WASTE WATER REUSE

OUTLINE

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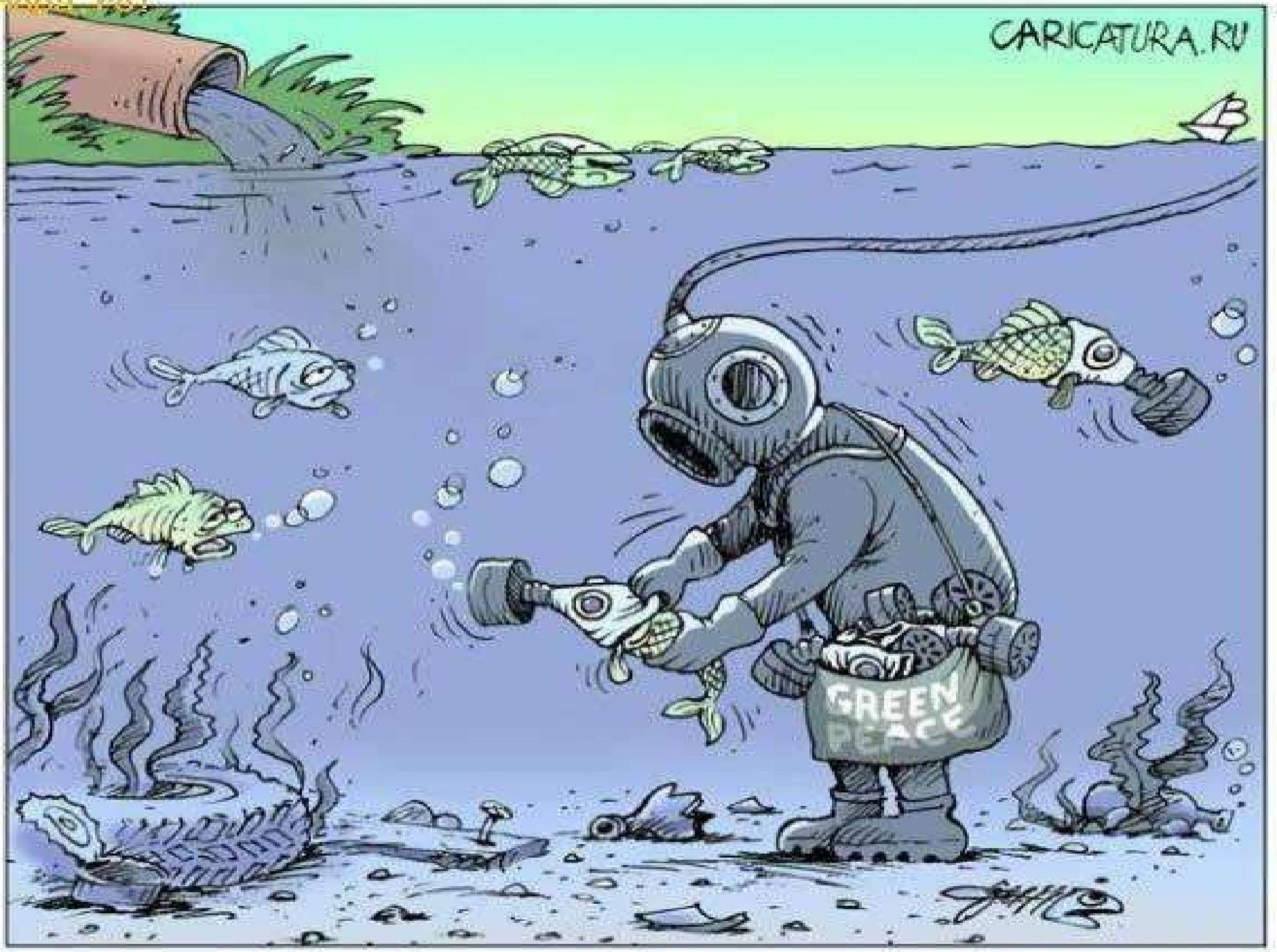
  - Need for Wastewater Reuse
- **Wastewater Reclamation Technologies**
- **Wastewater Reuse Applications**
  - Historical Examples
  - Agricultural and Landscape Irrigation
  - Industrial Reuse
  - Groundwater Recharge
  - Planned Indirect & Potable Water Reuse
- **Public Health and Environmental Considerations**
  - Constituents in Reclaimed Water
  - Public Health Issues
  - Environmental Health Issues
  - What level of treatment is necessary?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GREEN
PEACE

