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Environmental Finance Center
Syracuse University

Great Lakes Environmental Infrastructure Center
Environmental Finance Center for EPA Region 5

Onsite Wastewater Processes

August 22, 2024 | 1pm – 2pm EST

www.efcnetwork.org

This program is made possible under a cooperative agreement with US EPA.

Zoom Logistics

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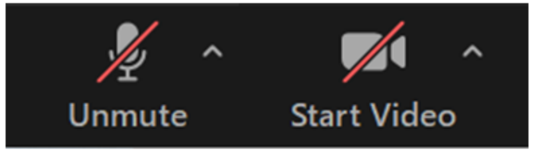

Asking a Question

Type questions into the chat box any time throughout the session

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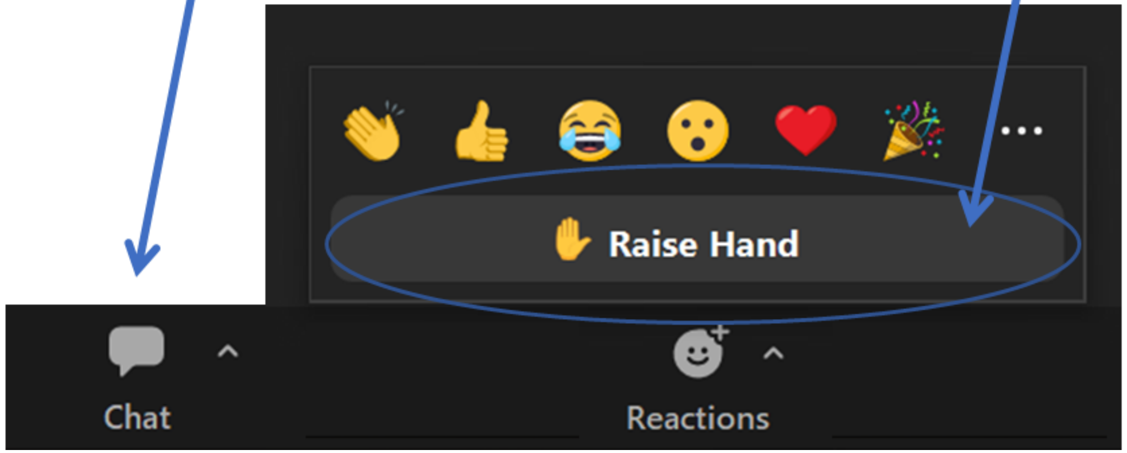

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Certificate of Completion

This session has **NOT** been submitted for pre-approval of Continuing Education Credits, but eligible attendees will receive a certificate of attendance for their personal record.

To receive a certificate:

- You must attend the entire session
- You must register and attend using your real name and unique email address - group viewing credit will not be acceptable
- You must participate in polls
- Certificates will be sent via email within 30 days

If you have questions or need assistance, please contact smallsystems@syr.edu.

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About Us

The **Environmental Finance Center Network (EFCN)** is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and water infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

What we will cover

Wastewater treatment processes that occur in onsite systems

- microbiological, chemical, and physical processes
- comparison to similar processes used in conventional systems

Relationships between O&M and onsite processes

- treatment goals and trouble-shooting
- design variations of systems

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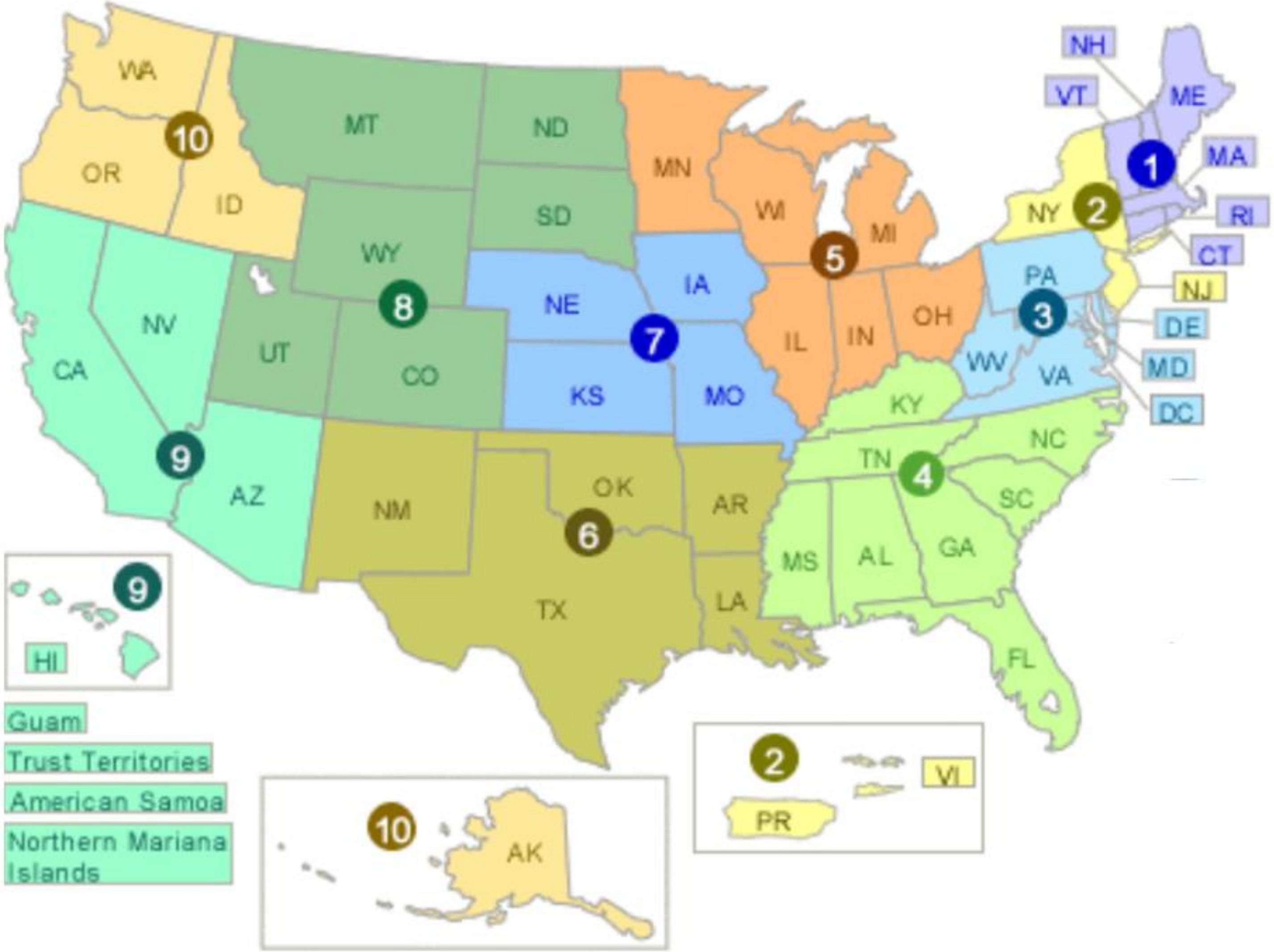
Environmental Finance Center for EPA Region 5

