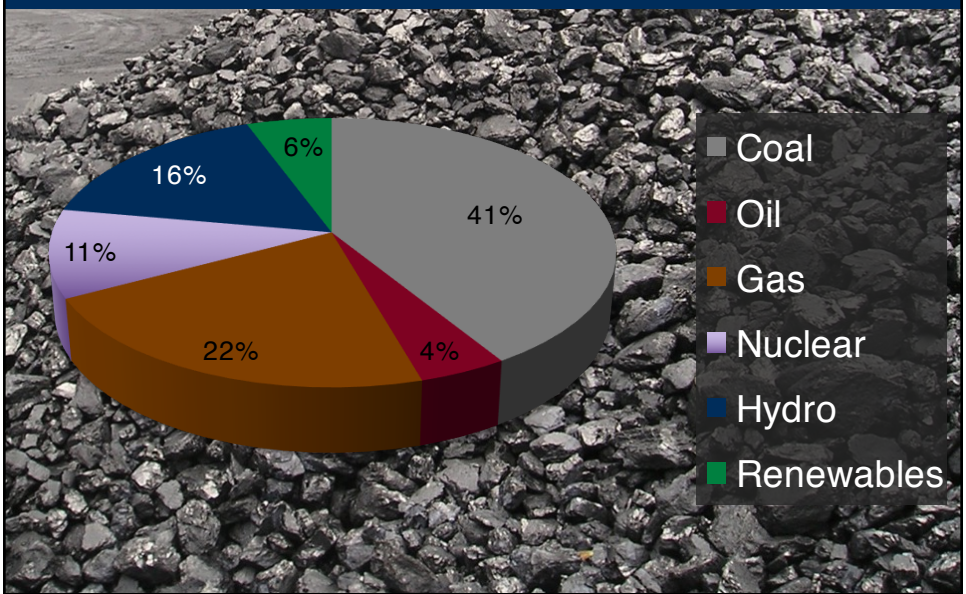
Penn
University of Pennsylvania

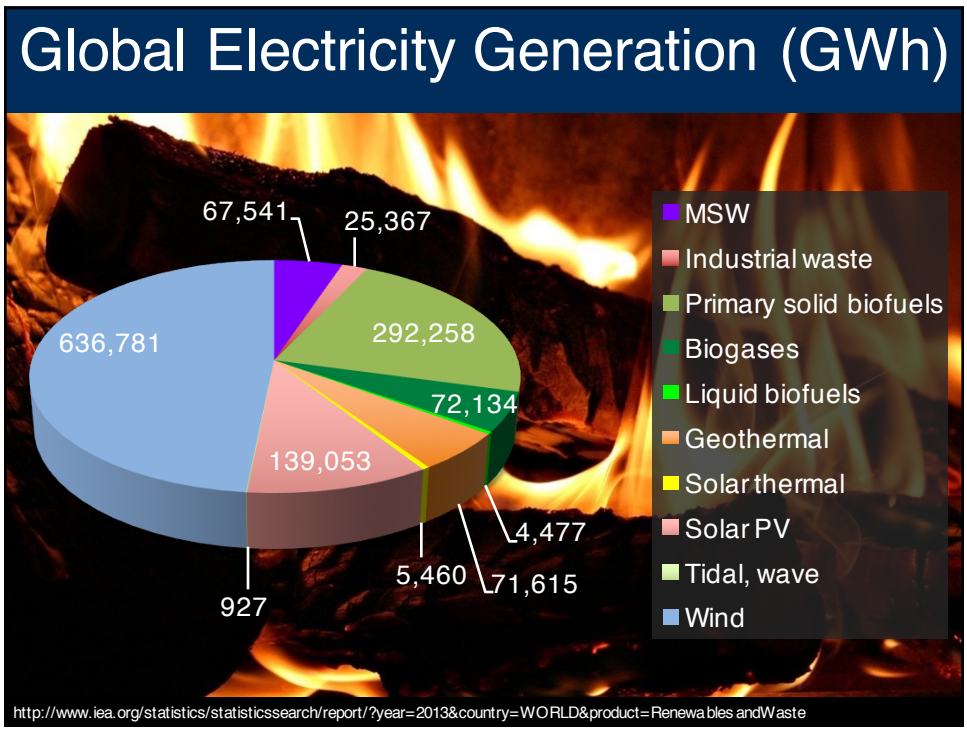
Energy from Combustion of Solid Biomass

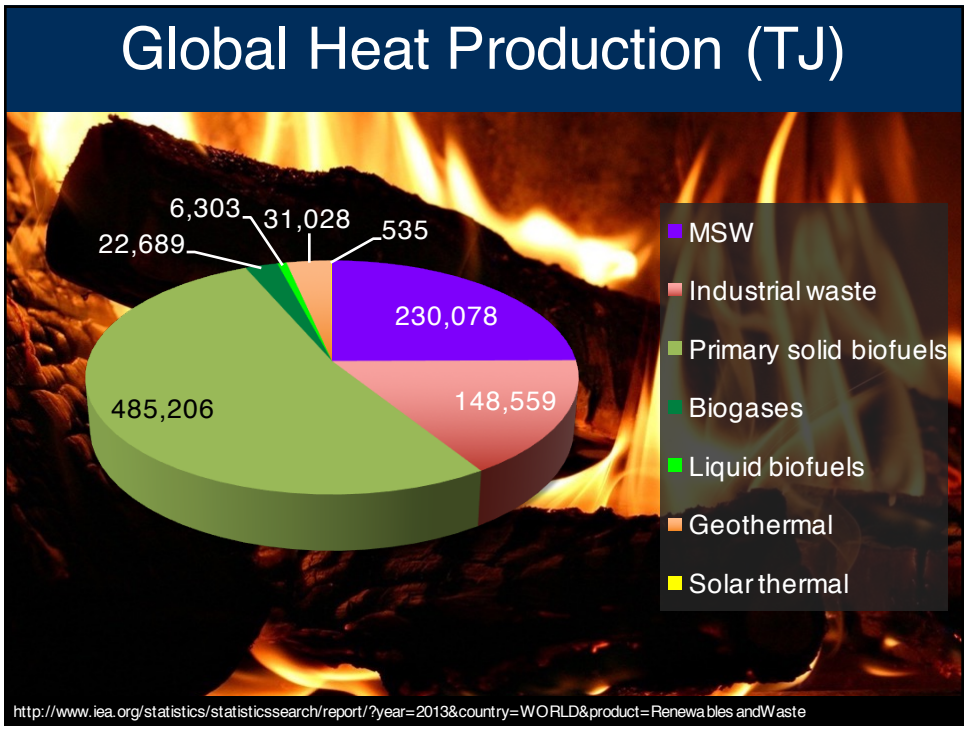
Reto Gieré
Department of Earth and Environmental Science

