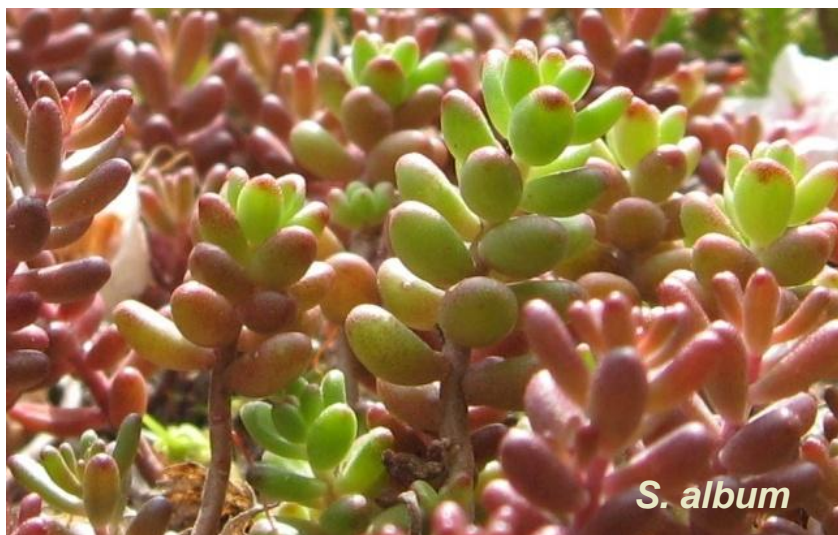


Green Tram Tracks

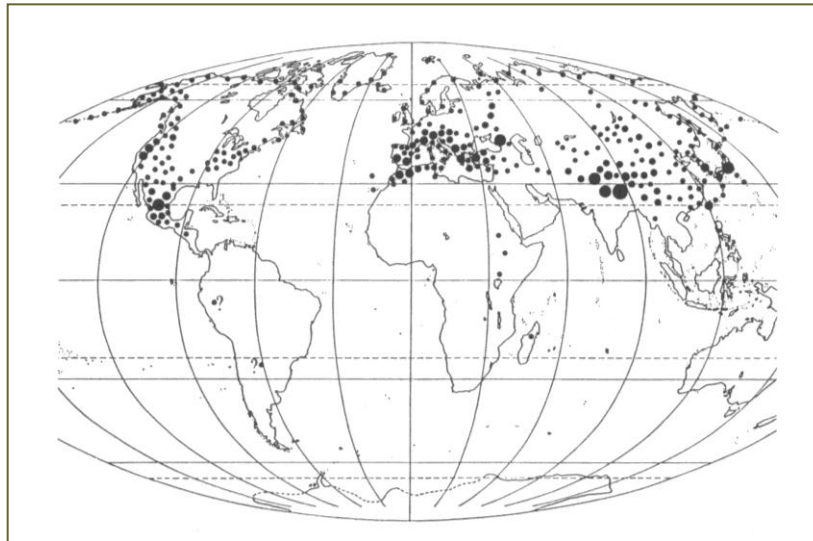
The Advantages of Implementing Vegetation Systems in Tram Tracks



1 Sedum



- Sedum: genus of 500 species
- Distribution: Northern hemisphere,
- 3 contrasting areas especially rich in Sedum:
Mexico, Mediterranean Sea, Himalayan Mountains



Natural Sedum distribution (STEPHENSON 1999)