Need for Wastewater Reuse:
Mediterranean & Near East Countries examples

Country	Area (Km^2)	Total renewable fresh water (Km^3/year)	1990		2050[a]	
			Popln. (1000's)	Water availability (m^3/capita year)	Popln. (1000's)	Water availability (m^3/capita year)
Cyprus	9,250	0.90	702	1282	1006	895
Egypt	1,000,500	58.90	56312	1046	117398	502
Greece	132,000	69.00	10238	5763	8591	6868
Israel	20,700	2.15	4660	461	8927	241
Lebanon	10,360	4.98	2555	1949	5189	960
Spain	504,800	111.00	39272	2826	31765	3494
Syria	185,000	25.79	12348	2089	47212	546
Turkey	780,000	203.00	56098	3619	106284	1910

[a] UN medium projection for population

Need for Wastewater Reuse:
Mediterranean Basin & Near East Countries

- Agricultural Production
  - Irrigation: the largest water user (~70-80% of total)
  - 50% of food requirements are imported
  - 30% of cultivated area is irrigated
    - But it accounts for 75% of total agricultural production

- Capacity to Sustain Domestic Food Production
  - 750 m^3 / inhabitant year necessary
  - 1990: 5 countries (Algeria, Israel, Jordan, *Malta*, Tunisia)
  - 2050: 4 more countries (Egypt, Libya, Morocco, Syria)

- Water Availability
  - Temporal and Spatial Asymmetries
  - "Misguided" agricultural practices

