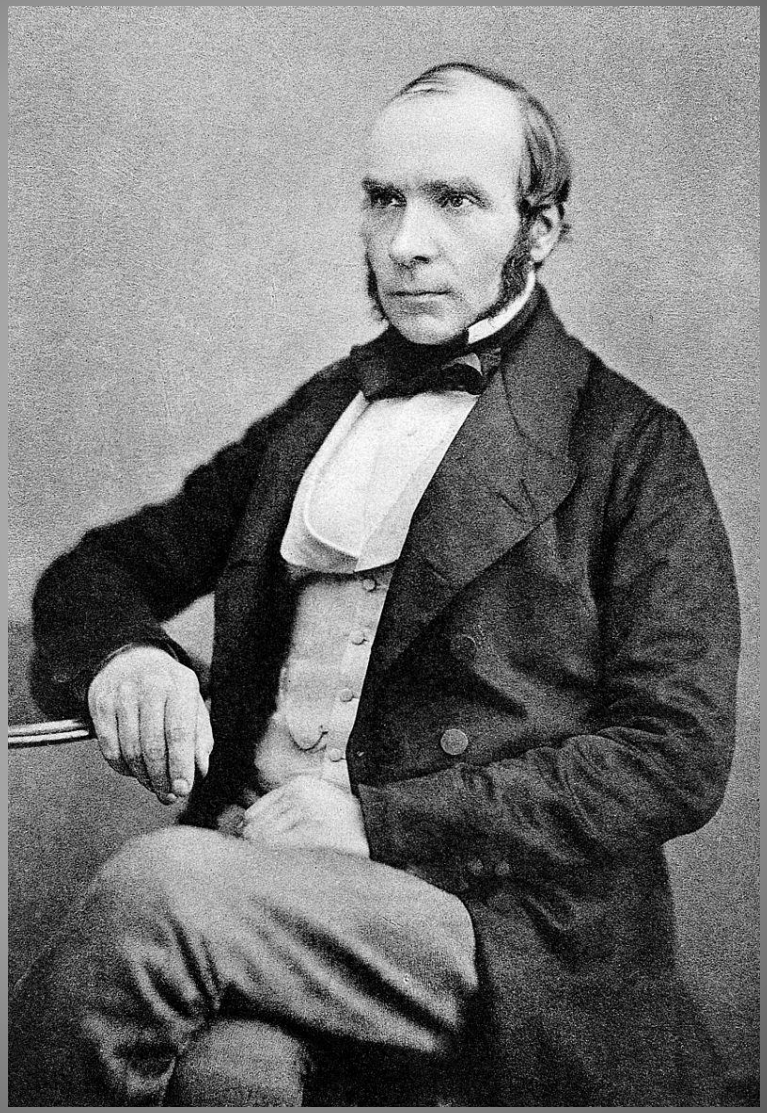
The Short History of Wastewater Treatment

