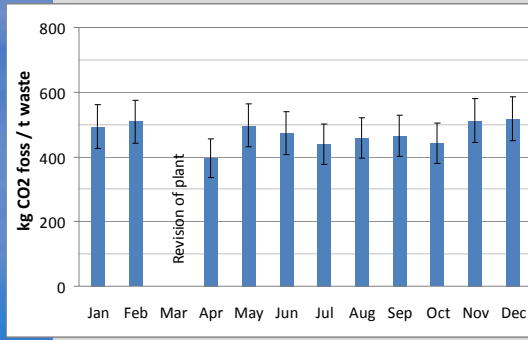
Concept of Balance Method

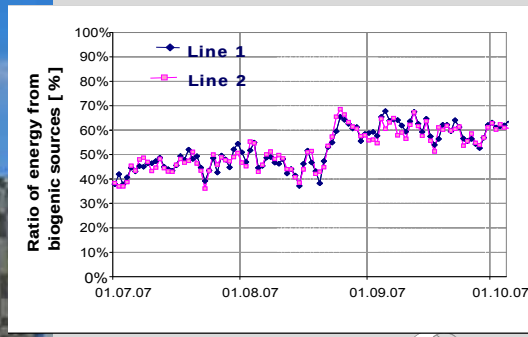
Material data of waste input
Biogenic matter C, H, O, N, S, Cl
Fossil matter C, H, O, N, S, Cl

Balance equations

$$
\begin{aligned}
m_B + m_F + m_I + m_W &= 1 \\
m_I &= a_{waste} \\
c_B \cdot m_B + c_F \cdot m_F &= c_{waste} \\
HV_B \cdot m_B + HV_F \cdot m_F - 2.45 \cdot m_W &= HV_{waste} \\
O_2{}^c{}_B \cdot m_B + O_2{}^c{}_F \cdot m_F &= O_2{}^c{}_{waste} \\
d_{O2\text{-}CO2} \cdot m_B + d_{O2\text{-}CO2} \cdot m_F &= d_{O2\text{-}CO2,waste}
\end{aligned}
$$

Operating data from WTE plant
Waste input, flue gas volume, CO2, O2, steam production





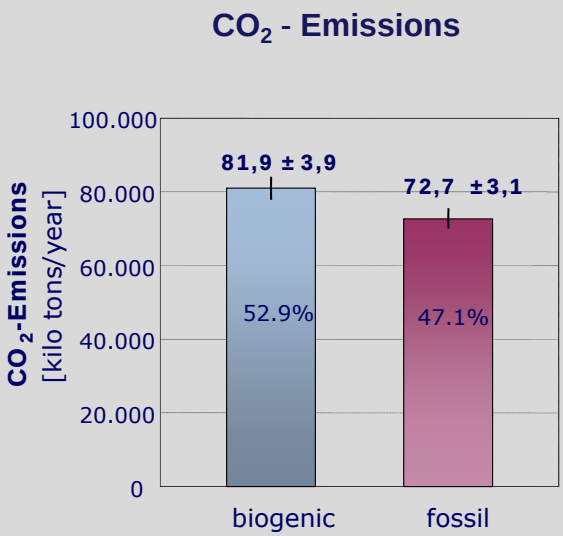
Balance Equation

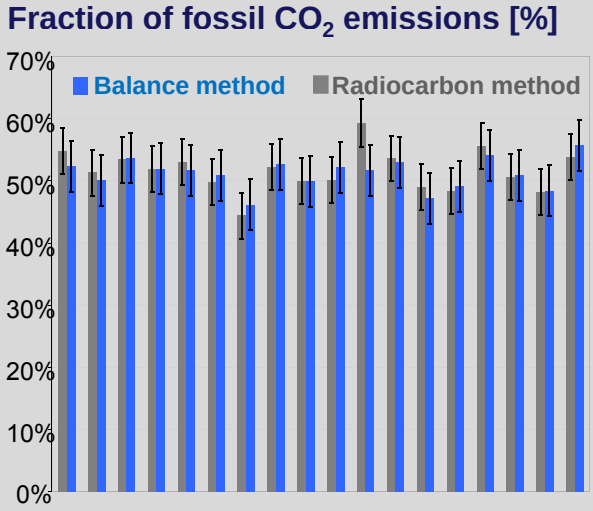
Mass balance	$m_B + m_F + m_I + m_w$	=	1
"Ash"-balance	m_I	=	a_{waste}
Carbon-balance	$c_B \cdot m_B + c_F \cdot m_F$	=	c_{waste}
Energy-balance	$HV_B \cdot m_B + HV_F \cdot m_F - 2.45 \cdot m_w$	=	HV_{waste}
O_2-consumption	$O_2{}^C{}_{,B} \cdot m_B + O_2{}^C{}_{,F} \cdot m_F$	=	$O_2{}^C{}_{waste}$
Difference of O_2-cons. +CO_2-prod.	$d_{O_2\text{-}CO_2} \cdot m_B + d_{O_2\text{-}CO_2} \cdot m_F$	=	$d_{O_2\text{-}CO_2,waste}$