Wastewater Reclamation Technologies

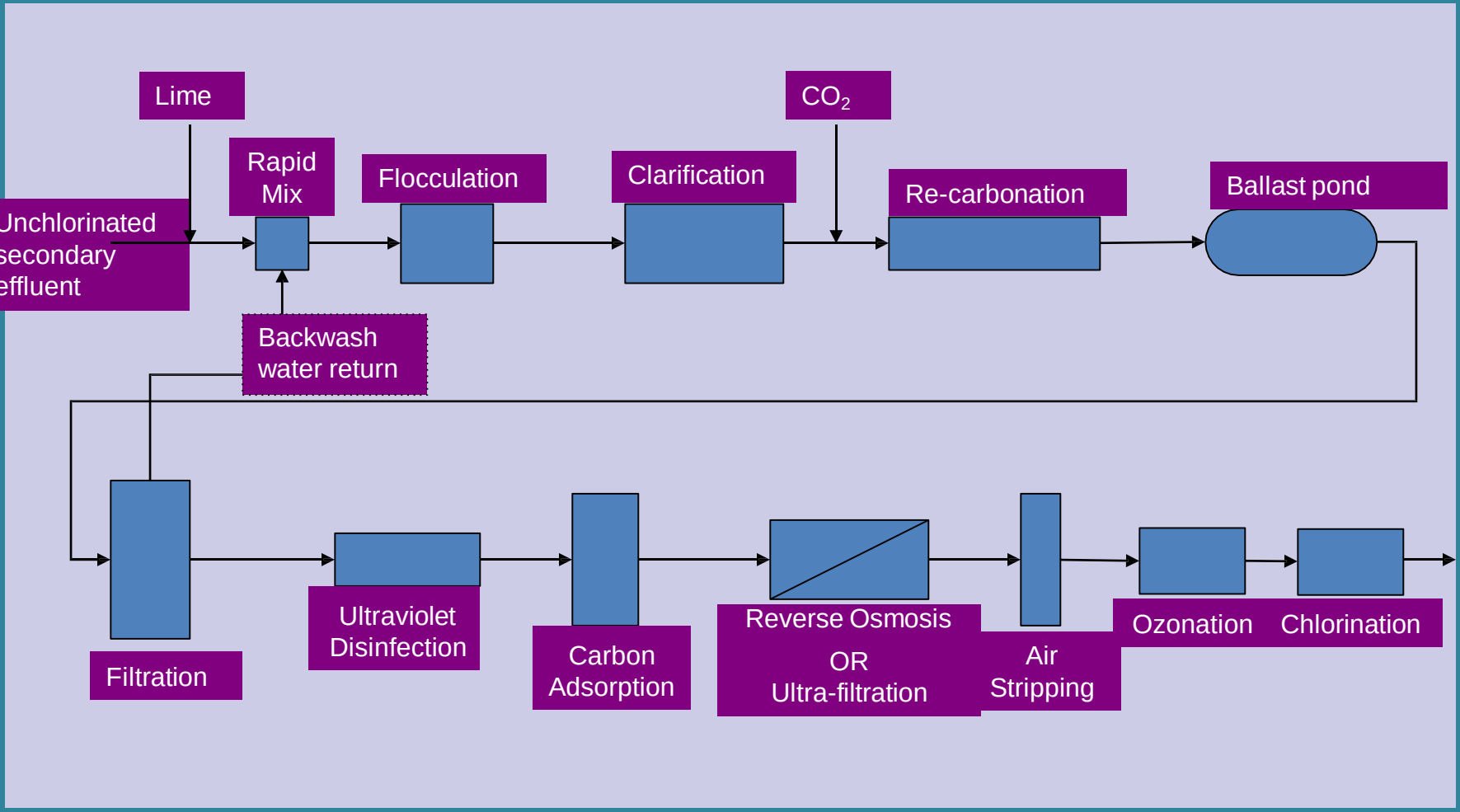
Conventional Methods

- Activated sludge (AS)
  - Aerobic
  - Anaerobic
- Filtration
- Biological nutrient removal (BNR)
- Combinations of the above unit processes

Wastewater Reclamation Technologies

Advanced Treatment Methods

(**Example**: Denver, Colorado, USA; 1 MGD plant, direct injection)



Wastewater Reclamation Technologies

Advanced Treatment Example

- El-Paso, Texas, USA
  - Use: Direct Injection of reclaimed municipal wastewater
  - Capacity: 38,000 m^3/day
  - Unit processes:
    - Primary treatment → Activated Sludge process with BNR → Lime clarification → Re-carbonation → granular medium filtration → activated-carbon adsorption → demineralization by reverse osmosis → chlorination

Wastewater Reclamation Technologies

Sustainability Issues

- Sustainability of treatment method
  - WW reclamation and reuse; a sustainable practice
  - Are the treatment technologies sustainable?
  - Natural Treatment Systems
    - Constructed Wetlands
    - Duckweed Ponds
- How much treatment is enough?
  - What is the source of wastewater?
    - Greywater vs. Blackwater
  - Who is the end user?
    - Agriculture
    - Industry
    - Communities