Dr. John Snow
1813-1858
British



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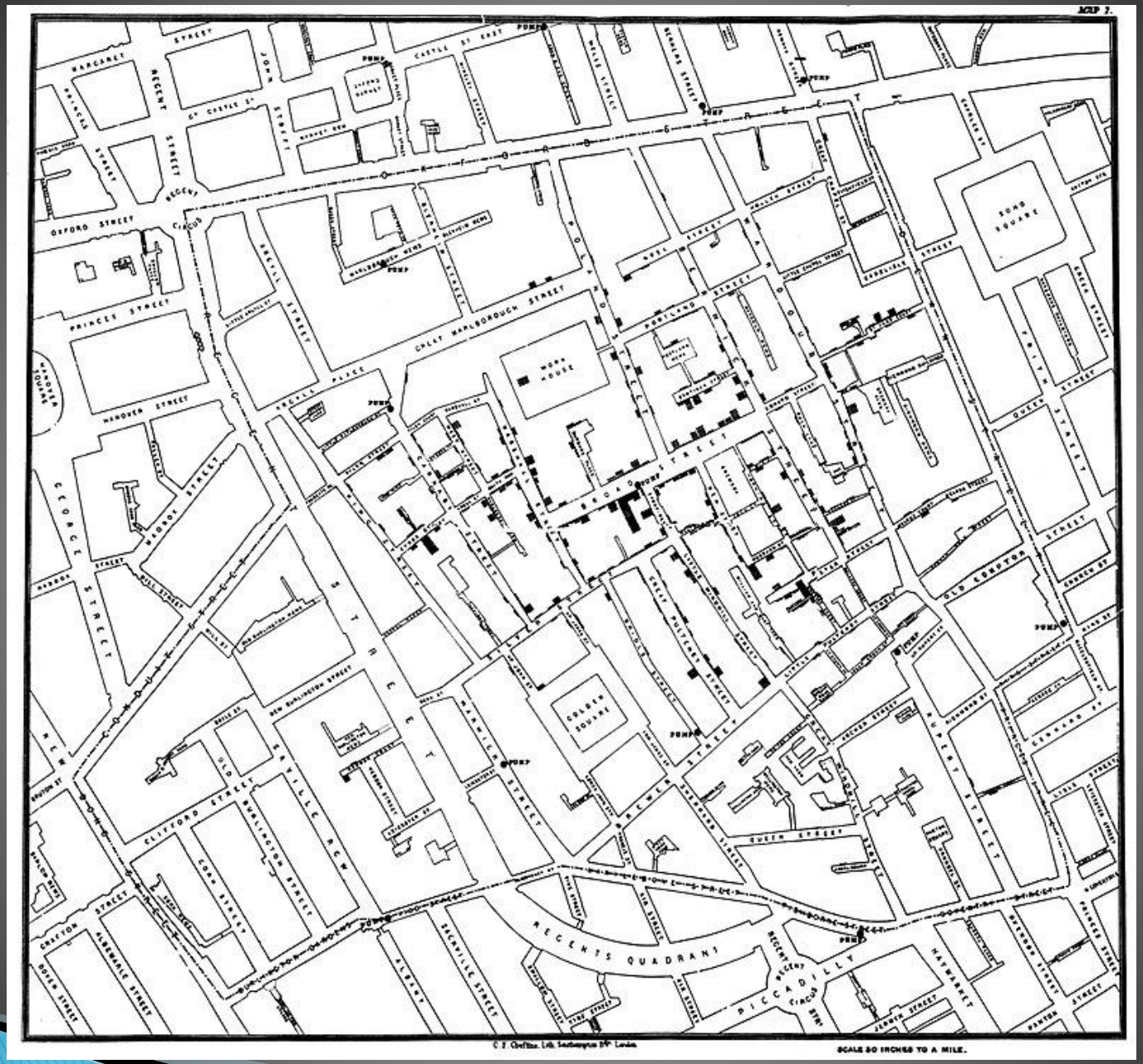

Some things don't change…

Political controversy

After the cholera epidemic had subsided, government officials replaced the Broad Street pump handle. They had responded only to the urgent threat posed to the population, and afterward they rejected Snow's theory. To accept his proposal would have meant indirectly accepting the fecal-oral route of disease transmission, which was too unpleasant for most of the public to contemplate.

It wasn't until 1866 that William Farr, one of Snow's chief opponents, realised the validity of his diagnosis when investigating another outbreak of cholera at Bromley by Bow and issued immediate orders that unboiled water was not to be drunk.

Broad Street pilgrimage London

Courtesy of buechners on Flickr. Used under CC BY-NC.

