IFT09
ANNUAL MEETING + FOOD EXPO

June 6-9, 2009
Anaheim Convention Center
Anaheim/OC, CA

Session #188 Water Sustainability

# Overview of challenges for water quality protection and conservation across the food supply chain and tools for assessing sustainability

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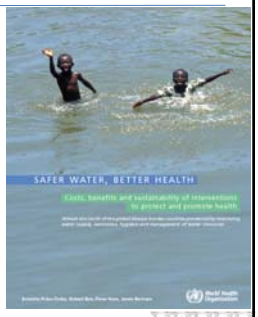
## Water Quality Challenges

- **Global scarcity of water of any quality**
  - **Need to meet a better balance between:**
    - **ecosystem water needs (ultimately impact on us)**
    - **Food production (irrigation & animal waste-impacts)**
    - **Drinking water needs**
  - **Water-based waste disposal is not sustainable as practiced today in developed & developing regions**
- **Eutrophication paradox**
  - **Energy and fertilizer recovery from excreta/food 'wastes' can be net +ve; currently a heavy burden**
  - **–Essential for future global agriculture (NPK)**



## WHO Report, 2008

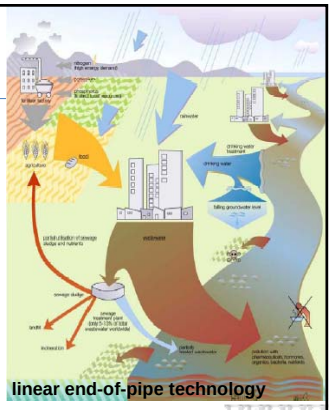
- **An estimated 24% of the global disease burden and 23% of all deaths can be attributed to environmental factors**
- **Diarrheal disease:**
  - **Developed regions**
    - **15k deaths**
    - **648k DALYs**
  - **Developing regions**
    - **1,507k deaths**
    - **51,812k DALYs**






## Shortcomings of conventional wastewater discharges

death by flushing'
1868 river pollution commissioner
(E. Frankland)




http://www.ecosanservices.org



## Water Facts: Increasing demand

- Water needed to create:
  - a single apple - 70 liters
  - a kilogram of maize - 900 liters
  - a kilogram of industrial beef - 15,500 liters
- 70% global water use goes to food production
- Americans consume (120 kg/y) 3 x global average of beef
- **US citizens use more than 500 billion litres of fresh water per day — That's roughly the same as the quantity used for irrigation**
- Chinese use 700 vs 2,500 tonnes of water by the average American per year

From www.waterfootprint.org



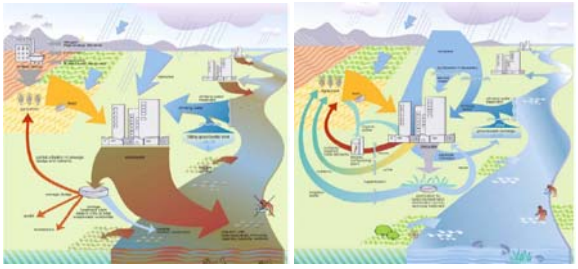
## Sustainable water management

- Sustainable water systems should over a long time perspective provide required services while protecting human health and the environment, with a minimum of scarce resources

*Child carrying water across an open drain, Ghana*

## We need a paradigm shift

**Current: use water once & disposal**

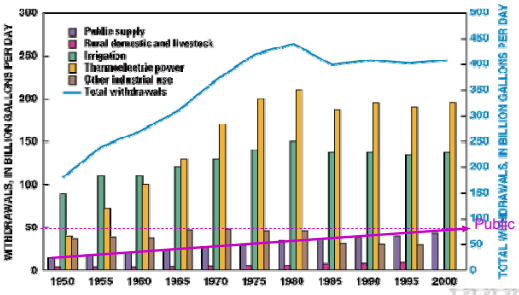


**Resource recycle instead of disposal**

From: http://www.ecosanservices.org



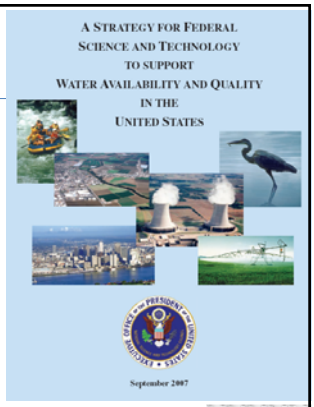
## Water Use Trends in the U.S.