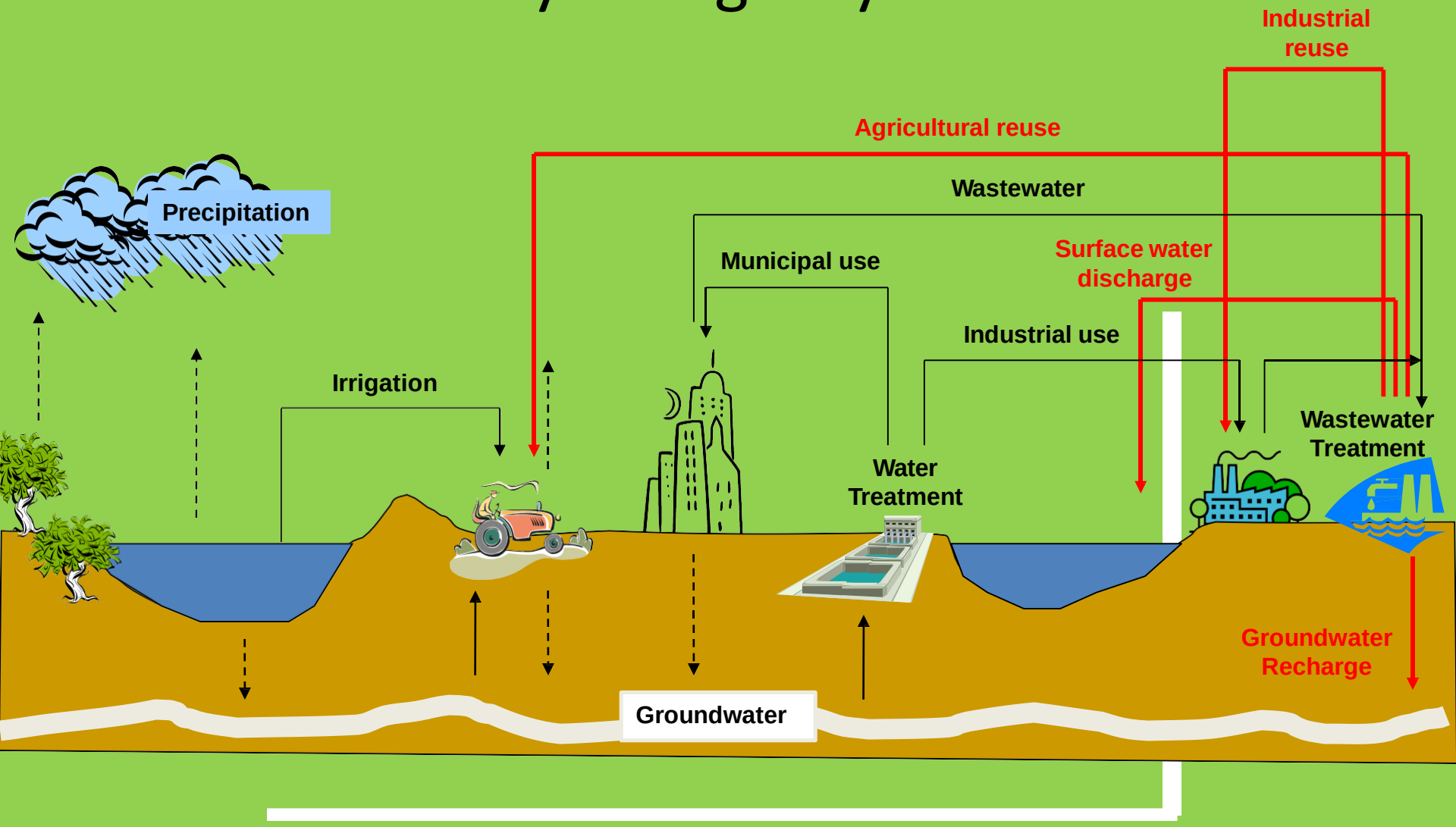
Historical Examples

- 3000 BC – Crete (Minoan culture)
  - Collection of rainwater and sand “filtration” for reuse
- 1890 – Mexico
  - Agricultural irrigation
- 1912 – Europe & US
  - Landscape irrigation
- 1926 – US & Europe
  - Industrial uses: cooling processes & boilers
- 1960 – US; Europe; Africa; Australia
  - Landscape Irrigation (including golf-courses)
  - Groundwater Recharge
  - Advanced WW reclamation for potable water supply augmentation
- 1980 – US; Europe; Japan
  - Water recycling for toilet flushing in urban areas
  - Agricultural irrigation of food crops eaten uncooked