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Excreta Safely Managed

2.9 billion people used safely managed sanitation services in 2015

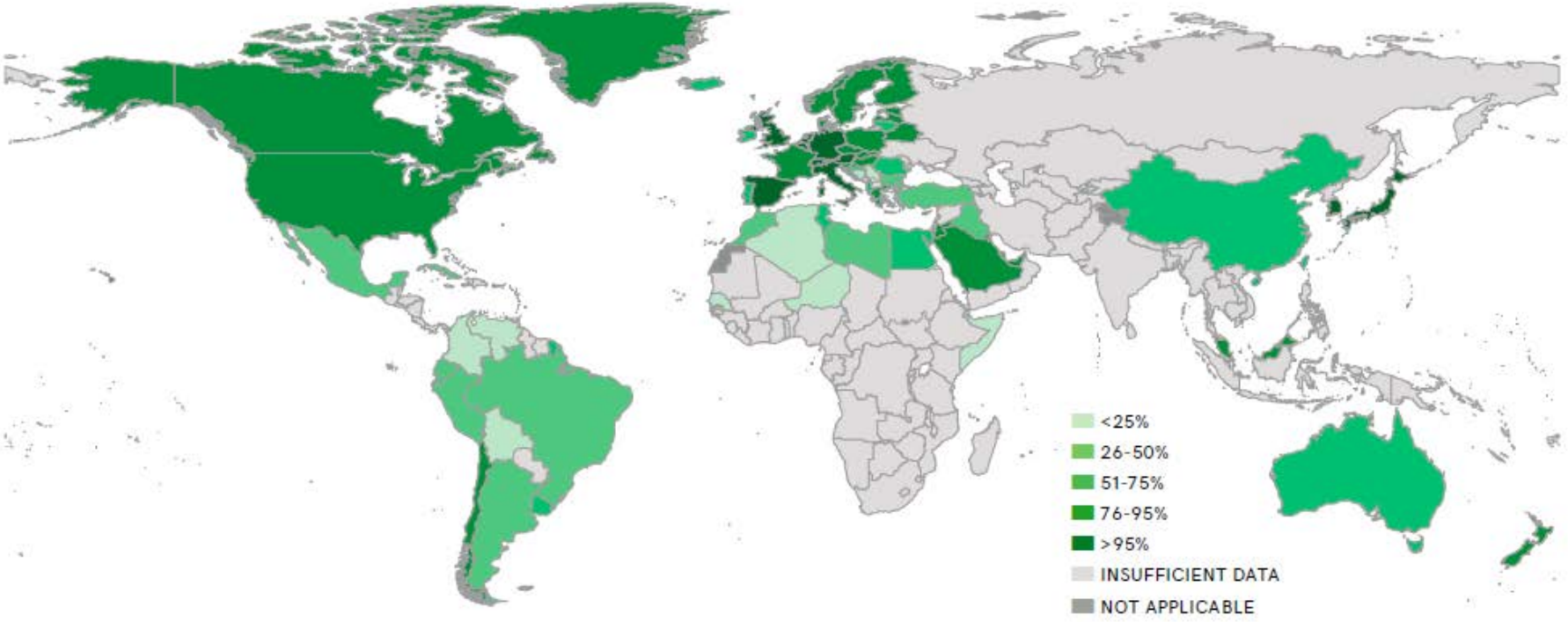
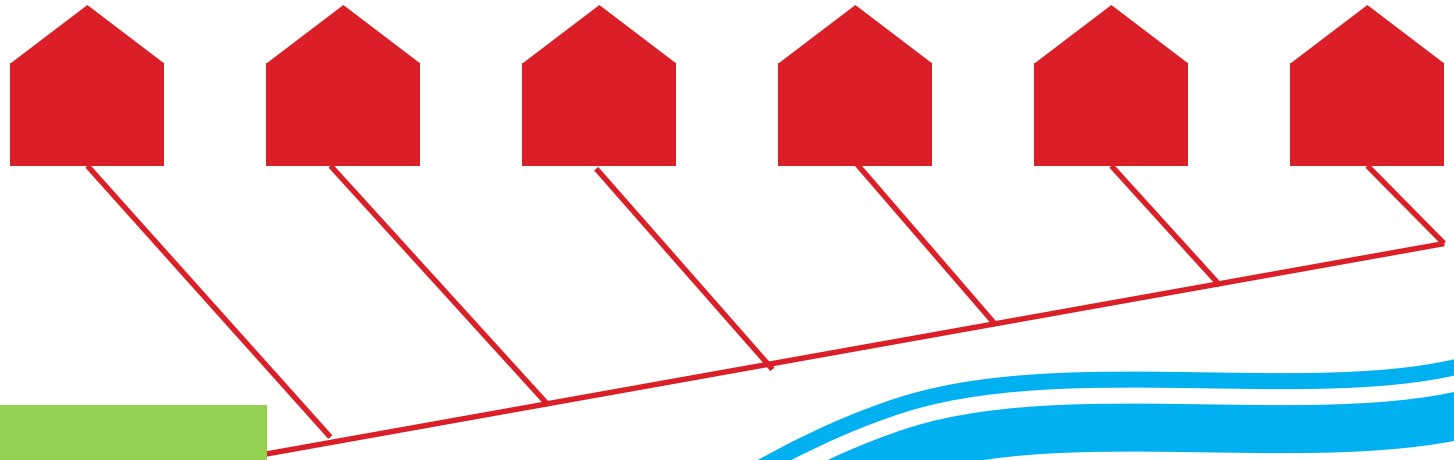