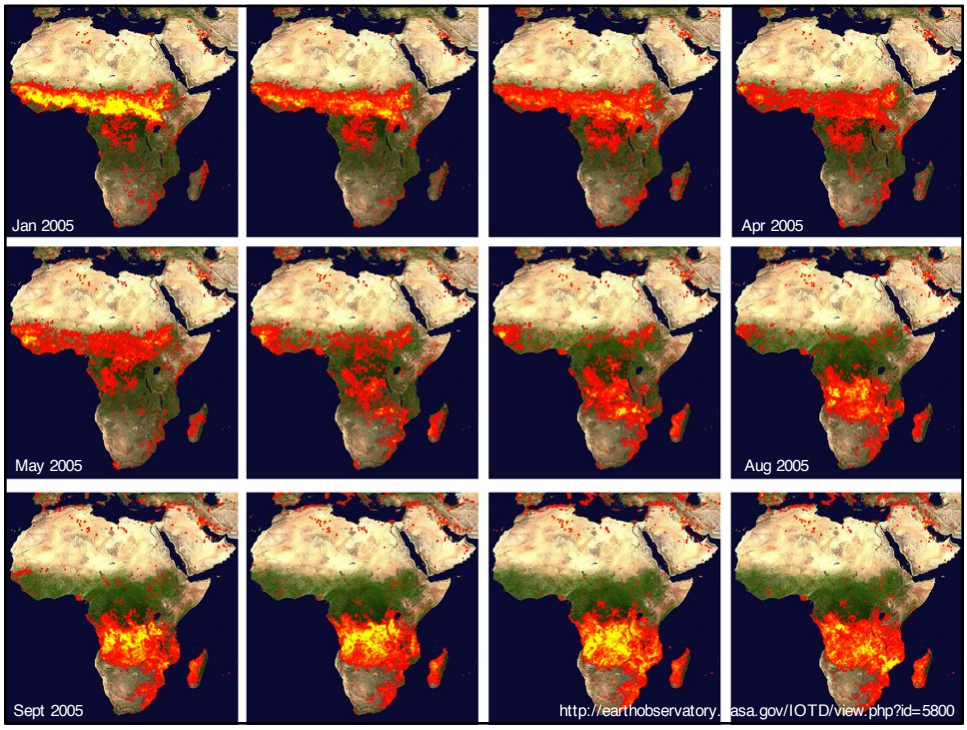
Global Electricity Generation

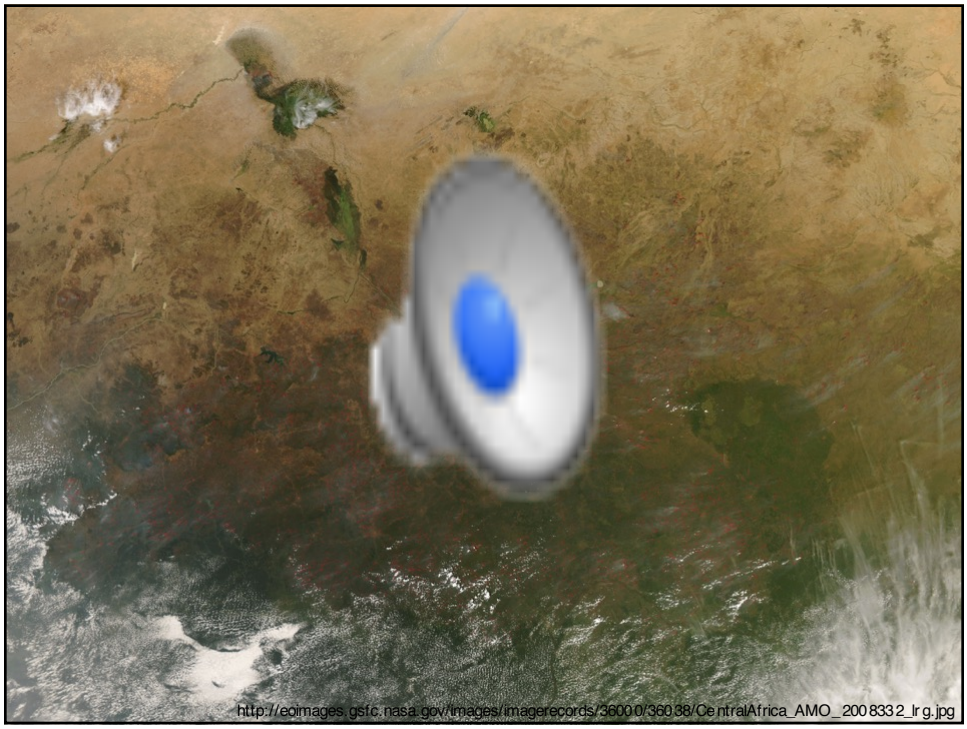


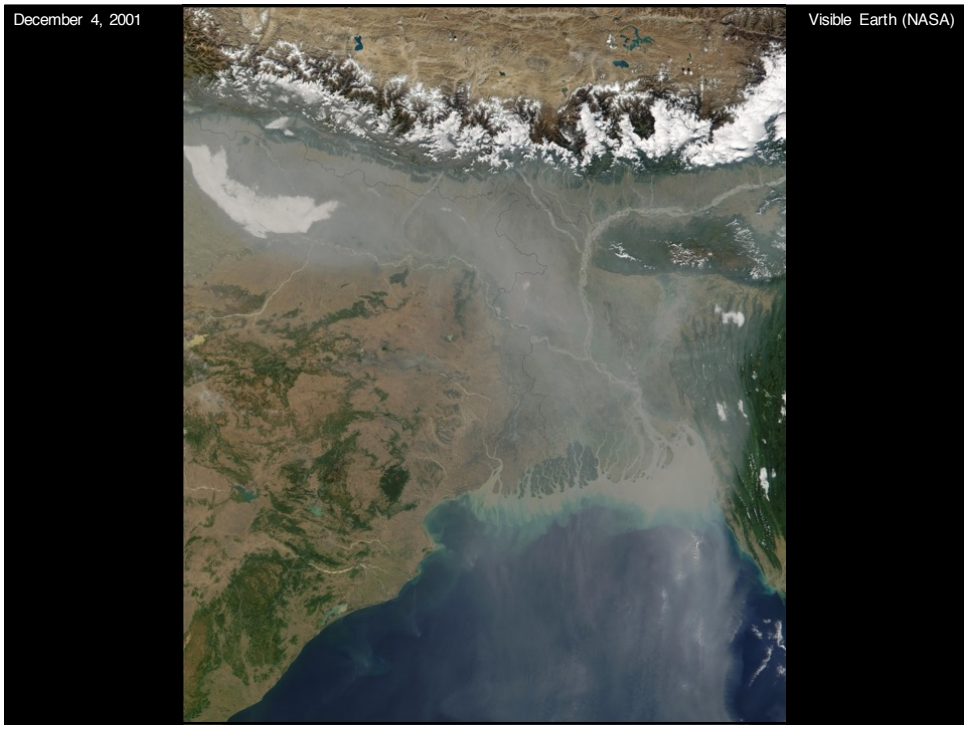
http://www.iea.org/statistics/statisticssearch/report/?country=WORLD&product=electricityandheat&year=2013


Global Electricity Generation (GWh)
67,541
25,367
636,781
292,258
72,134
139,053
4,477
5,460
71,615
927
MSW
Industrial waste
Primary solid biofuels
Biogases
Liquid biofuels
Geothermal
Solar thermal
Solar PV
Tidal, wave
Wind
http://www.iea.org/statistics/statisticssearch/report/?year=2013&country=WORLD&product=RenewablesandWaste

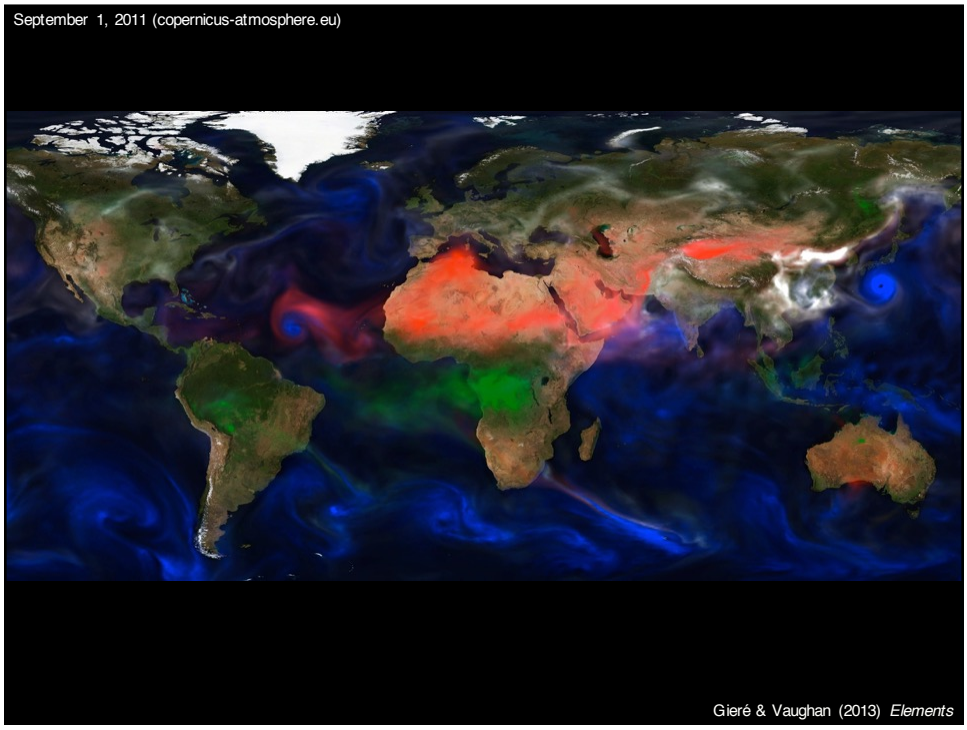

Global Heat Production (TJ)
6,303
31,028
535
22,689
230,078
485,206
148,559
MSW
Industrial waste
Primary solid biofuels
Biogases
Liquid biofuels
Geothermal
Solar thermal
http://www.iea.org/statistics/statisticssearch/report/?year=2013&country=WORLD&product=RenewablesandWaste

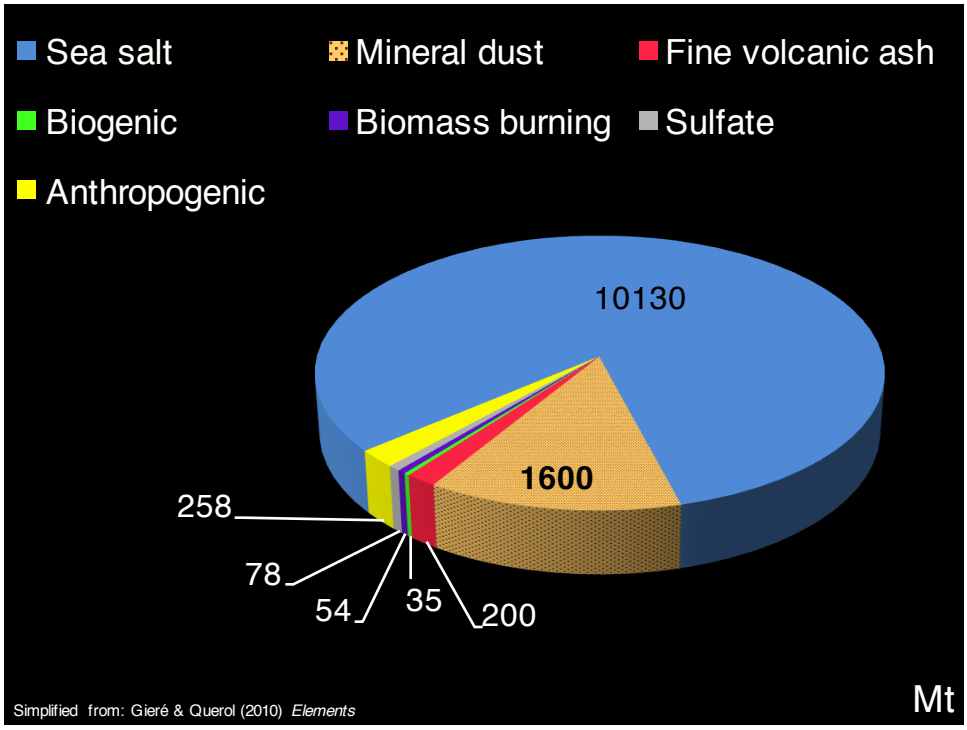

Jan 2005
Apr 2005
May 2005
Aug 2005
Sept 2005
http://earthobservatory.nasa.gov/IOTD/view.php?id=5800


http://eoimages.gsfc.nasa.gov/images/imagerecords/36000/36038/CentralAfrica_AMO_2008332_lrg.jpg

