Virus Reduction Credits for Viruses.

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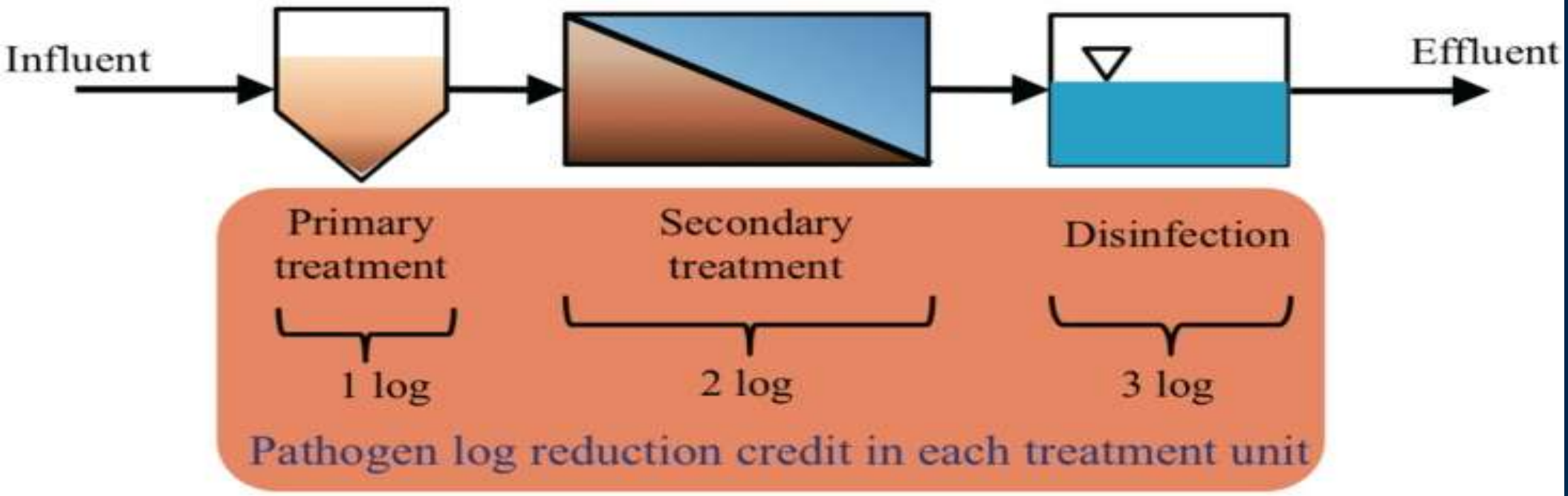
WATER & ENERGY SUSTAINABLE TECHNOLOGY

Direct Potable Reuse
Controlling Risk from Pathogens

- California 12/10/10 Rule by treatment
  - 12 log removal of virus
  - 10 log removal of *Giardia*
  - 10 log removal of *Cryptosporidium*
- Goal is not more than 1 infection in 10,000 person per year (USEPA guidance for drinking water)
- Each step in the treatment is given a log removal value up to 6 log maximum for each process in atreatment trian