Fig. 38 Proportion of population using safely managed sanitation services, 2015

Source: JMP 2017

Centralized Treatment

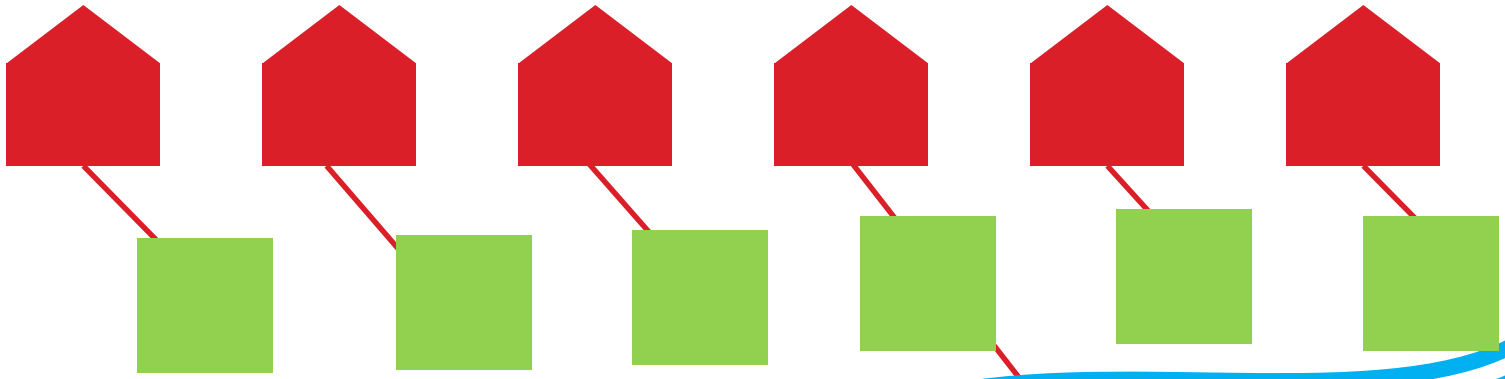
- Community wastewater collected and sent to a centralized location for treatment



Treatment Plant

Decentralized Treatment

- Community wastewater is not collected but rather is treated at the point of generation

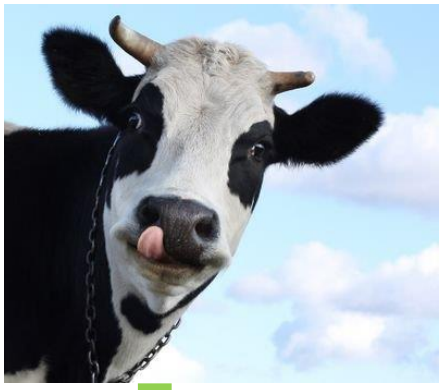


Fecal Sludge Management

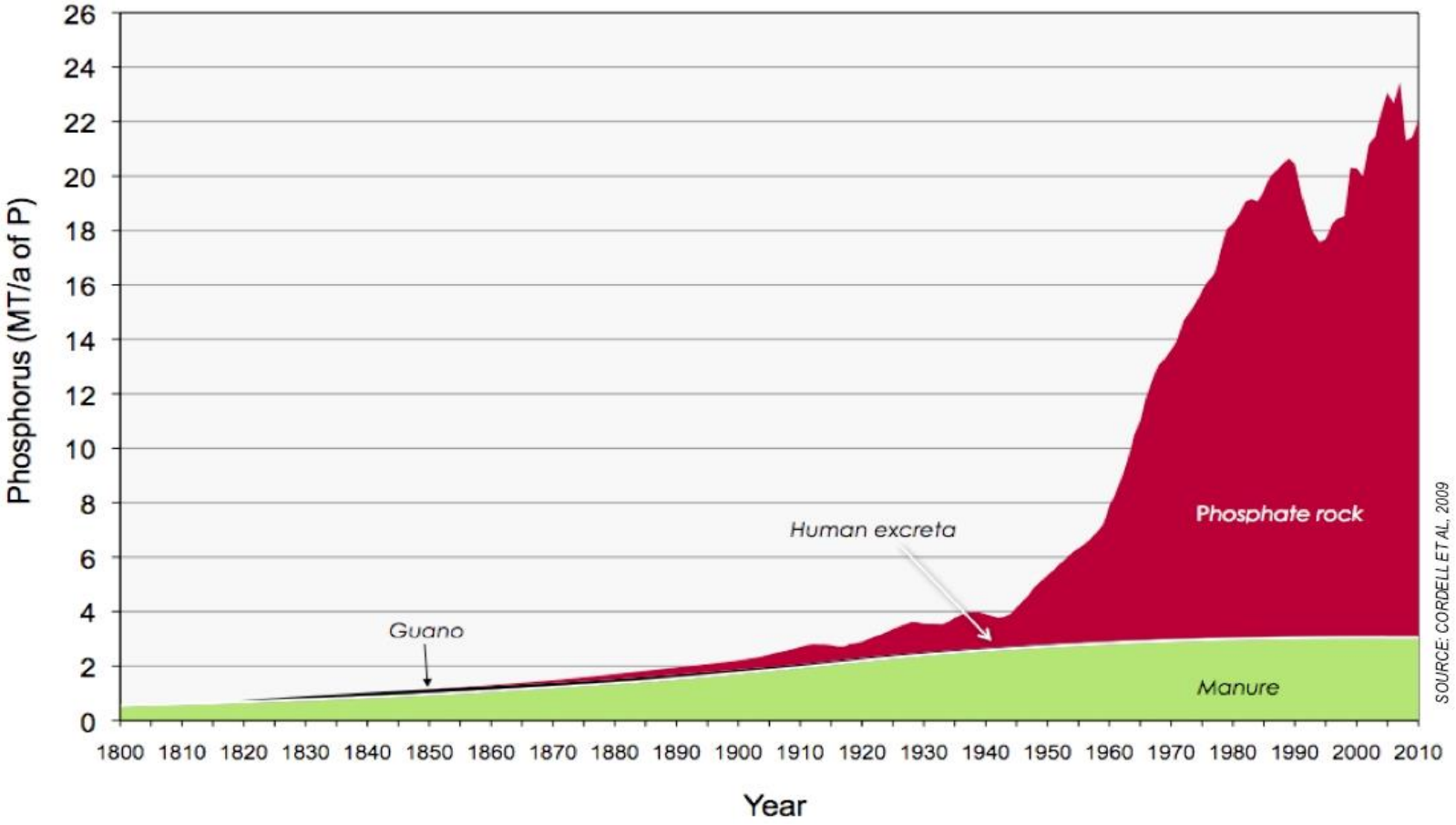
- Goal: Convert sludge into biosolids with beneficial reuse as fertilizer/soil conditioner
  - Reduce Pathogens
  - Reduce Heavy Metals
  - Nutrients: N-P-K
  - Organic Material