Sedum track, Berlin, Prenzlauer Allee, June 2009

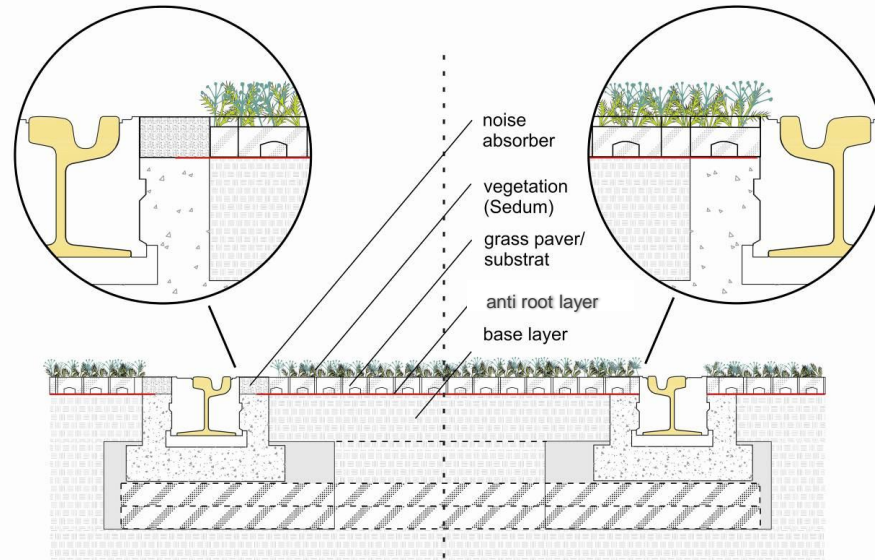


- Adaption to track condition and local condition
- Stray current (EN 50122-2)
- Reduction of life cycle costs, which also means low maintenance
- Optic all year round
- Accessibility for snow clearing
- Drainable but water retaining
- Reduction of noise reflection
- Drivable for emergency vehicles



3 Drivable but Green

Track design for test site Brussels



Special absorber: Drain concrete



Special absorber: Porous rubber



Grass paver up to rubber jacket

3 Drivable but Green

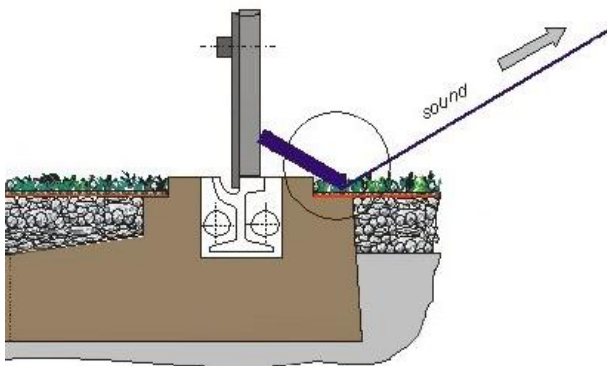
► Fatigue test

- simulated more than 34 years fatigue, at three wheel crossings a day



Drain concrete test body at STUVA fatigue laboratory, after testing

- ▶ Main noise source: contact of rail and wheel
- ▶ Reduction of reverberant surfaces
- ▶ Noise absorption at tor-level up to 2 - 4 dB (A) vs. ballasted track
- ▶ Comparison of green track materials: noise absorption in impedance tube
- ▶ Substrate, Sedum, artificial grass, cavity elements, absorber, grass paver