Coefficients *(given by the chemical composition of biogenic and fossil matter)*

Derived from operating data

Results (annual values)





MFA for environmental protection and resources management

1st generation MFA: Environmental protection:

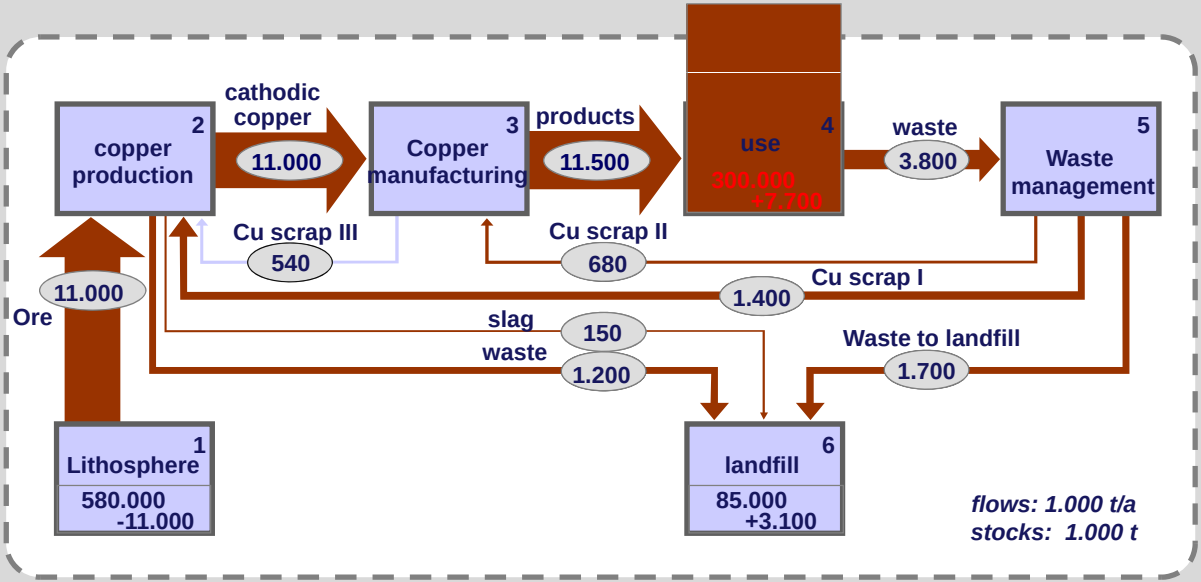
- **DDT**
- **CFCs**
- **PCBs, NP etc.**
- **C -> CO_2 and CH_4**

2nd generation Resource management:

- **Regional nutrient flows -> integrated P management**
- **Regional and global metal flows and stocks (Graedel)**

-> future metal management

Copper management based on MFA



"World 1994"

source: Graedel et al. 2002 and Rechberger

Application of MFA for governance in waste management

Goal: improve waste management practice

step 1: professional MFA standard ÖWAV guideline (consensus)

step 2: Austrian Standard ONORM S 2096 “MFA- Application in waste management”

step 3: easy to use software STAN (freeware) for MFA in wm

step 4: mandatory MFA requirement for certified MSW companies

step 5: routine waste analysis by MFA on selected MSW incinerators

step 6: Link all relevant information for a new knowledge base (e.g. for national waste management plan)

Conclusions

Objective:

- sustainable resource use

- long-term environmental protection

MFA is instrumental for this objective because:

- **it is a rigid, transparent, and objectiv method to model and visualize material flows including uncertainty**
- **It facilitates understanding and public acceptance of decisions**
- **It is a key decision support tool for resource management, environmental management, and waste management**
- **It is indispensable to establish knowledge bases for em, rm, and wm**
- **It needs to be standardized in order to fully exploit its potential**

Thank you