Multiple-barrier system

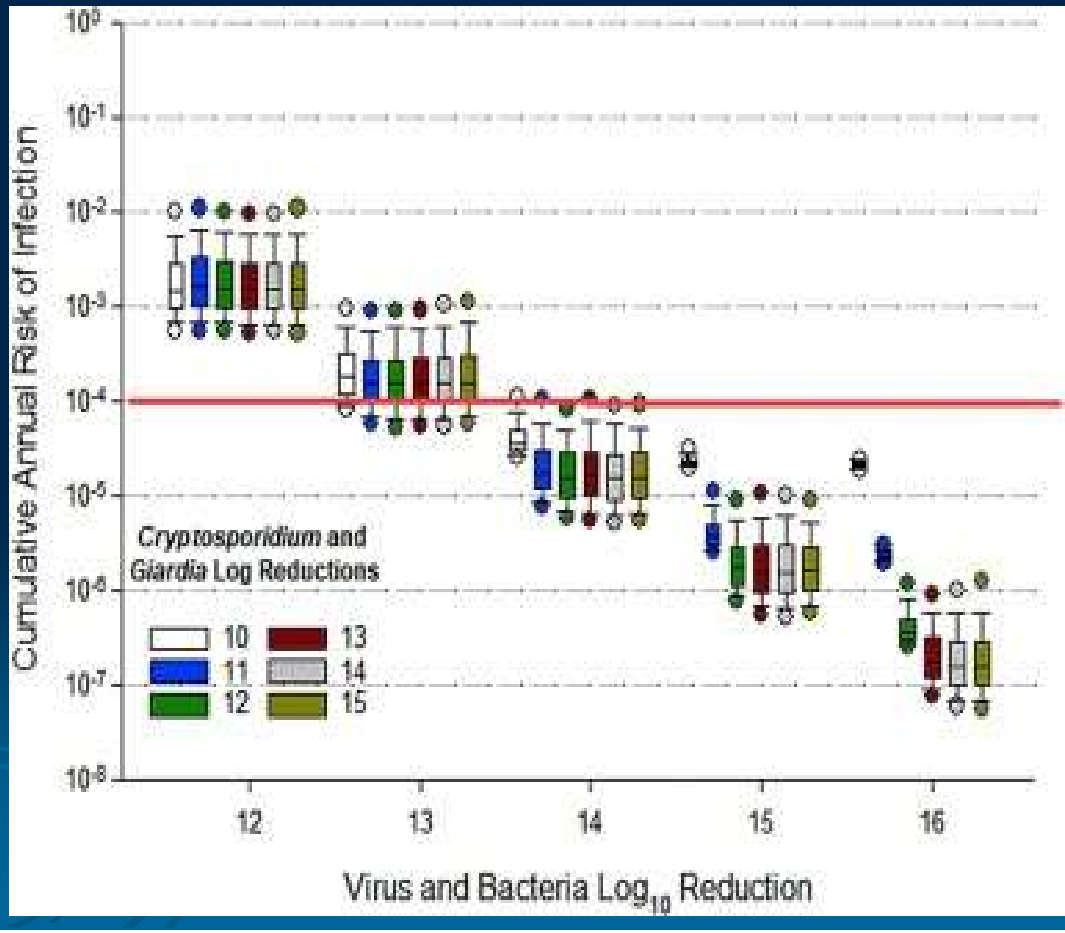


Pathogen log reduction in the system = 6 log

Performance target of pathogen log reduction with respect to the purpose of effluent usage

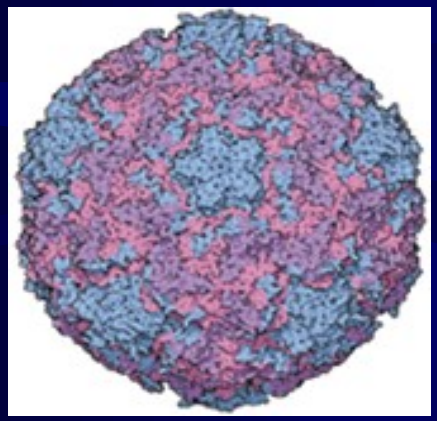
Greater Log removal of pathogens if you consider treatment variability (Sollor et al 2017)

- Cumulative annual risks are driven by days with highest wastewater pathogen loads
- Viruses need more than 14 logs reduction to achieve benchmark of 1/10,000 annual risk of infection



Types of Water borne/based Pathogens

Viruses

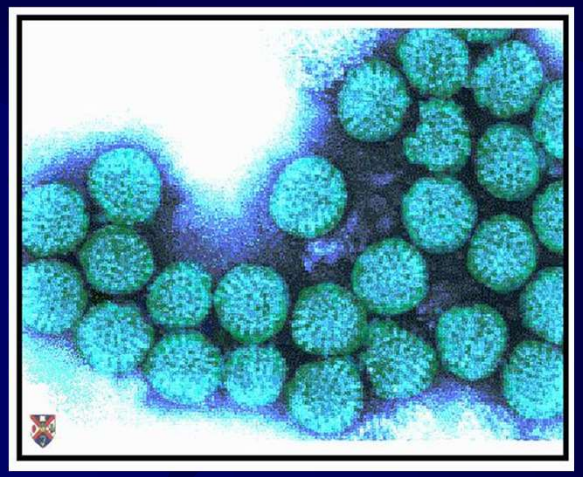


Bacteria

Parasites

Illnesses Associated with waterborne viruses

- Diarrhea
- Hepatitis A and E
- Fever and rash
- Meningitis
- Hand, foot and mouth disease
- Myocarditis
- Paralysis
- Mental disorders



Factors which influence the concentration of viruses in wastewater

- Incidence of infection within a community
- Social economic status of the community
- Season
- Per capita water use
- Time of day
- Age of distribution with in community
- Chronic infections
- Epidemics/pandemics

Issues with viruses?