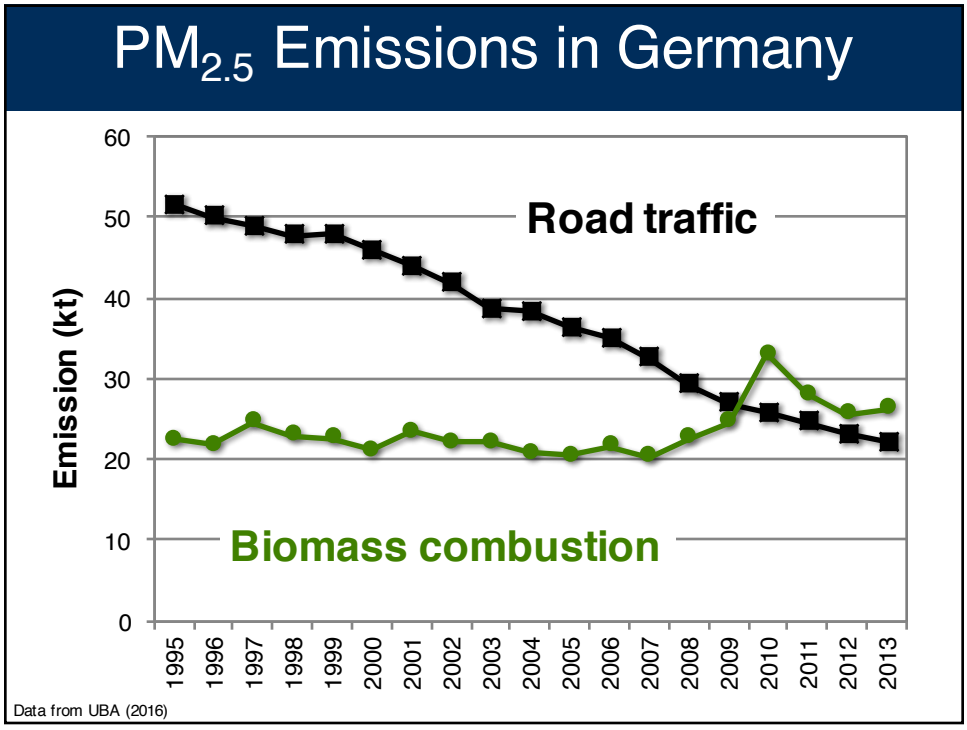

December 4, 2001
Visible Earth (NASA)


June 23, 2013
REUTERS

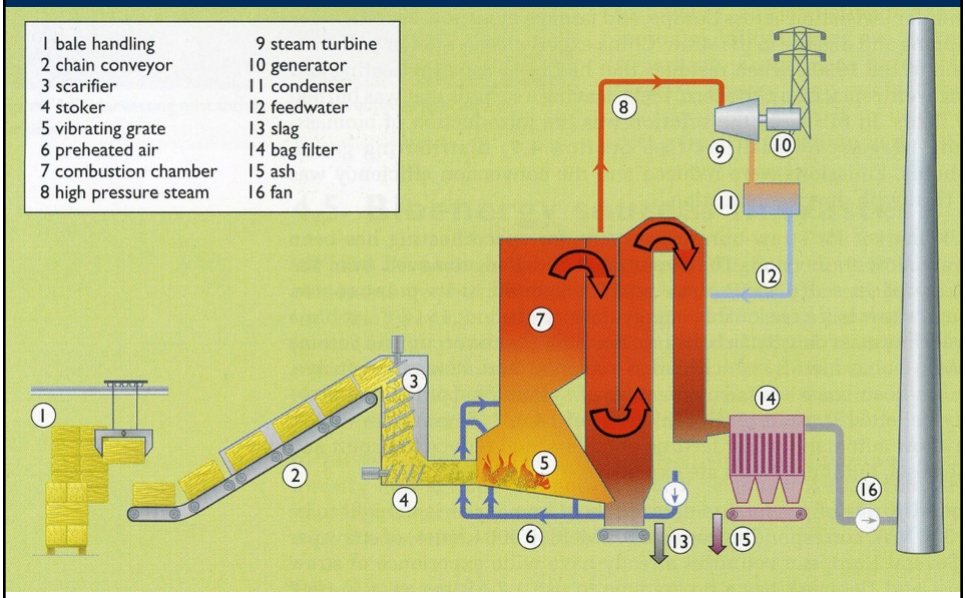

September 1, 2011 (copernicus-atmosphere.eu)
Gieré & Vaughan (2013) *Elements*


Sea salt
Mineral dust
Fine volcanic ash
Biogenic
Biomass burning
Sulfate
Anthropogenic
10130
1600
258
78
54
35
200
Mt
Simplified from: Gieré & Querol (2010) *Elements*


V. Dietze (DWD)

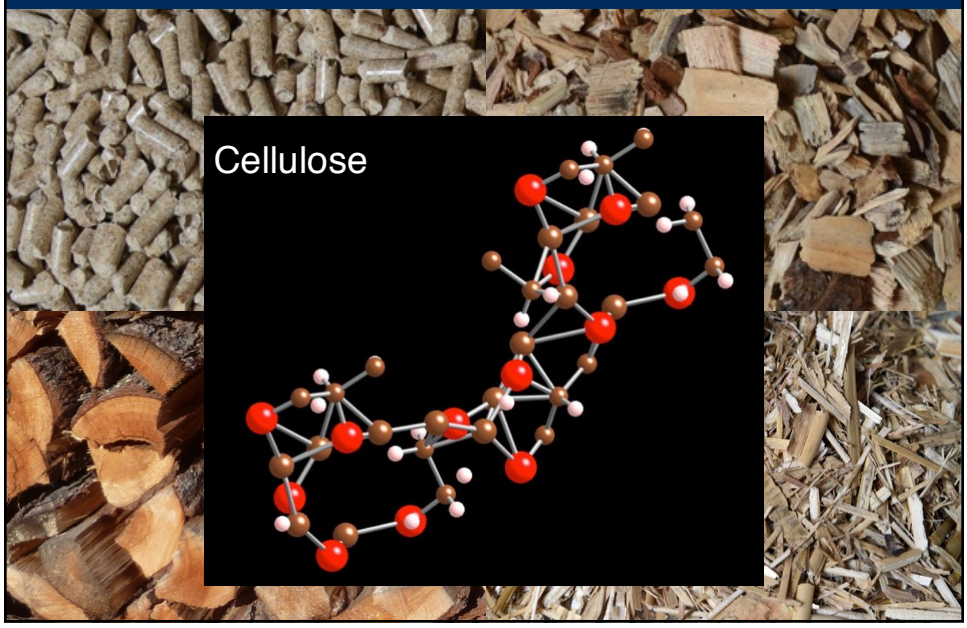

PM2.5 Emissions in Germany
Emission (kt)
60
50
40
30
20
10
0
Road traffic
Biomass combustion
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Data from UBA (2016)

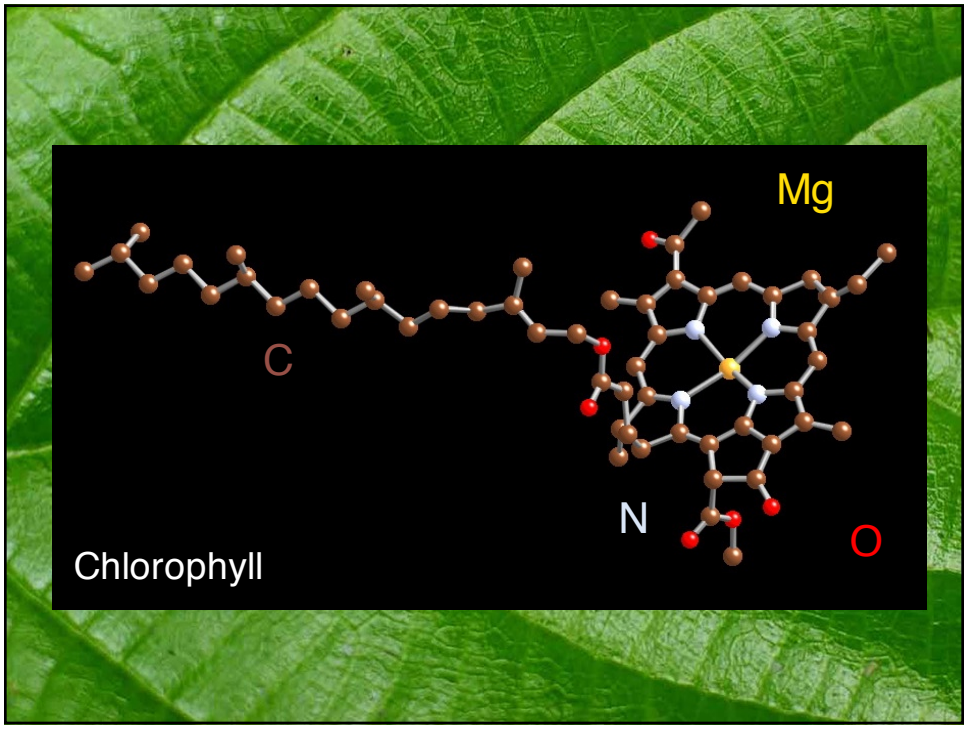
Controlled Combustion

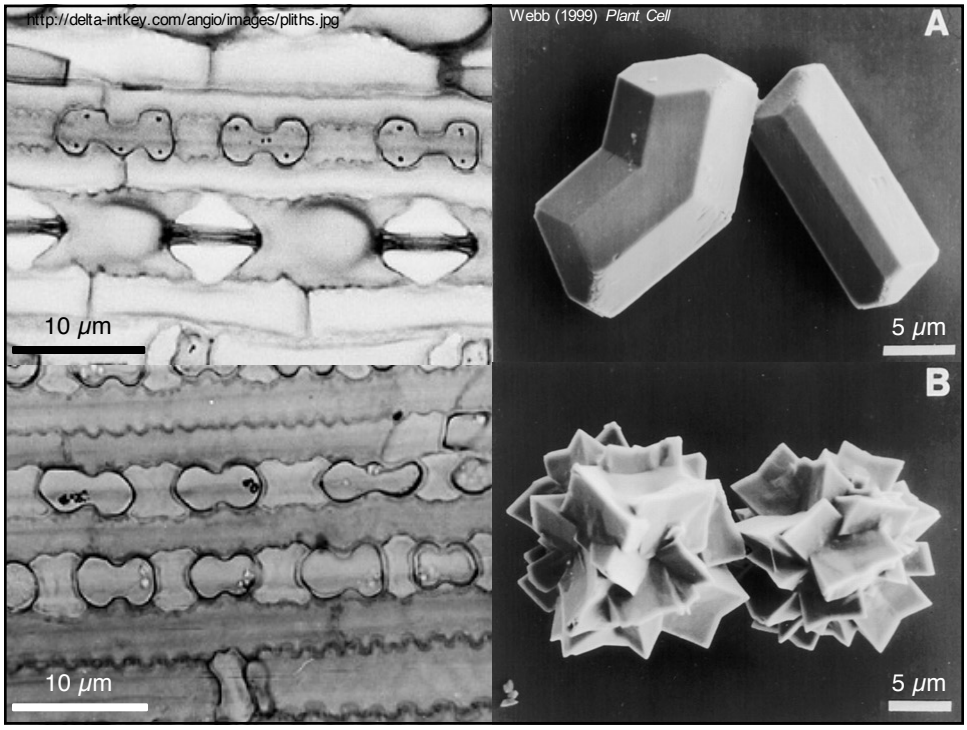


Boyle (2004)