Source: USGS Circular 1268










## The problem

- In current planning and decision-making processes related to water, product-oriented methods are rarely adapted to local circumstances
- Rather, approaches are guided by norms like linearity, objectivity, certainty and comprehensiveness (i.e. *status quo*)
- Consequently, more sustainable water systems are not actively selected for



## Three reasons current practices are not sustainable

1. Neither in US nor developing regions

   In the US the fastest growing regions are water scarce, infrastructure not being maintained, irrigation practices are water wasteful, food production is polluting…
2. Need for nutrient recycling to agriculture
3. Water-energy nexus



## 1. An opportunity for change due to aging infrastructure - USA

- Urban water use needs to change
- American Soc. Civil Eng. 2005 Infrastructure Report Card
  - 'D' for drinking water – new solutions are needed…risk reversing public health gains…
  - 'D' for wastewater – sanitary sewer overflows release 10 billion gal raw sewage annually…
- Hence, opportunity to build systems that recycle nutrients & energy – same in food production

## Difference between projected needs and spending trends ($ billions/y)

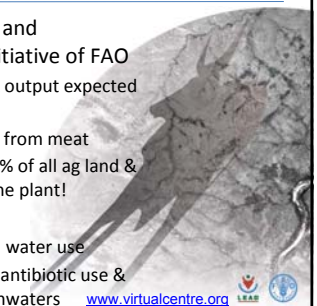
| For the USA 2002 | Drinking Water | Wastewater | Total |
|---|---|---|---|
| Congressional budget office | 0 – 8.3 | 3.2 – 11.1 | 3.2 – 19.4 |
| Water Infrastructure Network | 9.4 | 9.2 | 18.6 |
| EPA Gap Analysis Report | 2.3 – 13.3 | 1.6 – 13.5 | 3.9 – 26.7 |

EPA (2009) Drinking Water Infrastructure Needs Survey and Assessment. Fourth Report to Congress. www.epa.gov/safewater



## Livestock's long environmental shadow

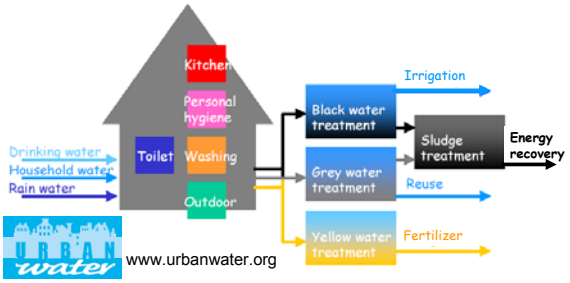
- Livestock, Environment and Development (LEAD) initiative of FAO
  - Doubling of meat & milk output expected from 2006 to 2050
  - ⅓ of humanity's protein from meat
  - Livestock account for 70% of all ag land & 30% of land surface of the plant!
  - Contribute 18% GHGs
  - Account for 8% of global water use
  - Largest polluter: 50% of antibiotic use & ⅓ of N & P loads to freshwaters
  - How to handle wastes?



www.virtualcentre.org
FAO 2006



## 2. Options for Households




www.urbanwater.org

Ashbolt *et al.* (2006) In: 2nd IWA Leading-Edge on Sustainability in Water-Limited Environments. WEMS vol 10, IWA Publishing, London.

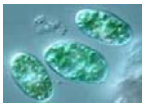


## Human & Ecological Hazards

- Pathogens

Viruses

Bacteria



Parasitic protozoa

- Chemicals

Cleaning agents

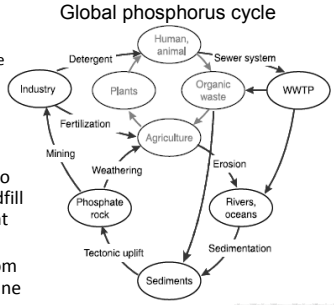
Pharmaceuticals



## Why P is important to recycle

- The cycle time for P is several million years
  - i.e. for a human timescale phosphate transported into the oceans can be considered as "lost" for agricultural use.
- Hence, P is 'lost' in wastewater discharges to oceans & sludges to landfill unless recycled as a plant fertilizer
- P price has increased from $50/tonne to $1000/tonne in last three years