Uses of Reclaimed Water

- **Agricultural Irrigation**
- **Landscape Irrigation**
- **Industrial Recycling and Reuse**
- **Groundwater Recharge**
- **Recreational / Environmental Uses**
- **Non-Potable Urban Uses**
- **Potable Reuse**

Wastewater Reclamation & Reuse and the Hydrologic Cycle



Agricultural Irrigation

- Why reuse wastewater in agricultural irrigation?
  - Freshwater resources can be reserved for other uses
  - Chemical fertilizer usage can be minimized
  - Discharge of reclaimed wastewater to water bodies can be prevented
- Agro-irrigation = Largest Current User of Reclaimed Water
- Main uses (in order of “preference”)
  - Non-food crops
    - Commercial nurseries; Timber
    - Animal Fodder
  - Food Crops
    - Fruit-tree Orchards
    - Cereals
    - Vegetables
- ALSO: Consider the Type of irrigation system

Agricultural Irrigation

Yorkshire - England

Potato irrigation from maturation pond

Agricultural Irrigation

Saudi Arabian Desert

Agricultural Irrigation

Negev Desert - Israel

Agricultural Irrigation & Reclaimed Wastewater:
Mezquital, Mexico

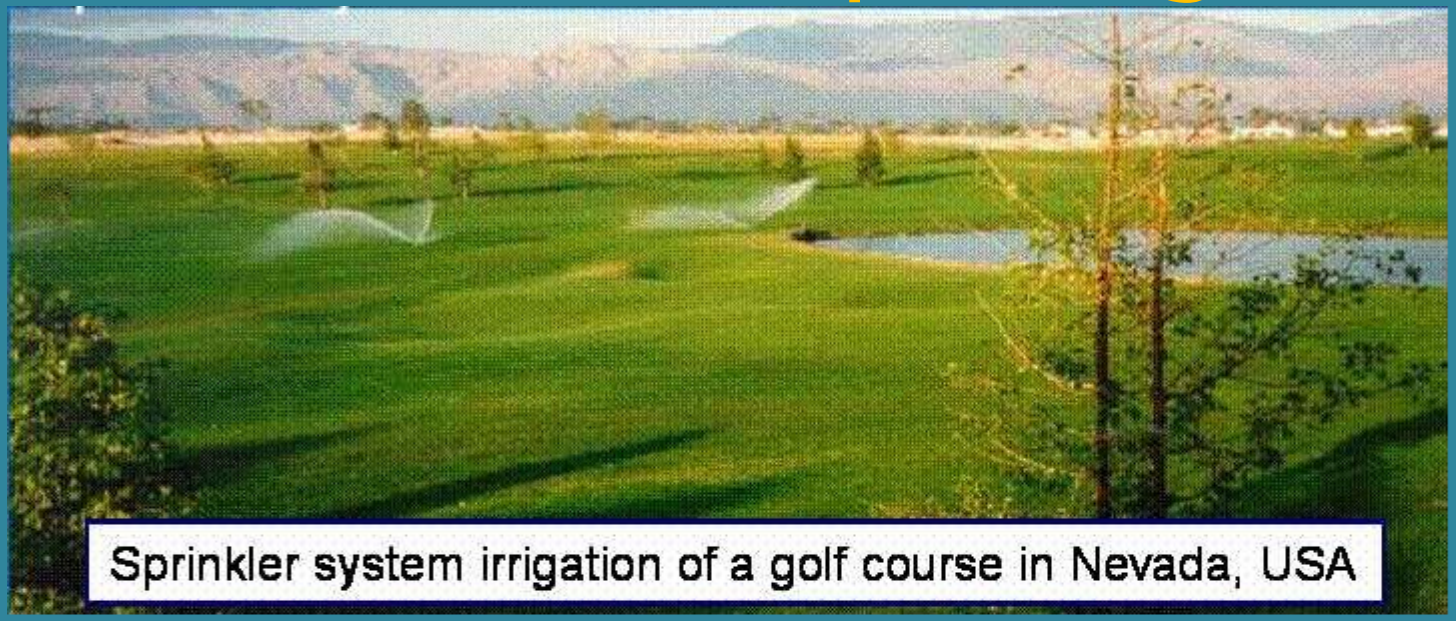
Crop	Yield in tons/ha		Increase (%)
	Wastewater	Fresh water	
Maize corn	5.0	2.0	150
Barley	4.0	2.0	100
Tomato	35.0	18.0	94
Alfalfa	120.0	70.0	71
Wheat	3.0	1.8	67