Rail-wheel contact

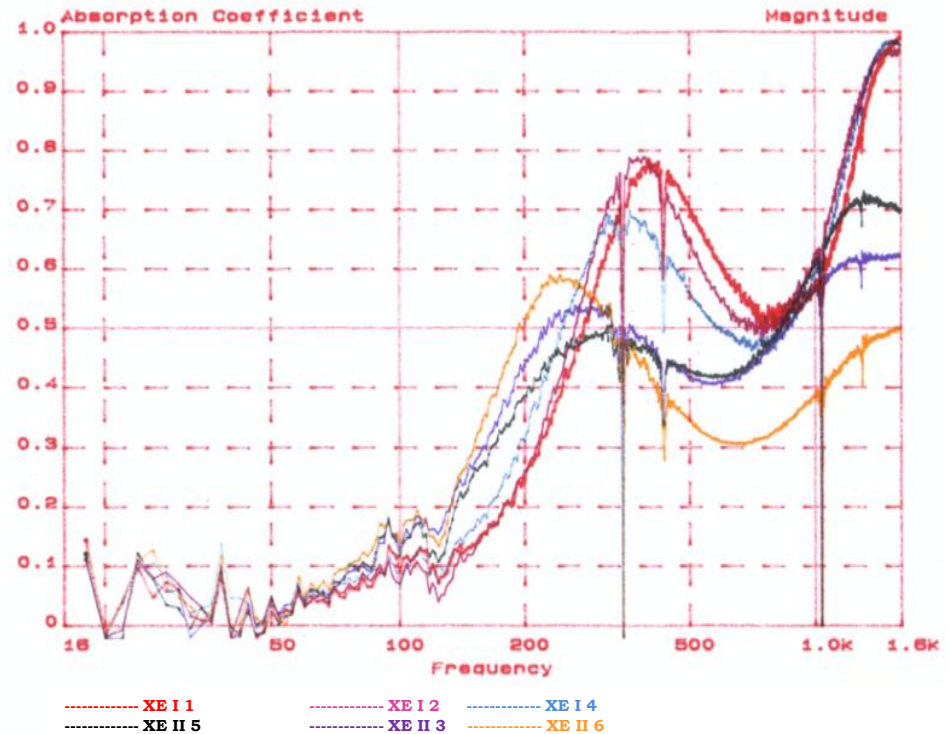


Impedance tube (Brüel & Kjær, type 4206)



Some test materials

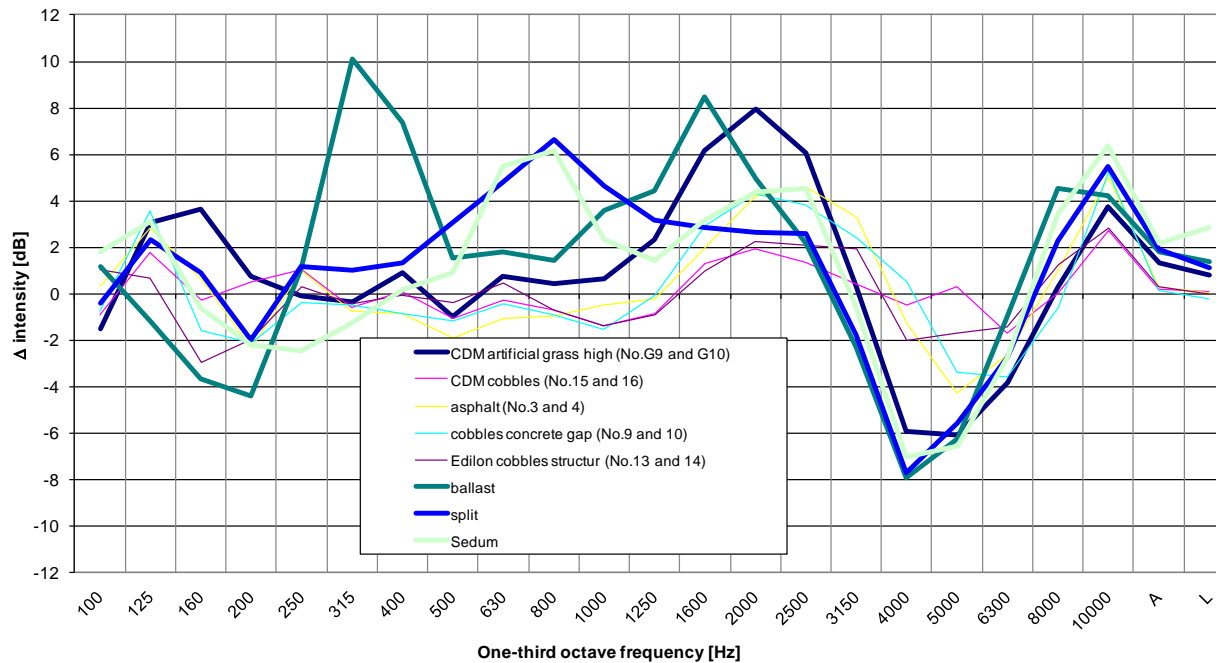
- ▶ Absorption between 500 - 1000 Hz: vegetation & artificial grass > substrate > drainasphalt and porous rubber mat > cavity elements
- ▶ Used materials with best absorption properties for track design



Comparison of two substrates: Xeroterr I (0/12) and Xeroterr II (0/8)
 $\alpha(\text{Xeroterr I}) > \alpha(\text{Xeroterr II})$