Nutrient Loop

"the movement and exchange of organic and inorganic matter back into the production of matter"



Why does this matter?



Earth is 40% beyond its carrying capacity due to fertilizers

Low-Cost, Alternative Wastewater Treatment Systems

- Waste stabilization ponds (a.k.a. lagoons and oxidation ponds)
- Aerated lagoons
- Oxidation ditches
- Constructed wetlands (reed beds)
- Wastewater bioremediation
- Land treatment
- Upflow anaerobic sludge blanket (UASB) reactors

Types of Wastewater Treatment Ponds

- Waste Stabilization Ponds (WSPs)
  - Natural bio-photosynthetic treatment
  - Earthen basins
  - No electricity-powered aeration is required
  - Four processes or types of WSPs:
    - Anaerobic ponds
    - Facultative ponds
    - Maturation ponds
    - High-rate aerobic ponds
- Aerated Lagoons
  - WSPs with powered aeration
- Oxidation Ditches
  - Oval channel shape with powered aeration

Key Design Aspects of Lagoons

- Hydraulic detention time
- Organic loading rate
  - Usually measured as mass of organic waste in BOD_5 added per day to a unit volume OR unit area
  - BOD_5 is a quantity of oxygen-depleting organic matter: "milligrams of oxygen needed to break down the organic matter contained in a liter of water over five days"
- Depth