Landscape Irrigation & Recreational / Environmental Uses

- Landscape Irrigation
  - Parks
  - School yards
  - Highway medians
  - Golf courses
  - Cemeteries
  - Residential

- Recreational / Environmental Uses
  - Lakes & ponds
  - Marsh enhancement
  - Fisheries

Landscape Irrigation



Sprinkler system irrigation of a golf course in Nevada, USA

Drip system irrigation of a football field (USA)

Fisheries
Kolkata - India

All the city's wastewater (550,000m3/day) is used to fertilize 3000 ha of fishponds, producing some 13,000 tons of fish per year.

Examples from India

- Thermax India, Pune has developed the waste water treatment process in their Cinchwad plant that can make the industrial waste water potable
- GMR IT park at Chennai has system that utilizes the waste water from sinks to flush the toilets

Industrial Reuse & Urban Uses

- **Industrial Recycling and Reuse**
  - Cooling water
  - Boiler feed
  - Process water
  - Heavy construction
- **Non-Potable Urban Uses**
  - Fire protection
  - Air conditioning
  - Toilet flushing
- **Potable Reuse**
  - Blending in water supply reservoirs (Namibia example)
  - Pipe-to-pipe water supply

Groundwater Recharge

- Groundwater replenishment
  - The following must be considered:
    - the quality of the recharge water;
    - the recharge method used;
    - the physical characteristics of the aquifer layers;
    - the water residence time;
    - the amount of blending with other sources;
- Saltwater intrusion control
- Subsidence control