Biomass Characterization

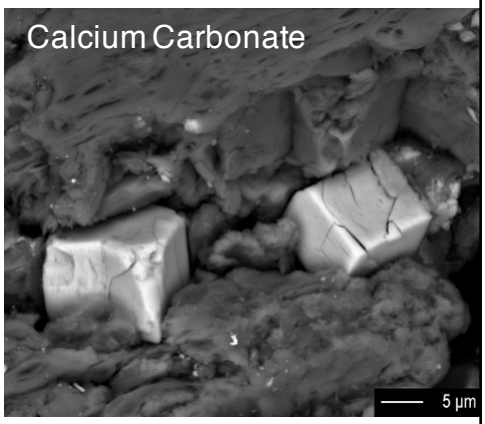




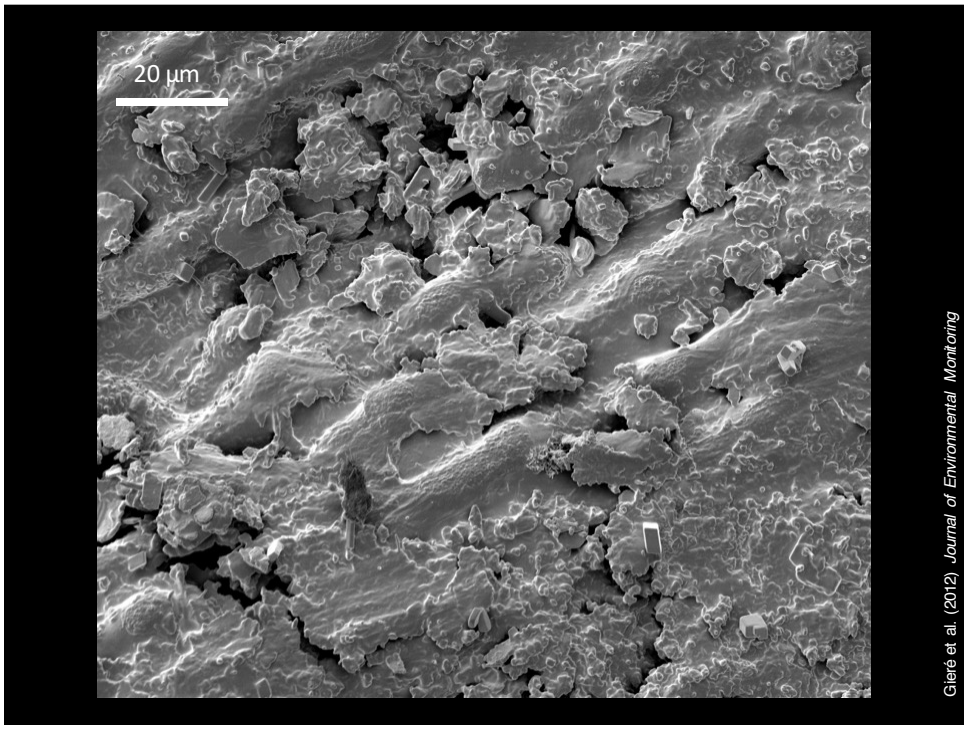

http://delta-intkey.com/angio/images/pliths.jpg
10 μm
10 μm
Webb (1999) Plant Cell
A
5 μm
B
5 μm

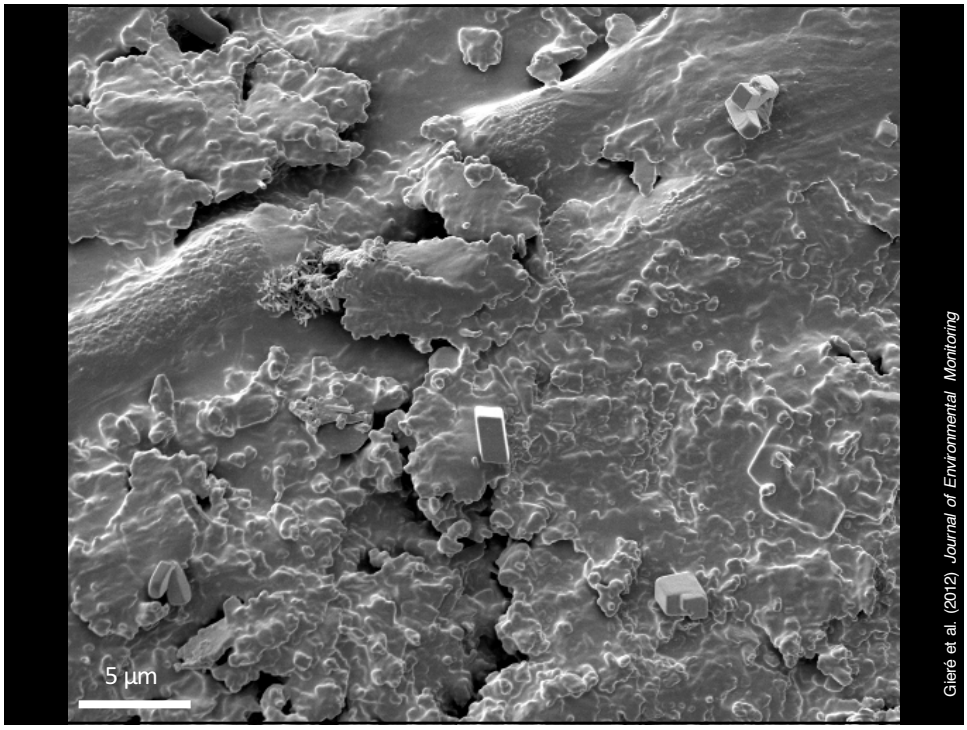

Arundo
Sugarcane
Wheat
Poacea Family
Miscanthus
Rice

Extraneous Components

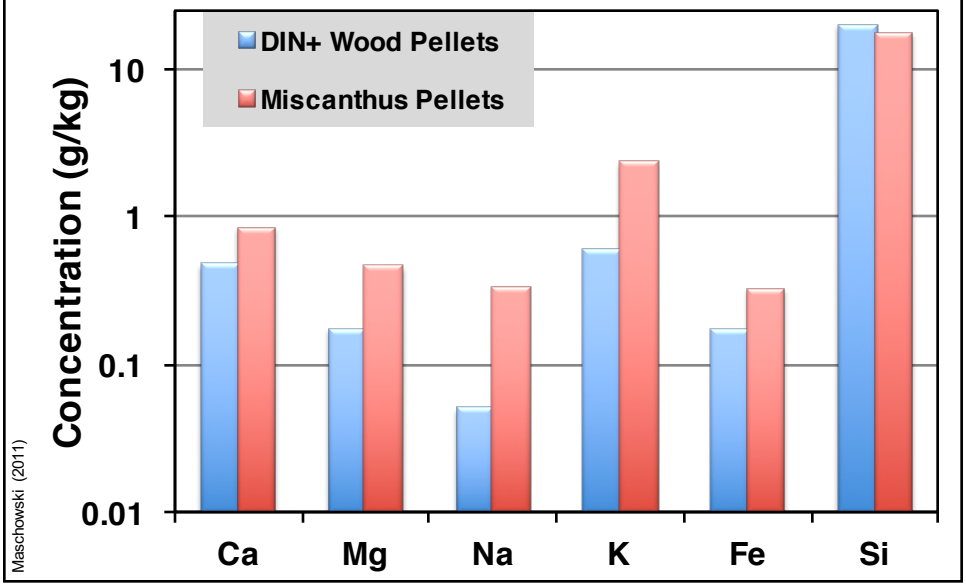


Maschowski (2011)

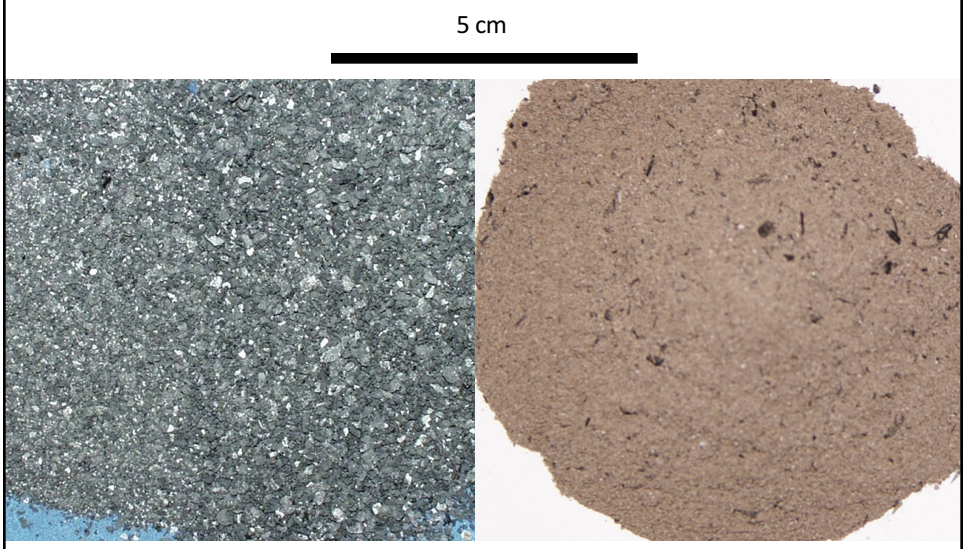

20 µm
Gieré et al. (2012) Journal of Environmental Monitoring


5 µm
Gieré et al. (2012) Journal of Environmental Monitoring

Chemical Composition (g/kg)