4 Noise Reduction

► Comparison of test bodies for sound absorption

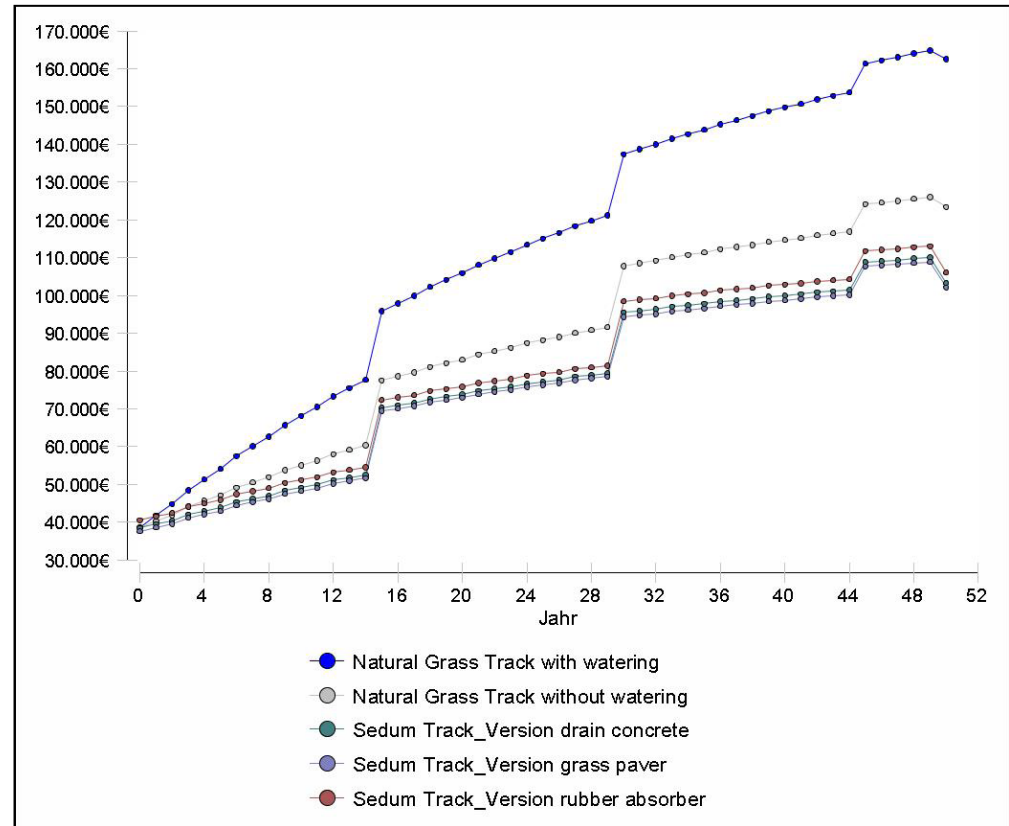


Sound measurements, STUVA lab

Results of sound absorption measurements on test bodies: means of lower level (stimulation pink noise, measurement of sound intensity, difference levels to “unruffled concrete no. 1 and 2)

5 Life Cycle Cost Reduction

- ▶ Sedum =extensive naturation system
- ▶ Low maintenance needs (fertilization)
- ▶ Compensating measures for surface sealing would cease to apply



Cumulative LCC of the candidates over 50 years

- ▶ Tram tracks are part of the cityscape
- ▶ Aesthetic aspect
- ▶ Green space is brought into cities, natural and calm atmosphere.
- ▶ Some Sedum varieties are evergreen
- ▶ Habitat for innumerable insects and other invertebrates



Chemnitz, Goethestraße before naturation



Chemnitz, Goethestraße after naturation

► Problems in urban agglomerations



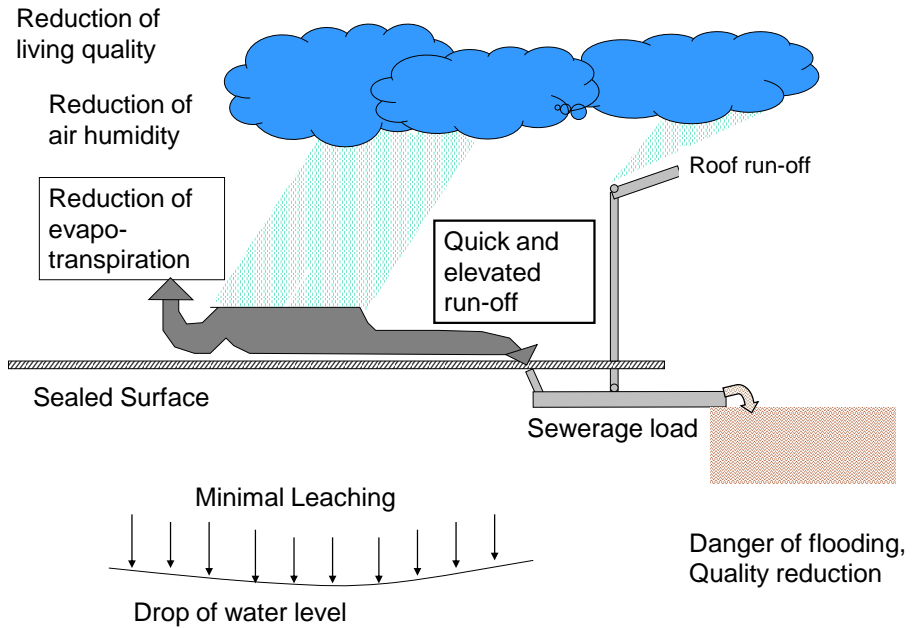
www.inmoskau.de/blog/wp-content/moscow-city-moskau-th.jpg