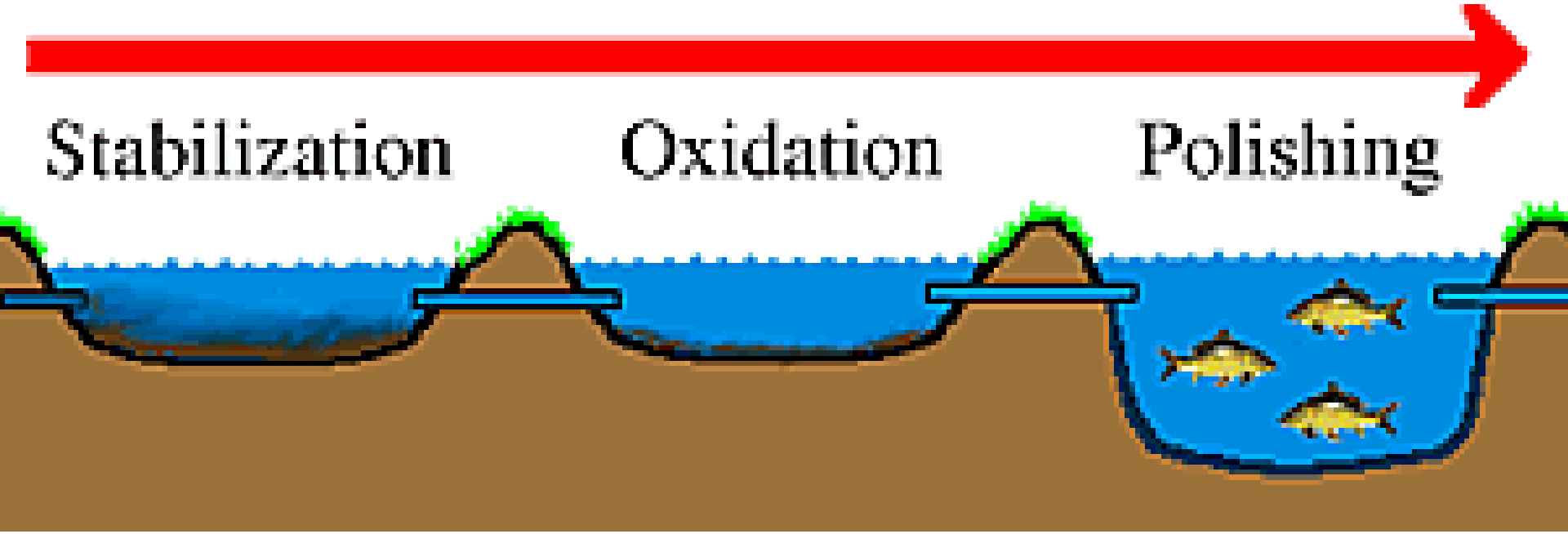
Reference books give average design parameters, BUT real conditions vary widely around the world – testing!!