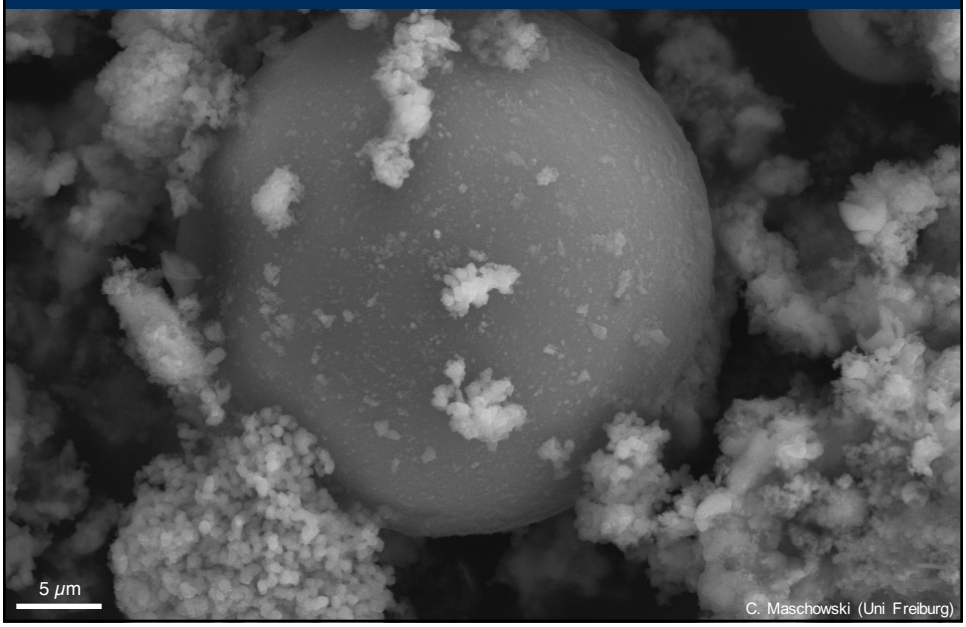


Bottom Ash *vs.* Fly Ash



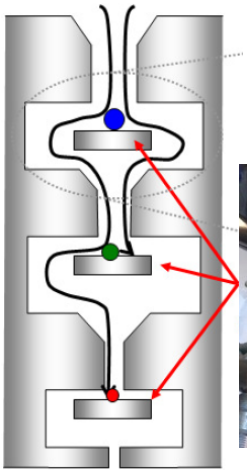
BIOCOMBUST

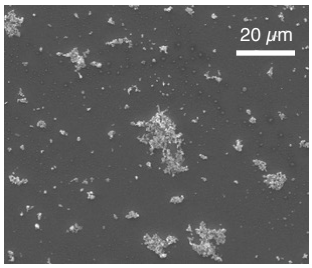
Fly Ash



Particle Sampling

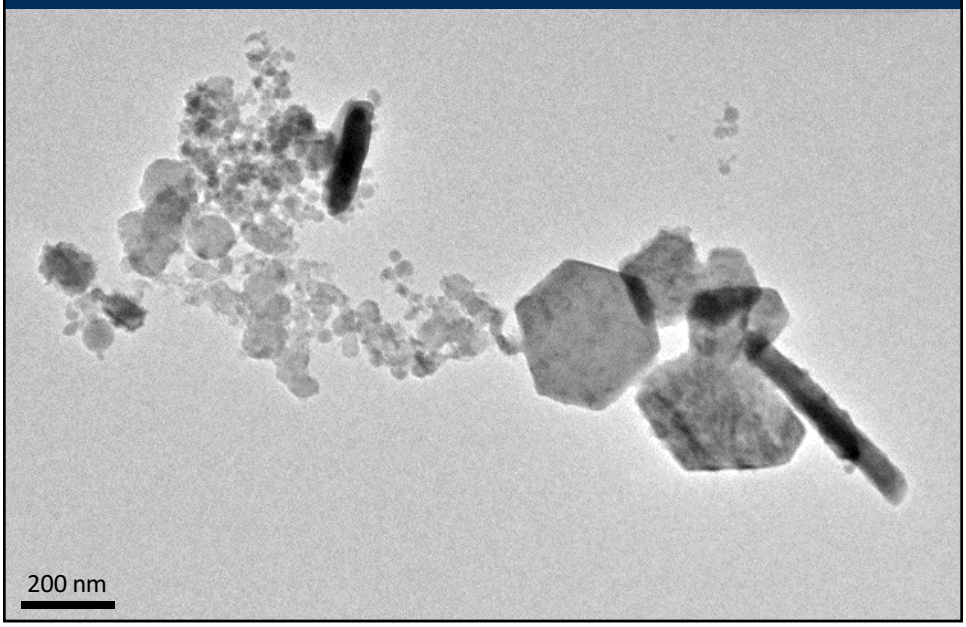
DGI Impactor

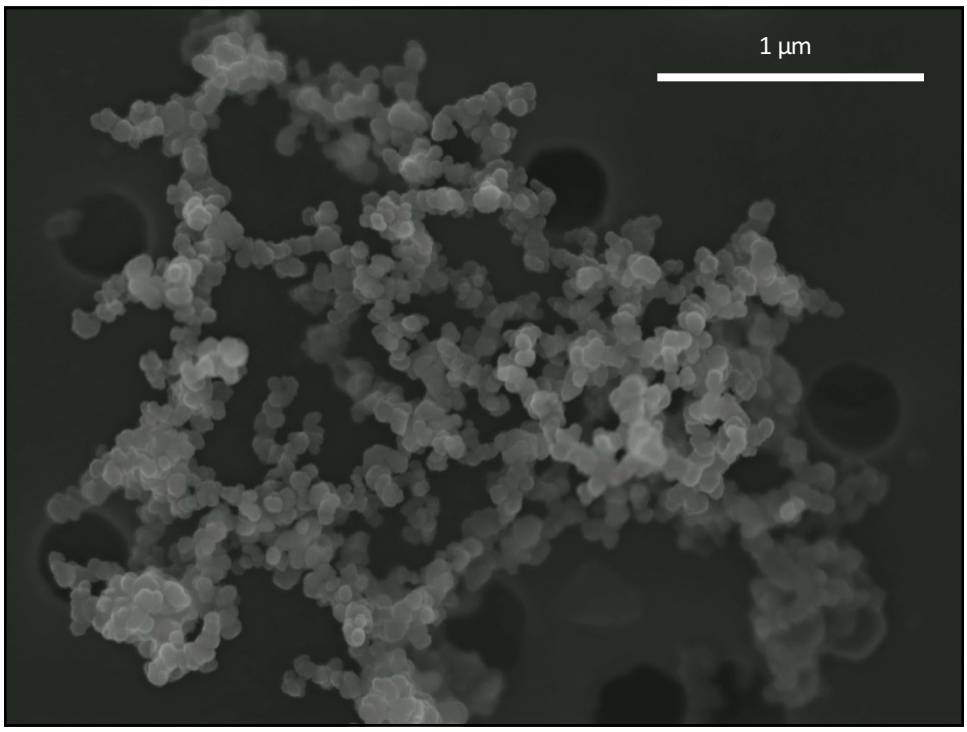


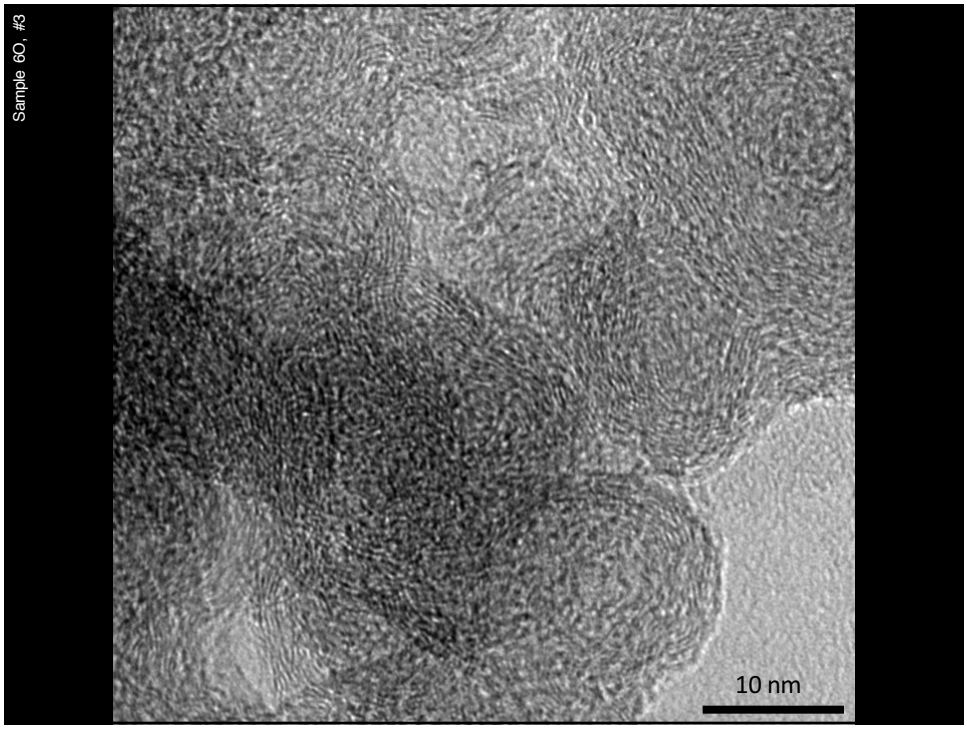


Université de Haute Alsace

Particle Sampling




1 µm


Sample 6O, #3
10 nm

Air Quality Measurements

F. Drewnick (MPI)

Ambient Particle Sampling

Mini-Volume Sampler

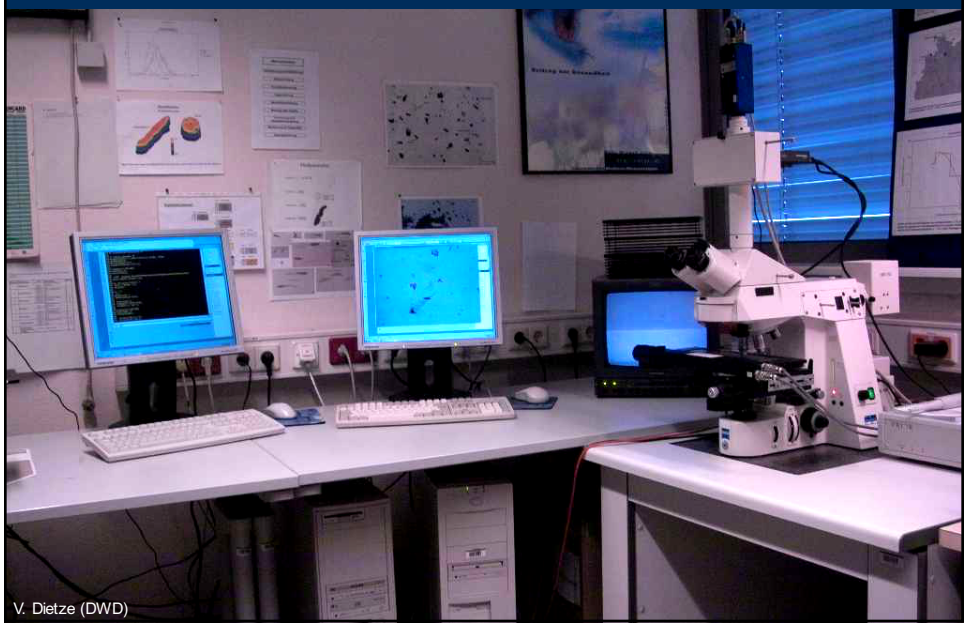
Passive Sampler

<2.5 μm

2.5-10 μm

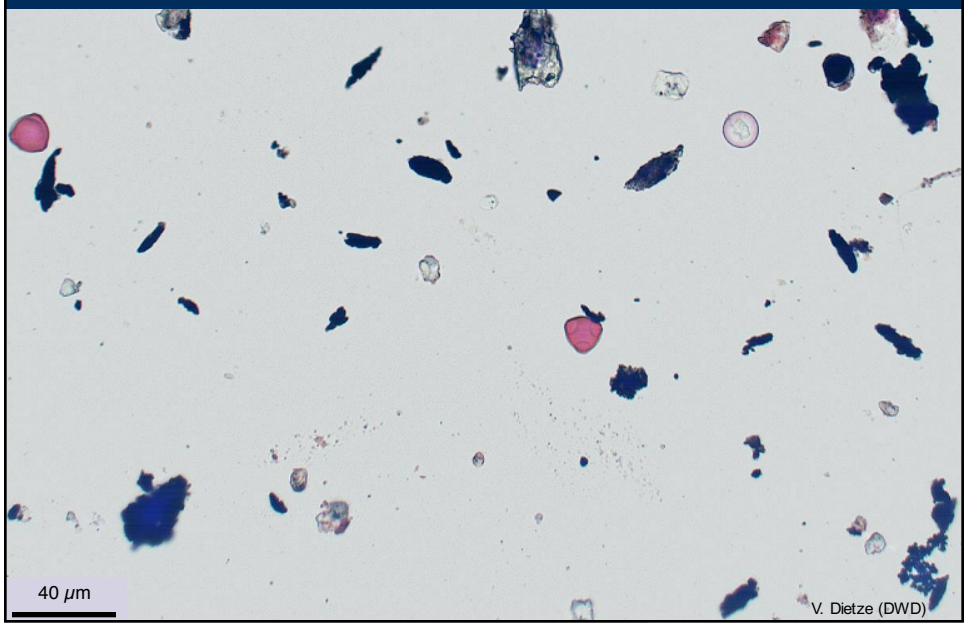
V. Dietze (DWD)