www.alleangebote.com/reisetipps/wp-content/uploads/2009/05/new_york_city.jpg

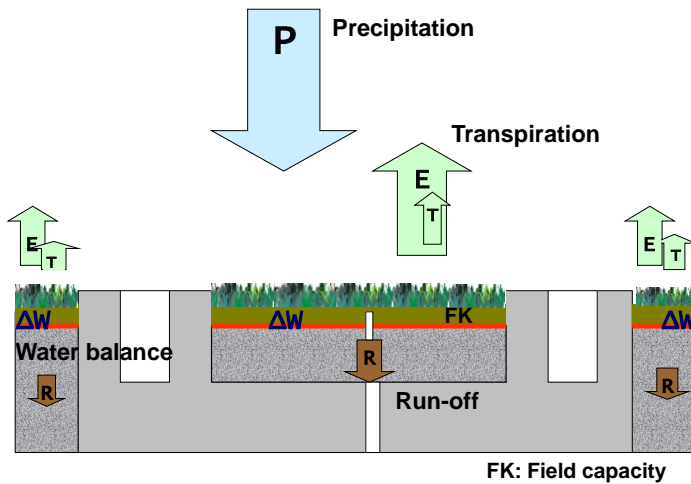


www.laits.utexas.edu/berlin/images/buildings/05PotsdamerPlatz/c215_PotsdamerPlatz.jpg



Negative impacts on urban water balance due to surface sealing
(modified, from ILS 1993)

Implementation of vegetation systems:
greened area = unsealed or partly unsealed



P= Precipitation;
ET= Evaporation and Transpiration;
R= Run-off;
ΔW=Water balance in the vegetations system [mm or l/m²];
FK = field capacity

$$P = ET + R + \Delta W$$

Elements of the water balance in a tram track naturation

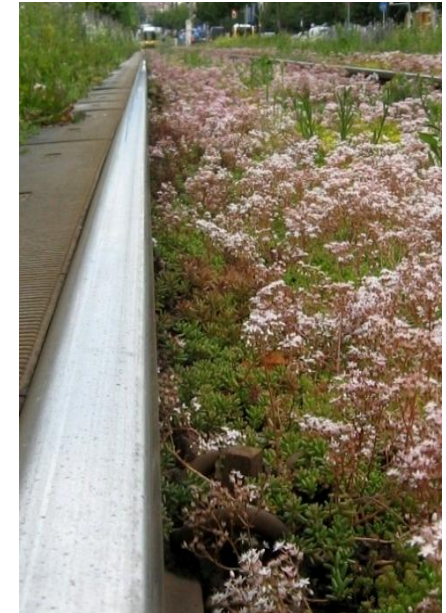


Barcelona www.tramvia.org

- ▶ Extensive vegetation systems: retain 50 % of precipitation.
- ▶ Intensive vegetation systems: retain 70 % up to 100 %