Wastewater Stabilization Ponds

Anaerobic

Facultative
Photosynthetic
Aerobic-anaerobic

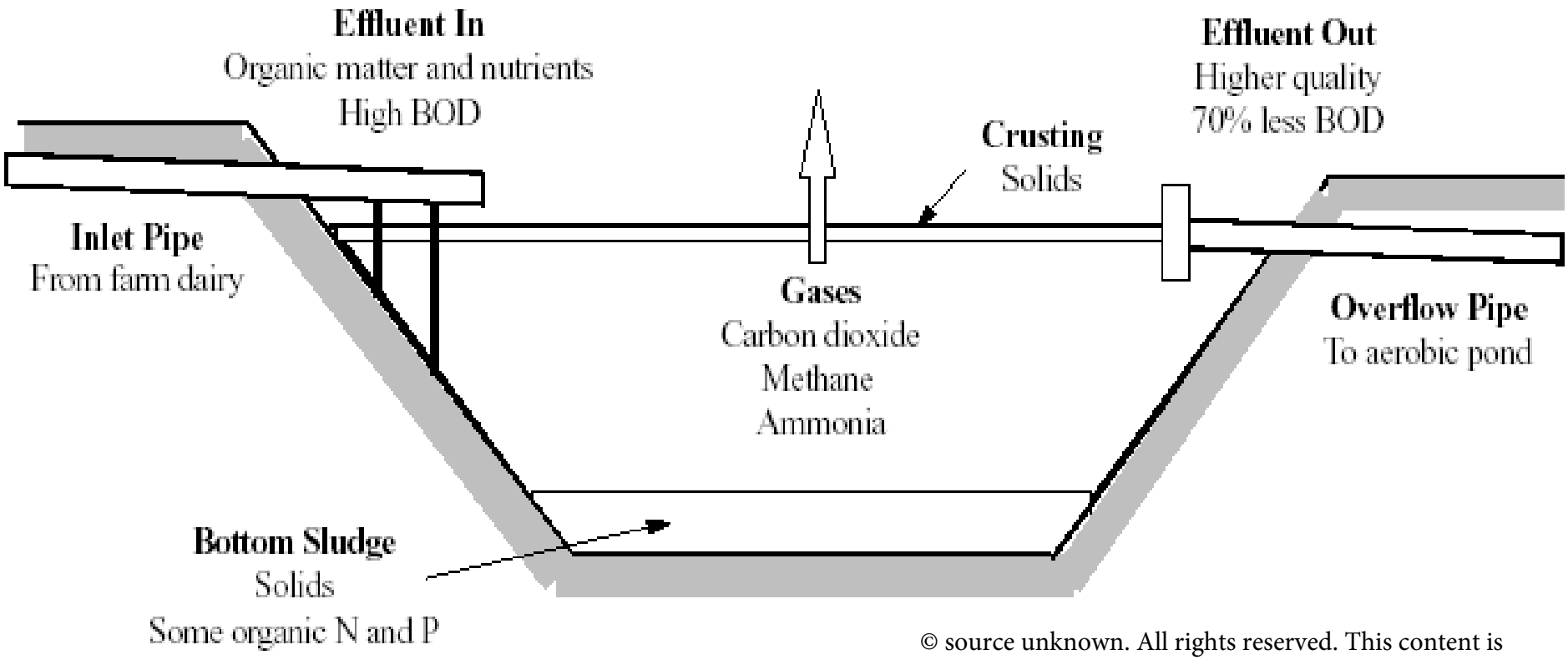
Tertiary
Maturation



Anaerobic Ponds

- Preliminary pond treatment stage (to reduce the organic load and allow algae to grow in the following stage)
- Deep pond, anaerobic throughout, no algae
- Bacteria break down organic matter and nutrients, and create CO_2 and CH_4
- Treats high-strength wastewaters with high solids content
- Maintains a surface cap of fresh water to seal in odors (may need powered aeration)
- ≈ 60 – 70% BOD removal

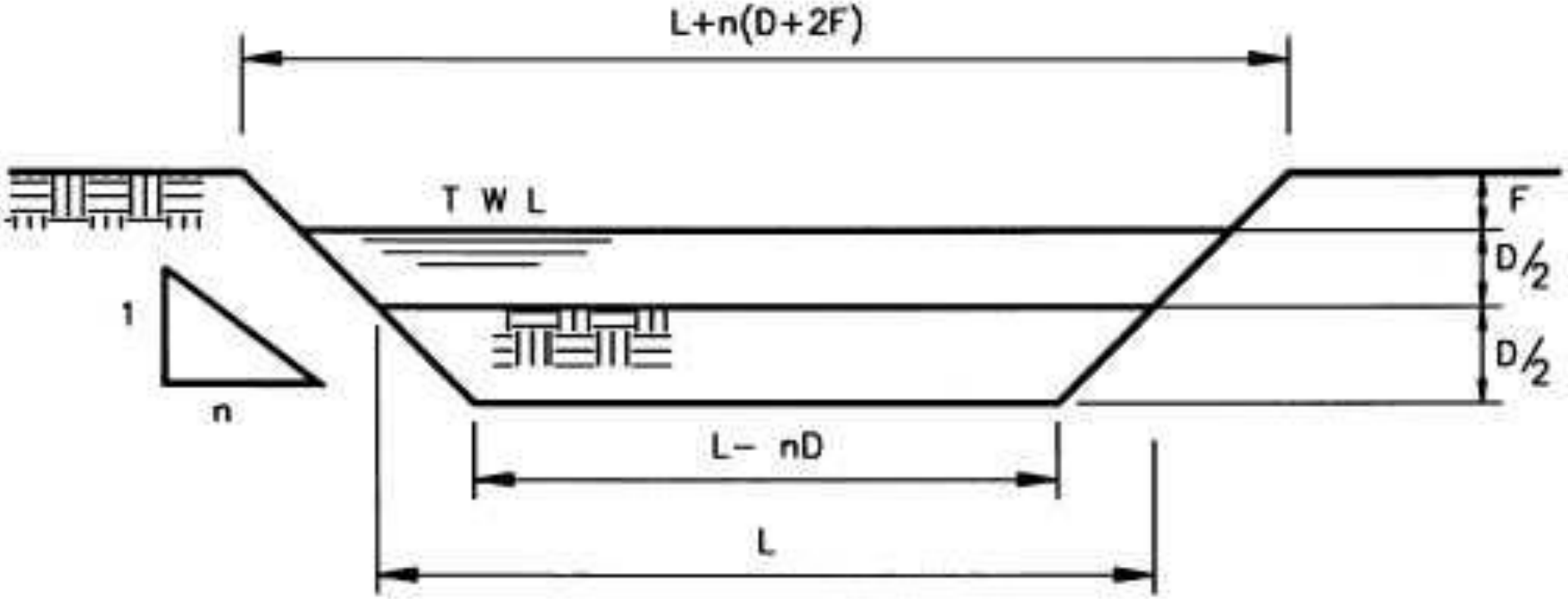
Anaerobic Ponds



Facultative Ponds

- Solids settle out on the bottom in an anaerobic sludge layer and create odorous gases
- Bacteria in the middle take in O_2, oxidize organics/nutrients, and create CO_2
- Algae on the top take in sunlight and CO_2, oxidize organics/nutrients, and create O_2
- 20% BOD removal