Single-Particle Characterization

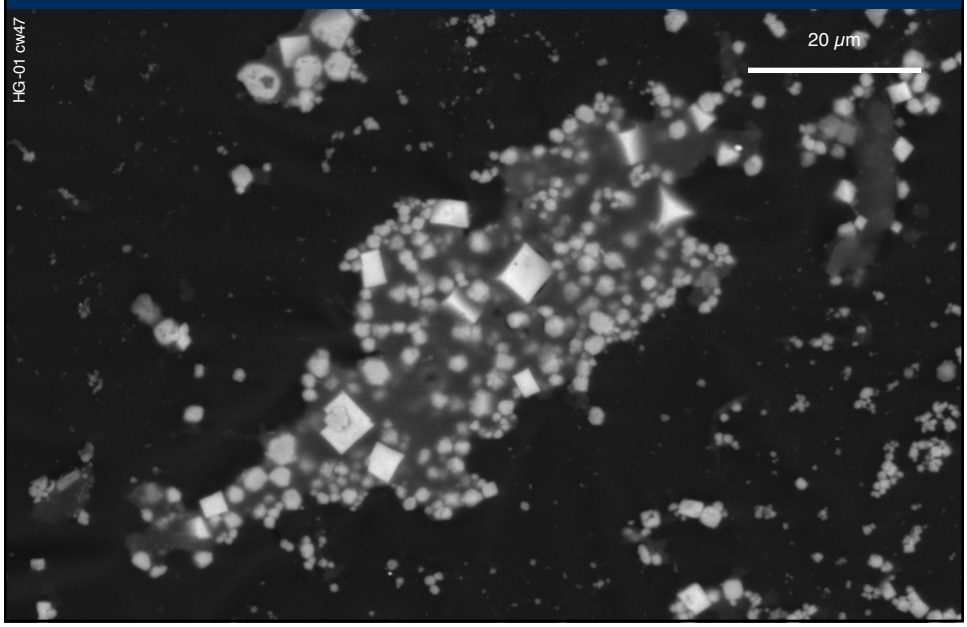


V. Dietze (DWD)

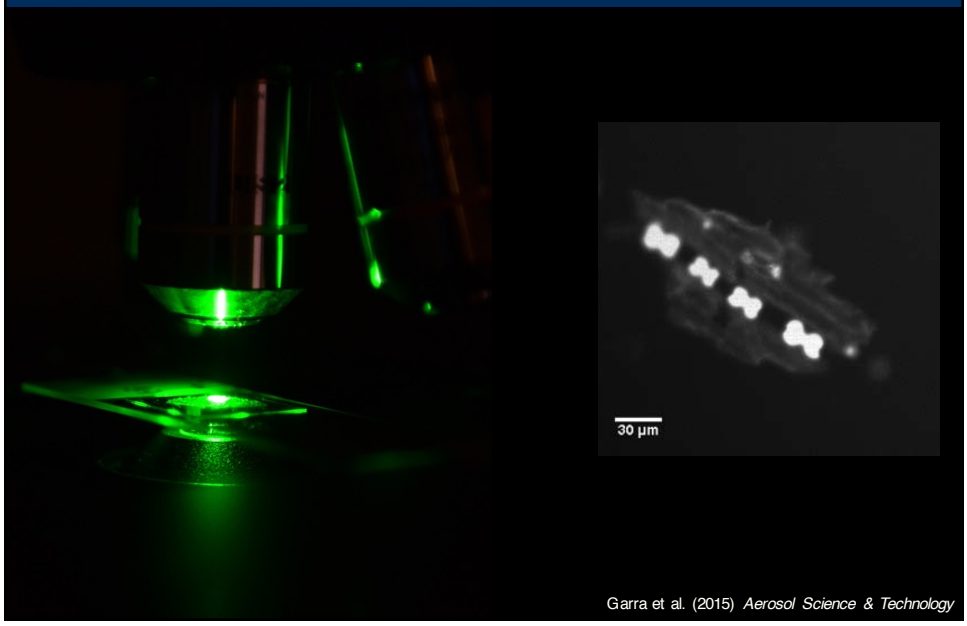
Single-Particle Characterization



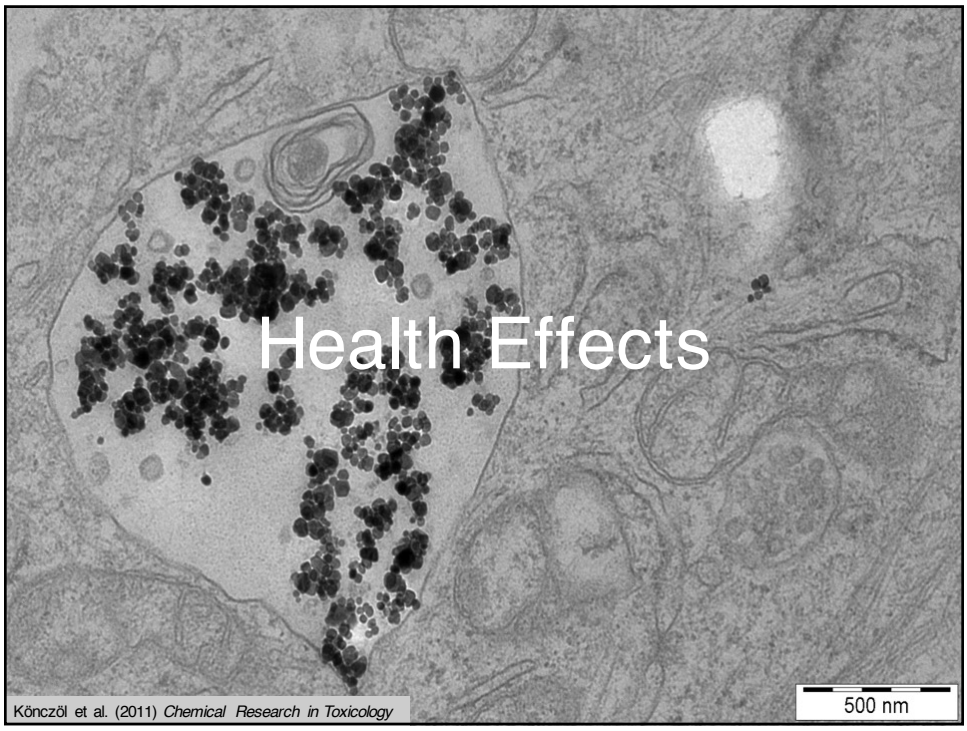
Single-Particle Characterization



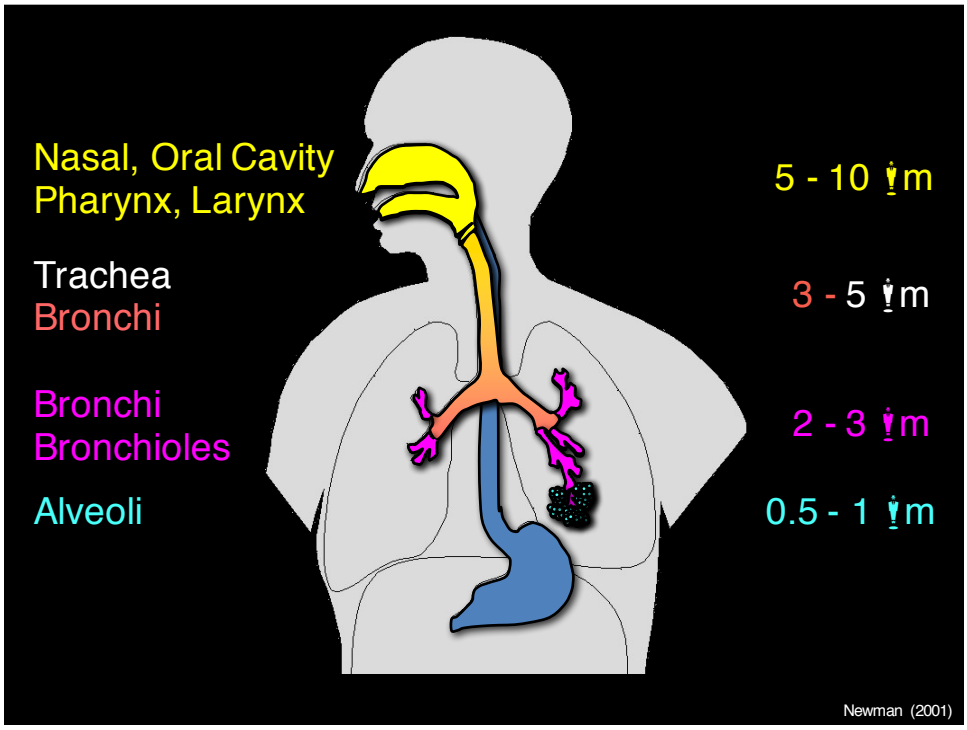
Fluorescence Microscopy

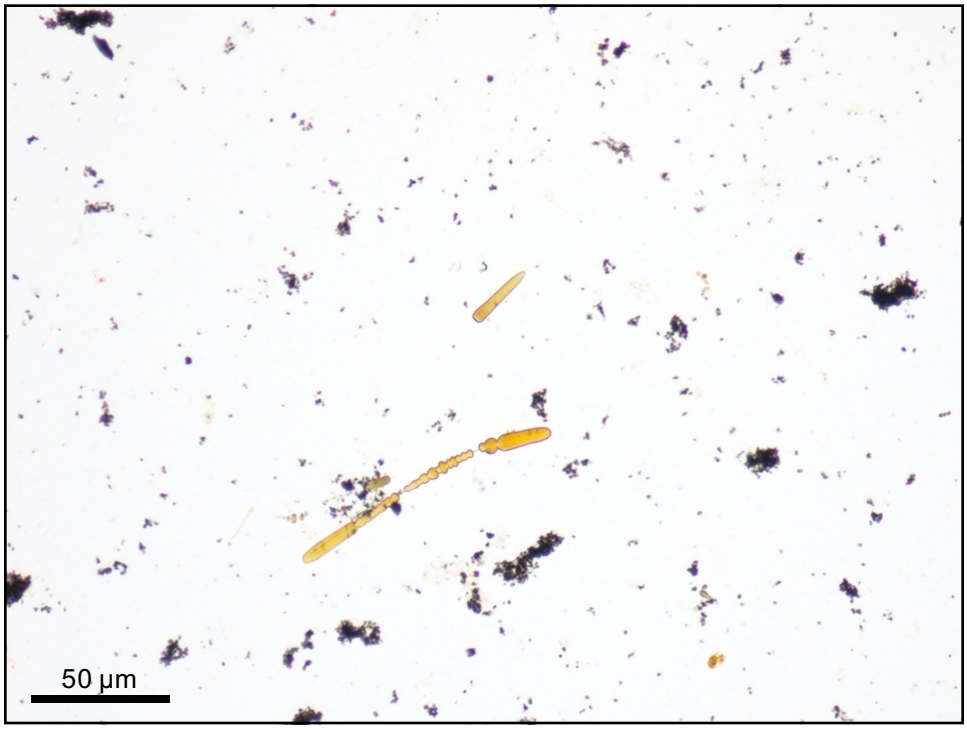


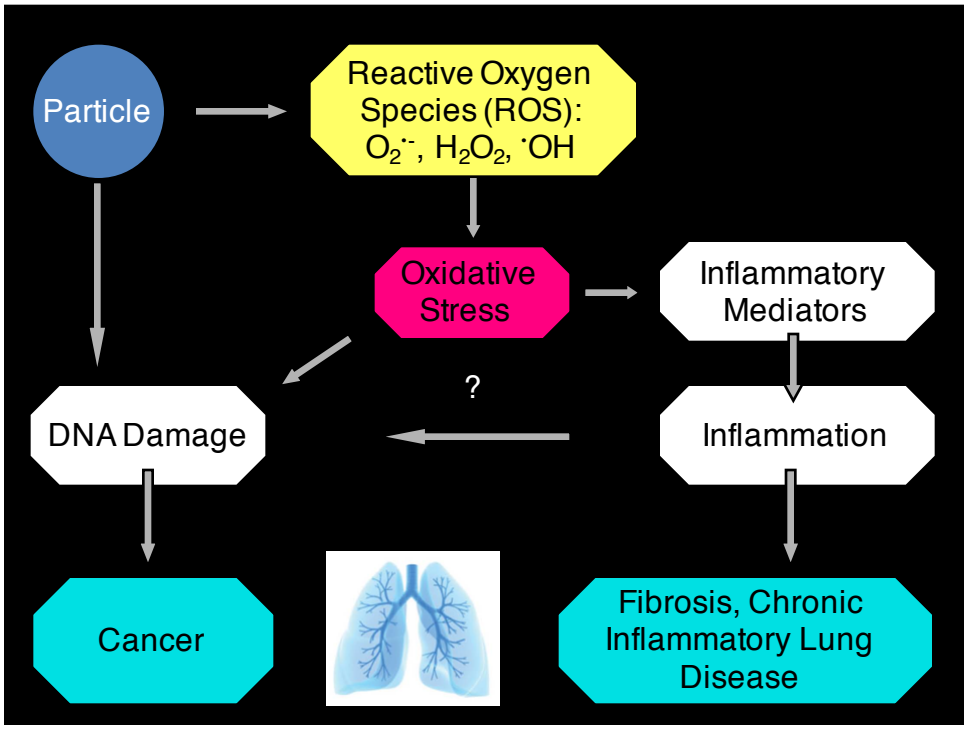
Garra et al. (2015) *Aerosol Science & Technology*