- Orders of multitude more sensitive detection than chemical methods.
- One part per billion trillion (10^{-21}). Can detect one virus in 1,000 liters
- Laboratory and pilot scale data not reflective of full-scale plants on virus removal
  - Viral Biodiversity
    - Viruses are individuals- no two of even the same type virus are the same
    - the larger the numbers the greater the diversity
    - Small differences in chemical make-up make a big difference in removal
    - Currently estimated to be from 200,000 to >500,000 viruses yet to be discovered
  - Viral Evolution/Natural Selection
    - Treatment processes can select for more resistant viruses
  - Modeling beyond the data set
    - Removal for viruses is not linear because of viral biodiversity and physical state differences

Factors Creating Uncertainty in estimating virus Removal by Treatment

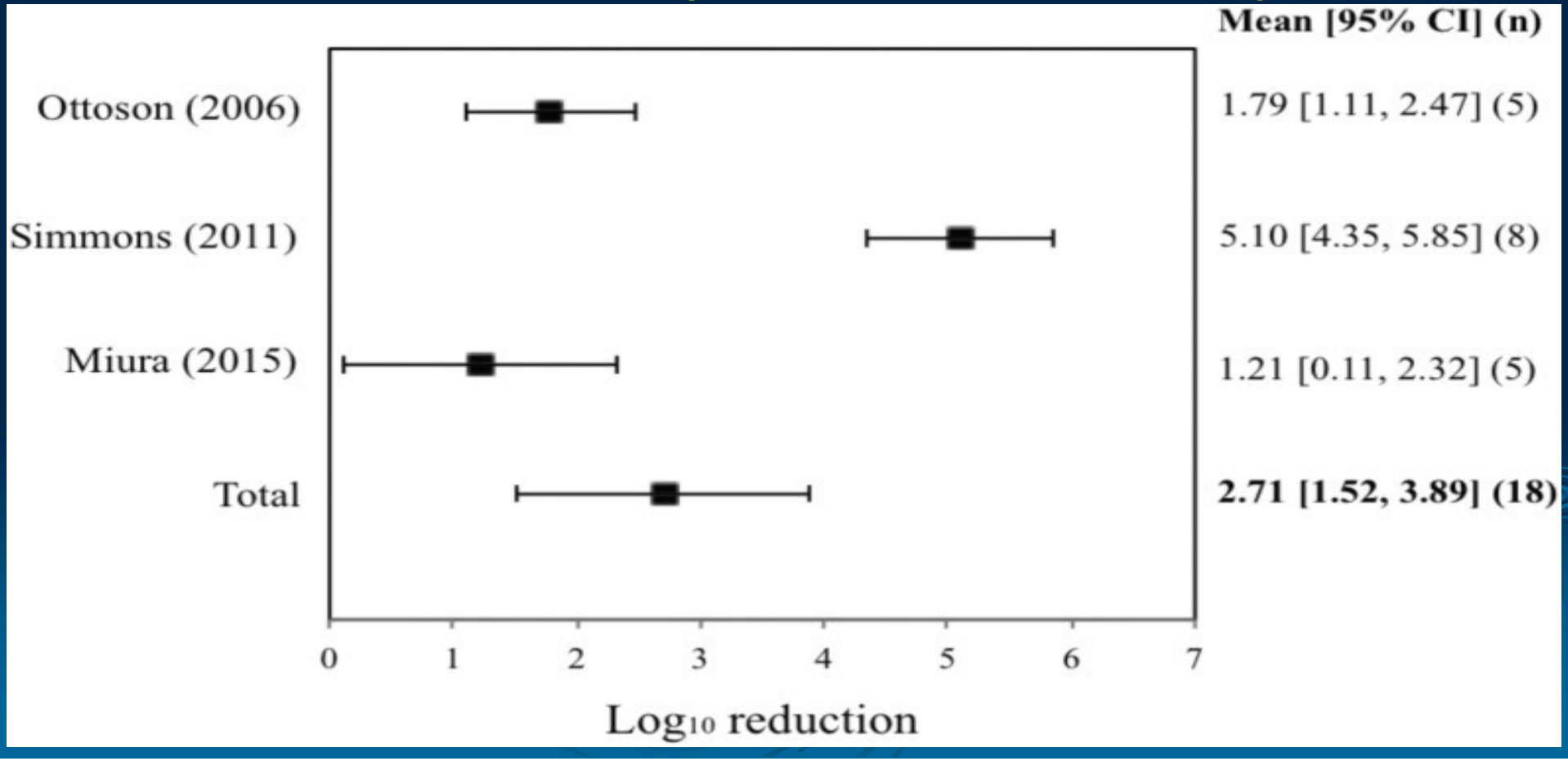
Factor	Uncertainty	Remarks
Disinfection	Large in application	Efficacy varies greatly dependent of the type and stain of virus and physical state (aggregates, association with particulate matter). Laboratory data may not reflect resistance of wild type strains.
Physical removal by membrane processes	0.1 log to 6.0 removal	Size, shape, hydrophobicity of the virus and membrane may affect removal; field scale operation conditions
Virus Concentration	Orders of magnitude	Varies greatly depending on the incidence of infection within a community