Facultative Ponds



Facultative Ponds

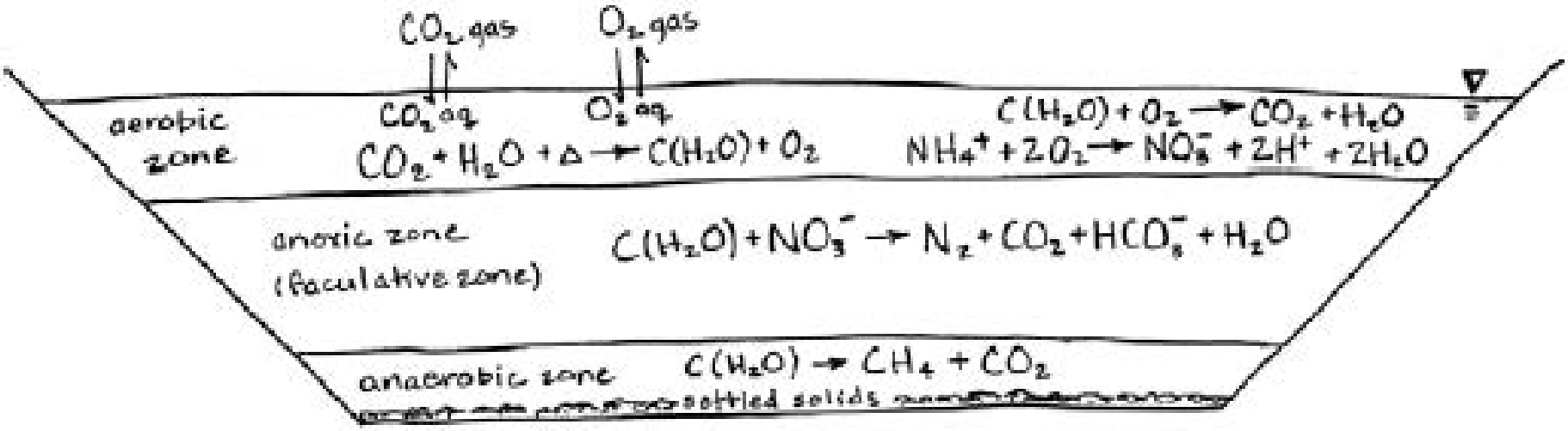


Figure 22-2. A Facultative Lagoon Consists of Three Zones for Wastewater Treatment.

Maturation Ponds

- Stage of treatment following the facultative pond (polishing step)
- Shallow pond (1-1.5m), aerobic throughout, sunlight penetrates entire depth
- Destruction of pathogens
- Wastewater effluent can be reused for agriculture or aquaculture
- 15% BOD removal (small) by N & P removal is significant (< 50% P,80+% N)

WSP Evaluation

- WSPs are simple, low-cost, and highly effective!
- WSPs are limited by the following factors:
  - Land availability and cost, siting constraints
  - Temperature (non-ideal in cold climates)
  - Wastewater quality (natural systems that cannot handle toxic shocks, highly variable loading, industrial waste)

What can we do with this water?

Table 22-2. Types of Lagoons That Correspond to Particular Water Reuse Scenarios

Type of Reuse	General Rule on Types of Lagoons Required to Meet Water Quality Guidelines
Restricted irrigation—Includes irrigation of crops, except salads and vegetables eaten uncooked	Anaerobic lagoon followed by facultative lagoon
Unrestricted irrigation—Includes salads and vegetables eaten uncooked	Anaerobic lagoon followed by facultative lagoon and maturation lagoon
Wastewater-fed fish ponds	Anaerobic lagoon followed by facultative lagoon to maintain total nitrogen load into fish ponds of 4 kg N/ha-day. It is important to check pathogen and ammonia concentrations in the facultative lagoon effluent.

Constructed Wetland

- Plant varieties are restricted or a monoculture
- Impermeable liner
- Preceded by a septic tank or oxidation pond
- Water flow may be controlled below the plant-growing surface or not
- Effective at reducing pathogens, BOD, and total suspended solids

Evapotranspiration Beds

- A type of subsurface flow wetland
- Water evaporates from the soil and is transpired by the plants growing there
- Use when the soil cannot treat the wastewater before it percolates to groundwater, or where soil prevents it from percolating correctly (very clay-ey soil)
- Cannot work in areas where rainfall rate is higher than evapotranspiration rate!

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