Könczöl et al. (2011) *Chemical Research in Toxicology*

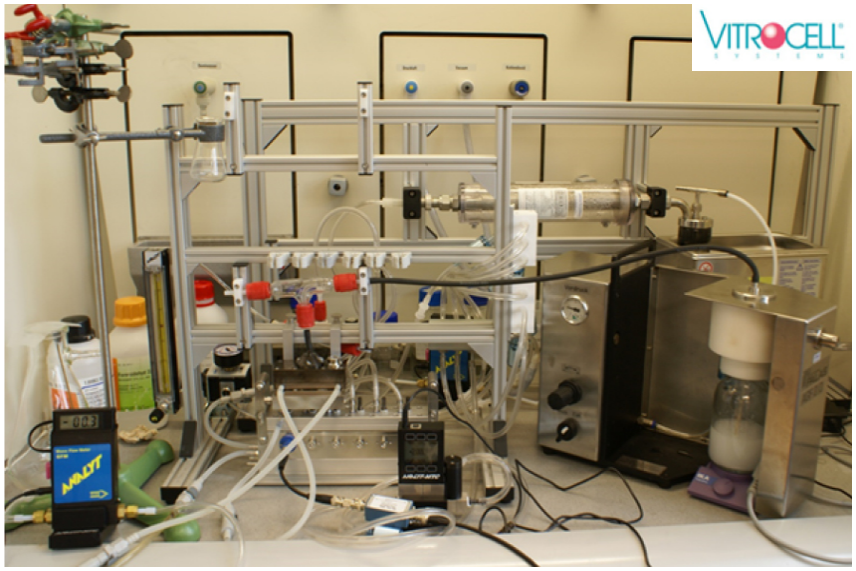

Nasal, Oral Cavity
Pharynx, Larynx
Trachea
Bronchi
Bronchi
Bronchioles
Alveoli
5 - 10 μm
3 - 5 μm
2 - 3 μm
0.5 - 1 μm
Newman (2001)


50 μm

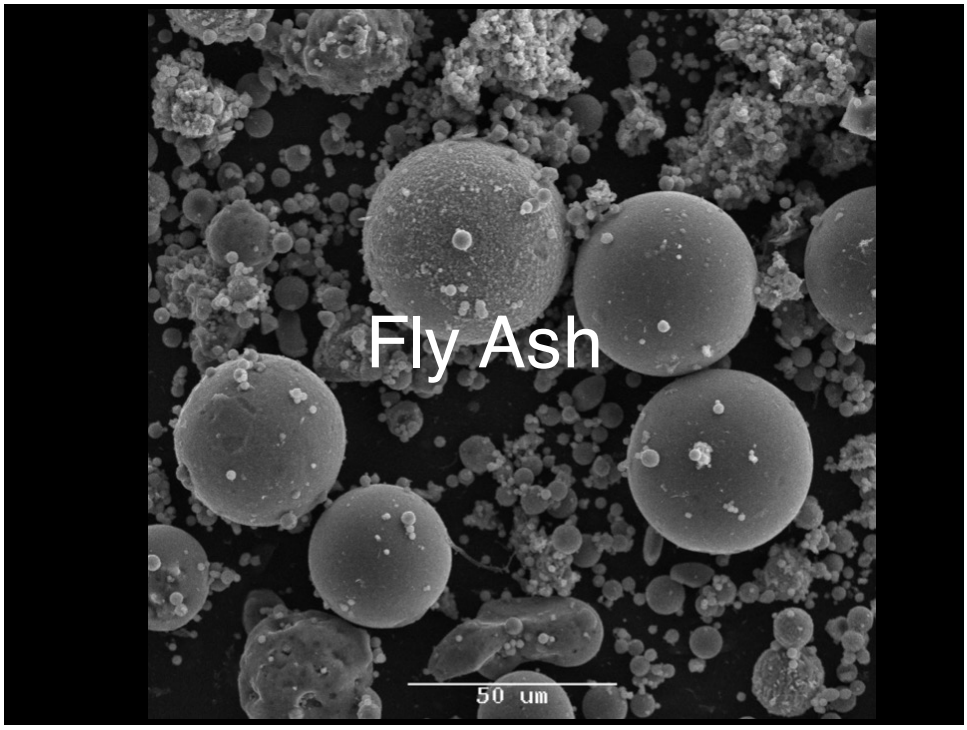

Particle
Reactive Oxygen Species (ROS): $O_2^{\cdot-}$, H_2O_2, $^{\cdot}OH$
Oxidative Stress
Inflammatory Mediators
?
DNA Damage
Inflammation
Cancer
Fibrosis, Chronic Inflammatory Lung Disease