Global phosphorus cycle




Cornel & Schaum (2009) *Water Sci & Technol* **59**, 1069-1076

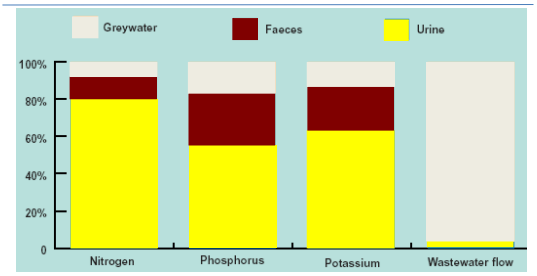


## Urine-Diversion: Sending P back to plants & pharmaceutical to soil

**Urine-diversion toilet**

**Waterless urinal**

## Why Divert Urine?




- Use as a plant fertilizer
  - Normal nitrogen application (80-100 kg/ha)
  - ≡ 10-40 tonnes of urine/ha is needed



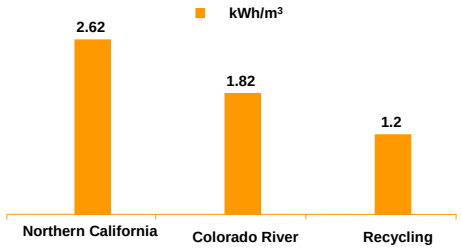
## 3. Water-Energy Nexus

- Domestic water and wastewater energy use for US cities consumes about 4-5% of the national electricity production
  - with some 1.5% used in wastewater treatment alone
  - > 10% of a US water utility's total operating cost is for energy
- Over 100-fold more waste & energy potential from intensive animal production facilities

Carlson & Walburger (2007) *Energy Index Development for Benchmarking Water and Wastewater Utilities*. Denver: American Water Works Association Research Foundation.



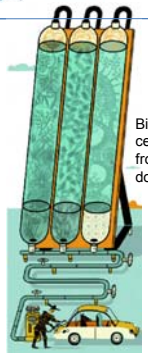
## Energy conservation & water recycling: Southern CA




Recycling Conserves Energy by reducing the need to import water



## Energy implications



Bio-refinery Microbial fuel cells for energy recovery from agricultural and domestic 'wastewaters'

Plug-in hybrid EVs would consume 3-times more water and require 17-times more water withdrawal than their gasoline counterparts if non-renewable energy used

*King & Webber (**2008**) Env.Sci.Technol. 42(12):4305*



## Likely Trends / Implications

- **Climate change**:
  - More intense storms, sewer overflows, outages & increased agricultural run-off
  - Aging population, more prone to respiratory diseases (Legionellosis etc.)
- **Need to reduce greenhouse gases**:
  - Move less water over longer distances/recycle, particularly reuse of greywater within facilities and increased use of drip irrigation
- **Renewable energy/recovery**:
  - Utilize energy within 'wastes' / energy recovery
  - Urban agriculture / recycle of local nutrients



## The Solution

- Use of specific process-oriented tools to aid in sustainability assessments, and
- Product-oriented decision support systems to aid in stakeholder involvement in the process

## Water Sustainability Framework


**Multi-Criteria Decision Aid (MCDA) using:**

- Human risk assess't
- Life Cycle Assessment
- Life Cycle Costing
- Reliability/ robustness
- Stakeholder participation

***http://www.urbanwater.org***

**Lundie *et al*. (2008) Sustainability Framework. WSAA Occasional Paper No.17. Water Services Association of Australia, Melbourne.**



## Conclusions

- Current irrigation & domestic water usage are generally unsustainable
  - Ecosystem services are being destroyed
  - Population growth & food production are currently causing significant detriment to health & amenity
- Global fossil phosphorus limit in 70-120 years
  - Hence the need to invest in systems to recycle
- Water availability is limiting energy production
  - Yet water pumping energy requirements could easily be met by energy recovery from wastewater/food residuals



## Acknowledgments

Drs. Sven Lundie, Greg Peters, Daniel Livingston, Eli Lai, Eric Kärrman, Jennie Blaikie, and John Anderson

*Disclaimer: This presentation does not necessarily reflect official U.S. EPA policy*

Questions?