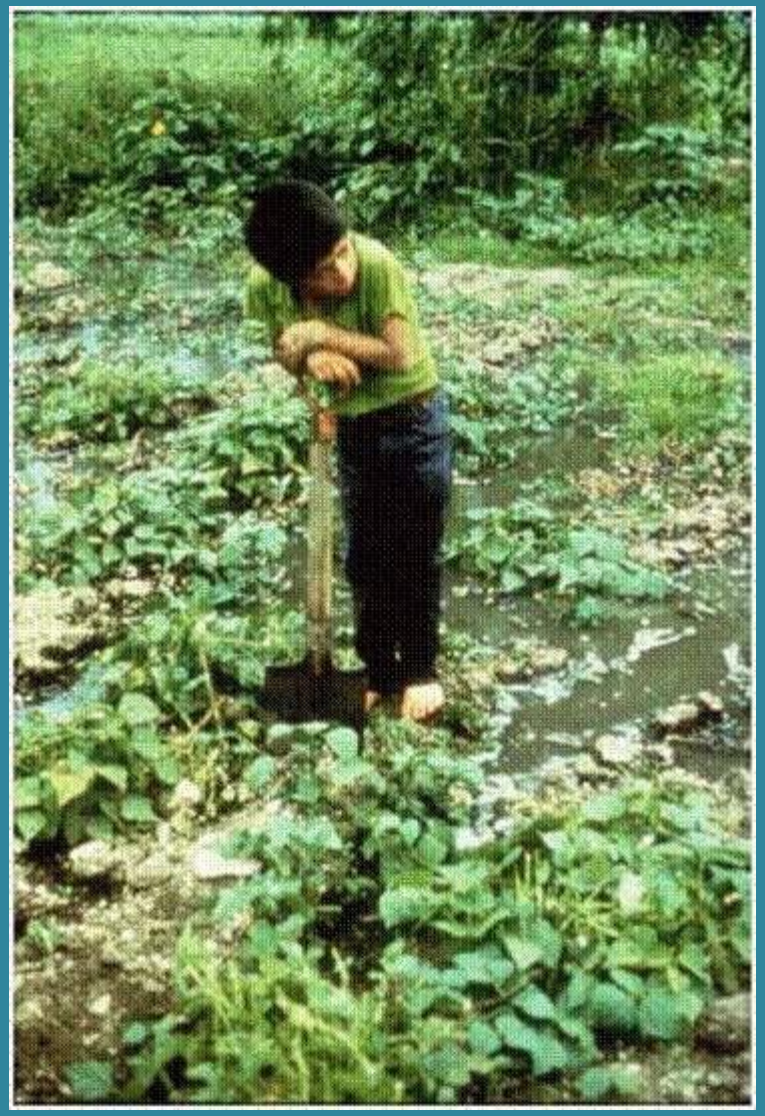
Constituents in Reclaimed Water

- **Conventional** *(measured in mg/L; used in designing conventional WWTPs)*
  - TSS
  - BOD; COD
  - TOC
  - Nitrogen (Ammonia; Nitrate; Nitrite)
  - Phosphorus
  - Microorganisms: Bacteria; Viruses ; Protozoan cysts & oocysts
- **Non-conventional** *(to be removed or reduced by advanced treatment processes)*
  - Refractory organics
  - Surfactants
  - Metals
  - TDS
- **Emerging** *(measured in µg/L; long-term health concerns possible; not easy to remove)*
  - Pharmaceuticals
  - Antibiotics (veterinary & human)
  - Home-care, industrial, and household products
  - Hormones (steroids) and Endocrine Disrupters

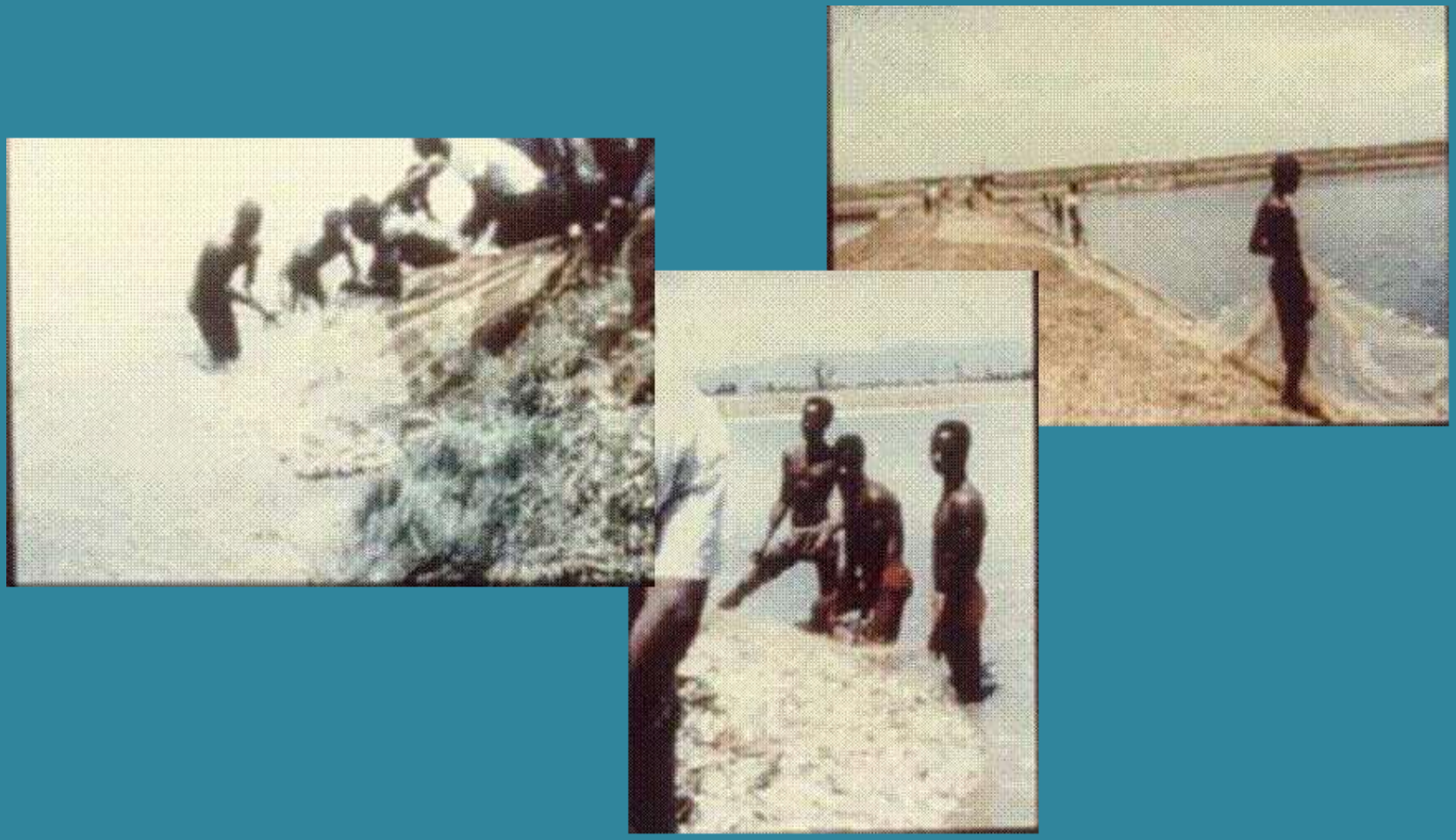
Public Health Issues:
Agricultural Irrigation: Mexico