Average Virus Removal (log copies/L) by Convectional Wastewater treatment (qPCR)

Influent to Final Effluent (Log Reduction Values) – 12 month study – composite samples

Treatment Plant	PMMoV	Aichi	GII Noro	Entero	Adeno	JC Polyoma	BK Polyoma
1	0.7	0.9	1.4	**2.0**	0.6	2.5	1.2
2	0.8	0.8	1.7	**2.0**	1.0	2.2	1.0
3	0.8	1.0	1.7	**2.6**	1.7	1.7	1.9

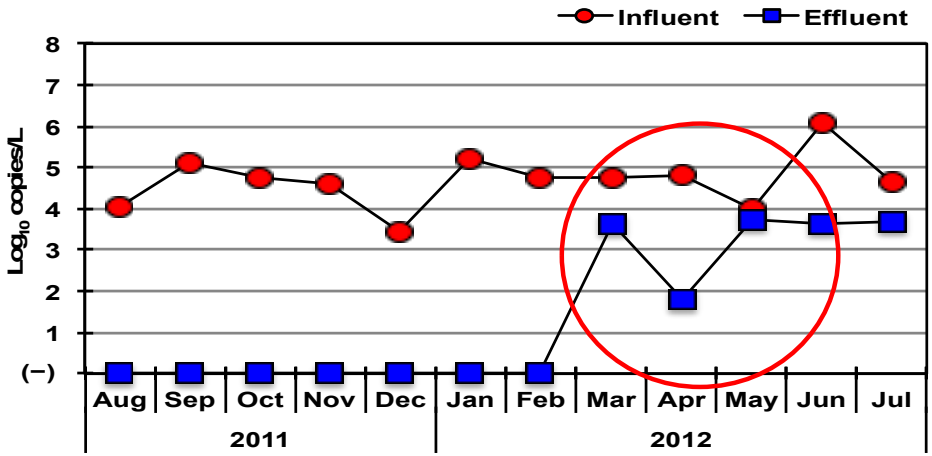
Removal of Enteroviruses by Membrane Bioreactors (Sano et al 2016)



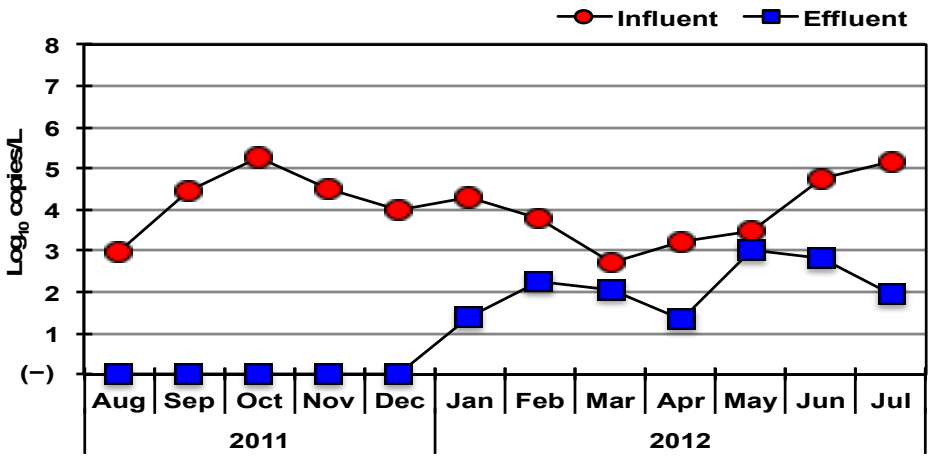
GI Norovirus Removal by Wastewater Treatment

- . Over time- varies over time - why? - new strain?

WWTP-A



WWTP-B



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To better understand the enteric virus levels in wastewater and removal by treatment processes we recommend:

- the concentration efficiency of every sample for enteric viruses be documented by use of a model virus
- collection of samples at peak flows (Composite sampling better?) into the wastewater treatment facilities
- peak values of viruses should be considered rather than average values
- more virus groups need to be quantified using better methods of virus quantification
- Data on application of Ct at full scale plants

New USEPA Sponsored Study on Virus Removal

- A Viral Pathogen and Surrogate Approaches For Assessing Treatment Performance in Water Reuse
- Several groups funded 2021-2024 including the WEST Center
- To assess virus removal to validate Log Reduction Values for viruses for water reuse treatment processes