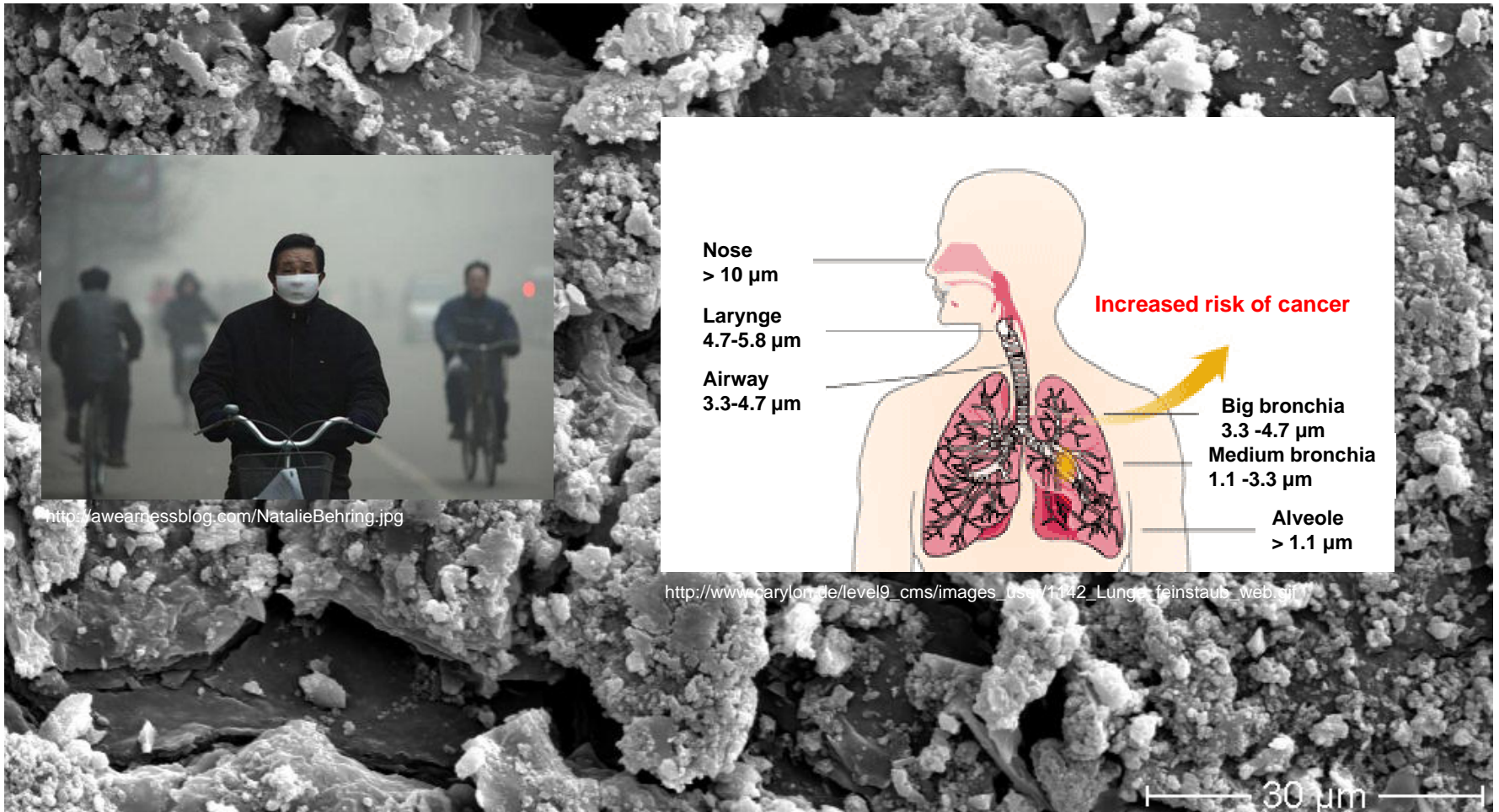
- ▶ Germany (IASP 2009):
 - ~ 4350 km single track
 - Potentially greenable: 1142 km
 - Momentarily greened: 374 km
- ▶ 326 km grass tracks => 81.5 ha: 453 460 m³ water storage
- ▶ 48 km sedum tracks => 12 ha: 47.400 m³ water storage

- ▶ Altogether: 374 km are 500 860 m³ at 790 l/m²/a precipitation on average.