Submersed Lung Cell Exposure
HAMILTON
BIOCOMBUST

Air-Liquid Exposure



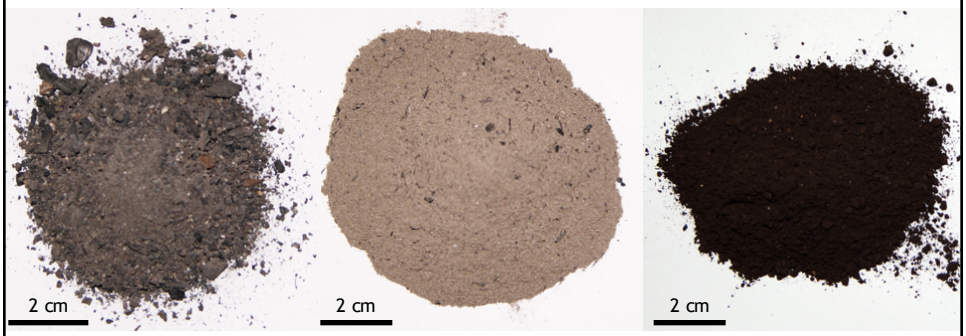
BIOCOMBUST



Cement Industry

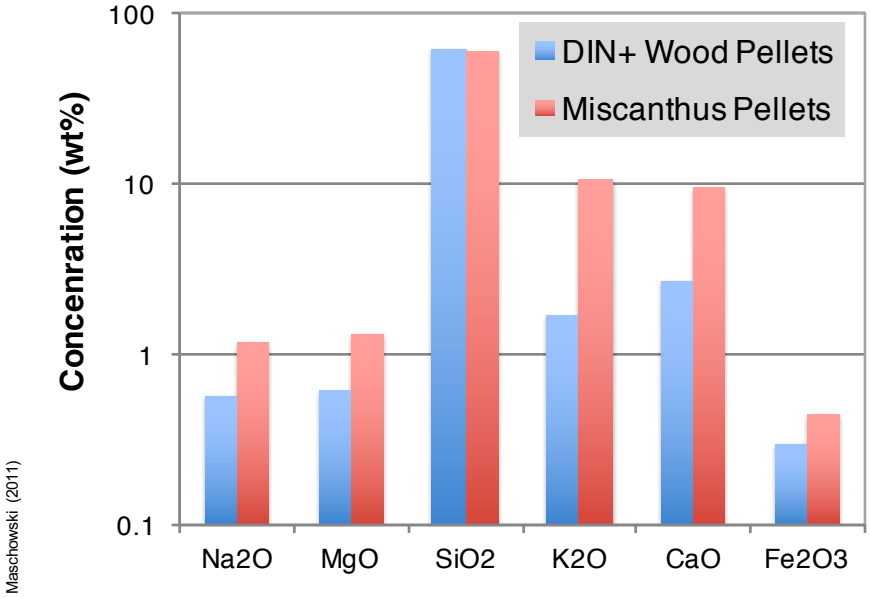
Cement Industry

Fly Ash



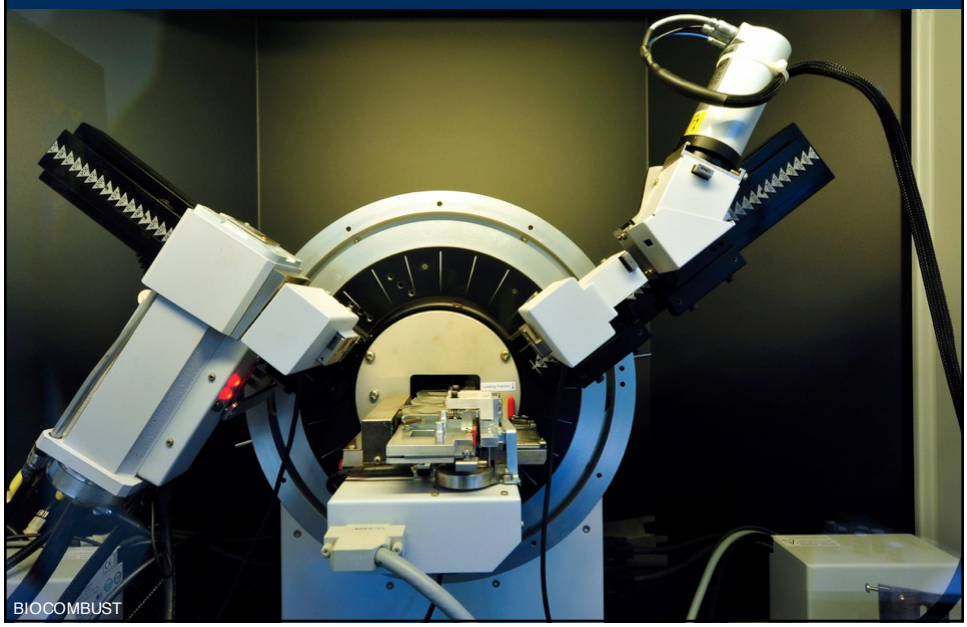
BIOCOMBUST

Fly Ash Composition (wt%)

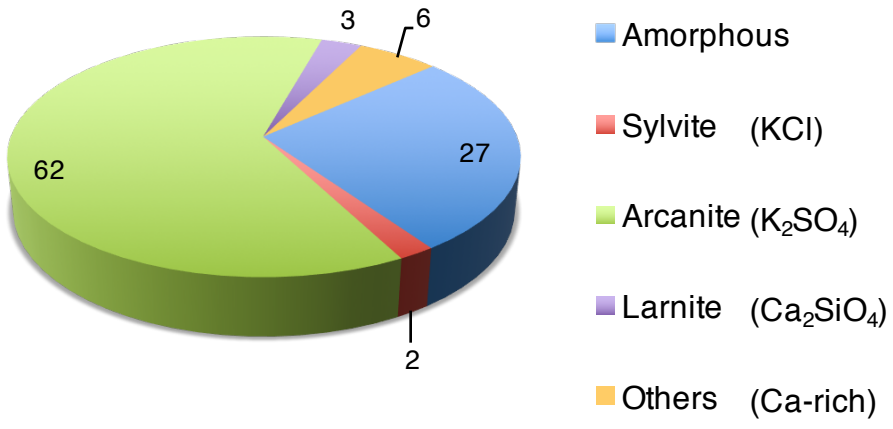


Maschowski (2011)

Phase Identification

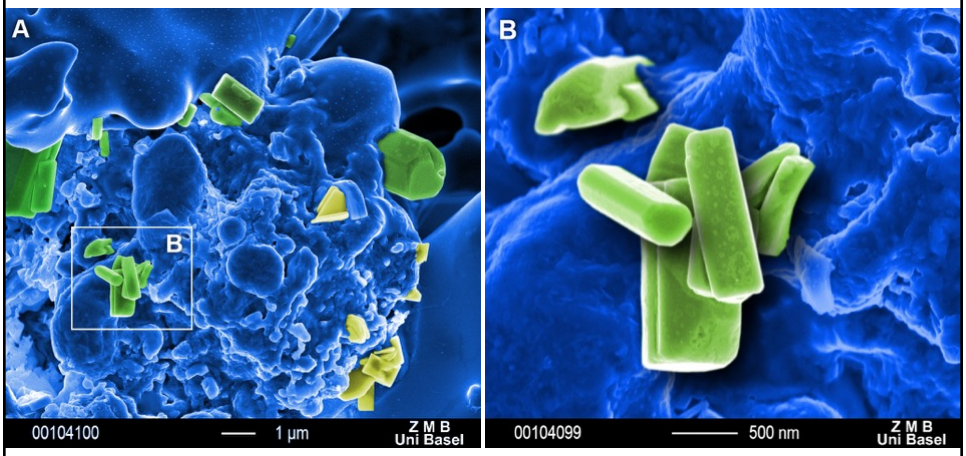


Mineralogical Composition (wt%)



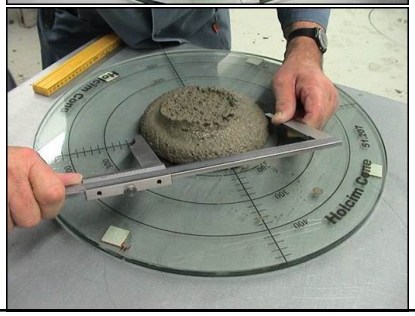
Maschowski et al. (in prep.)

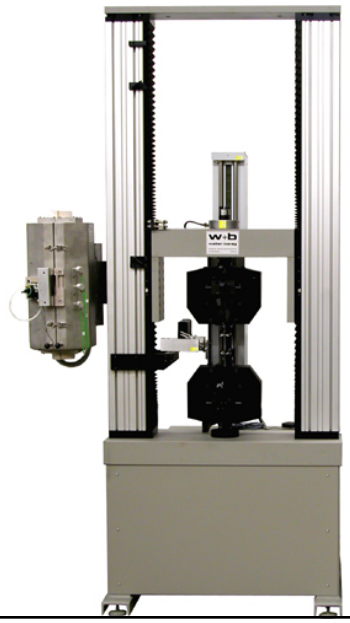
Mineralogy of the Ash



Maschowski et al. (in prep.)

Cement Tests





Holcim

Applications

http://dellabella.ch/gallery/aerial-dams/

BIOCOMBUST

biomass | energy | health

MAX-PLANCK-INSTITUT FÜR CHEMIE

Holcim

UNI FREIBURG

aspa

UNIVERSITÉ HAUTE-ALSACE

UNIVERSITÄTS KLINIKUM FREIBURG

DWD

www.biocombust.eu

www.biocombust.eu/backstage

Collaborators