- **All of Mexico City's, which is the largest city in the world, wastewater is used for irrigation.**

- **The boy on the right is standing barefoot in a field of wastewater-irrigated crops. He's at risk of hookworm infection (among other pathogenic organism infection).**
  - Lack of monitoring of irrigation methods and safety precautions is a big problem.



Public Health & Environmental Issues:
Fisheries: Kisumu, Kenya



Public Health & Environmental Issues:
Agricultural Irrigation: North Carolina, USA

Public Health & Environmental Issues:
Agricultural Irrigation: North Carolina, USA

- Eutrophication
  - Increased nutrients in surface waters
  - *Pfiesteria piscicida* outbreak
- Groundwater contamination
  - Nitrate contamination on private drinking wells
- Biological Aerosols
  - Gastrointestinal problems in nearby communities
- Antibiotics
  - lower effectiveness of antibiotics if irrigation of fodder is involved
- Odor
  - Public health of neighboring communities
  - Aesthetic concern - Reduced land values
- Marketability of crops
  - Public acceptance

Environmental Health Issues:
Agricultural Irrigation

- The most relevant reclaimed water qualities for irrigation are
  - Salinity
    - Increased osmotic pressure on plants
  - Specific Ion Toxicity
    - Worse in hot and arid regions (due to high evapotranspiration)
  - Nutrients
    - Reclaimed wastewater must be applied according to agronomic scales (i.e. in the EU: Directive 91/676/EEC : “230 kg nitrogen / ha year on agricultural land cropped by grass, grass catch crops or beets and other crops being under-sown by grass with low nitrate leaching potential”)

CONCLUSION

- **Wastewater reclamation and reuse is imperative for future.**
- **If wastewater reuse is exercised properly (treatment, end user, safety measures, education), and if public misapprehension is expelled, the benefits that can be reaped are great and will far outweigh any associated costs.**
- **However, if this important water resource is improperly managed, then the risks to both the public health and to the environment can be enormous.**

THANK YOU