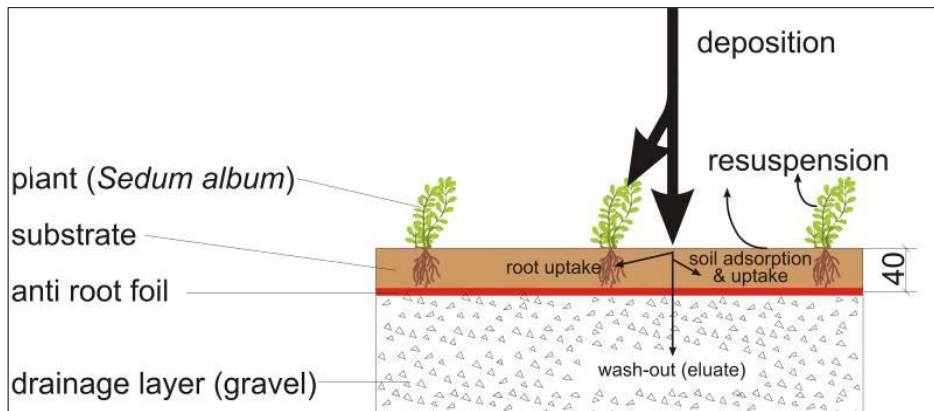


Sedum track, Berlin, Germany

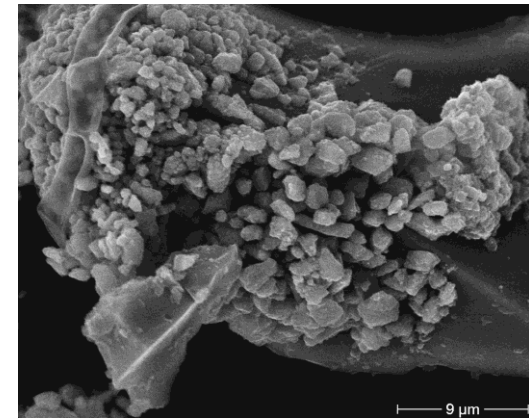
8 Fine dust – Problems in urban agglomerations



8 Fine dust – Contribution of green tracks



Path of dust through vegetation system



REM: Fe- and Si- particles on *Sedum spurium* leaf surface, 9 μm

Metals

Sedum track: Fe 5300 mg/kg dm,

Mn 110 mg/kg dm,

Cu 40 mg/kg dm

Reference: Fe 540 mg/kg dm,

Mn 34 mg/kg dm,

Cu 16.6 mg/kg dm

Polycyclic aromatic hydrocarbons (PAH)

Sedum track: 1.870 mg/kg dm

Reference: 0.989 mg/kg dm

SEM/EDX: Presence of particles below 2.5 μm
mainly Si- and Fe-particles

PSS: 99 % of the particles < 8 μm (values under reserve)
mean diameter 1,1 μm (values under reserve)

8 Fine dust – Contribution of green tracks

- ▶ During winter 100 % dust coverage of leaves
- ▶ Precipitation no big cleaning effect
- ▶ Accumulation of fine dust on leaf surface
- ▶ **Wind tunnel**

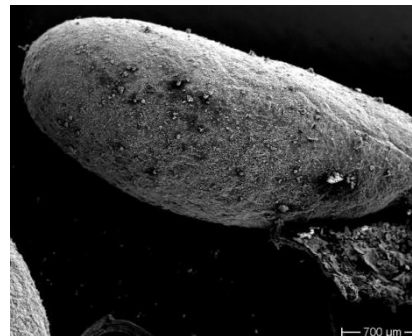
Comparison: sedum vs. gravel, 0.23-20 μm

Deposition: sedum > gravel

1 m/s > 2 m/s

highest deposition rate 2-10 μm

Resuspension: sedum < gravel (2-10 μm)



Sedum album - leaves from tram track, uncleaned



Sedum album - leaves, cleaned

► Anthropological impact on natural climate:

Higher air pollution

Accumulation of contaminants

Changed water balance

Heat island effect

Loss of biodiversity

Higher noise level



http://www.kgs-gotha.de/jahr08/projektarbeit1/smog_mexico-city.jpg



http://www.noise-busters.com/_borders/Original_NoiseBuster98.jpg



- Huge areas covered by tram tracks
 - Optical aspect
 - Fine dust binding
- Improves water balance & urban microclimate
 - Reduces noise
- No compensatory measures
 - Biotop for flora and fauna

➤ Ecological potential with flower power



S. sexangulare



S. album



S. spurium



S. floriferum