Serves small communities (population of less than 10,000) throughout EPA Region 5: Indiana, Illinois, Michigan, Minnesota, Ohio, Wisconsin, and 35 federally recognized American Indian governments.

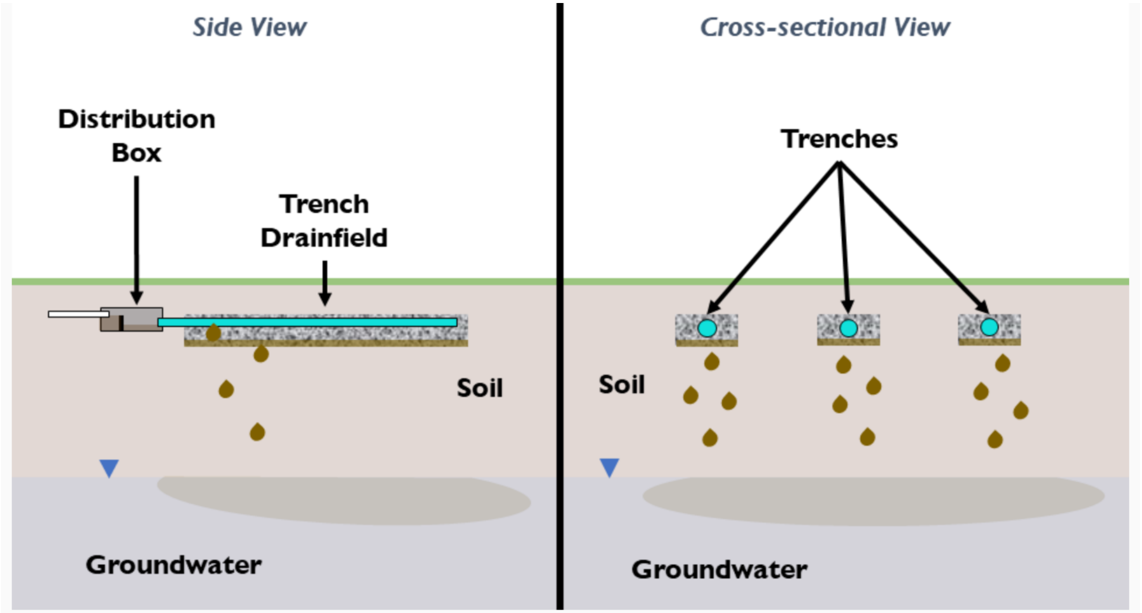
Training, Research, and Technical Assistance to increase technical, managerial, and financial capacity (TMF) of utilities. Focus areas: Asset management, infrastructure funding, & financial management.

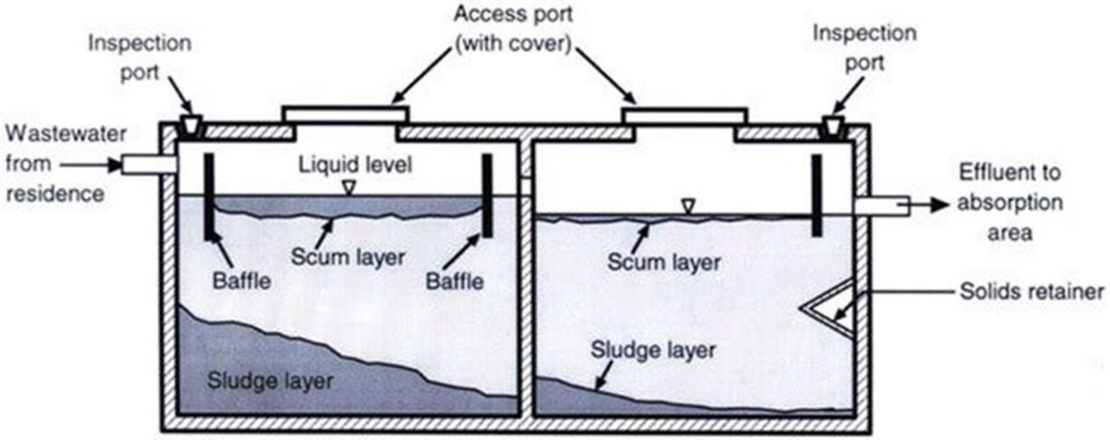
Greg Pearson, MBA Water & Wastewater Systems Trainer

Nationwide reach of EFC Network

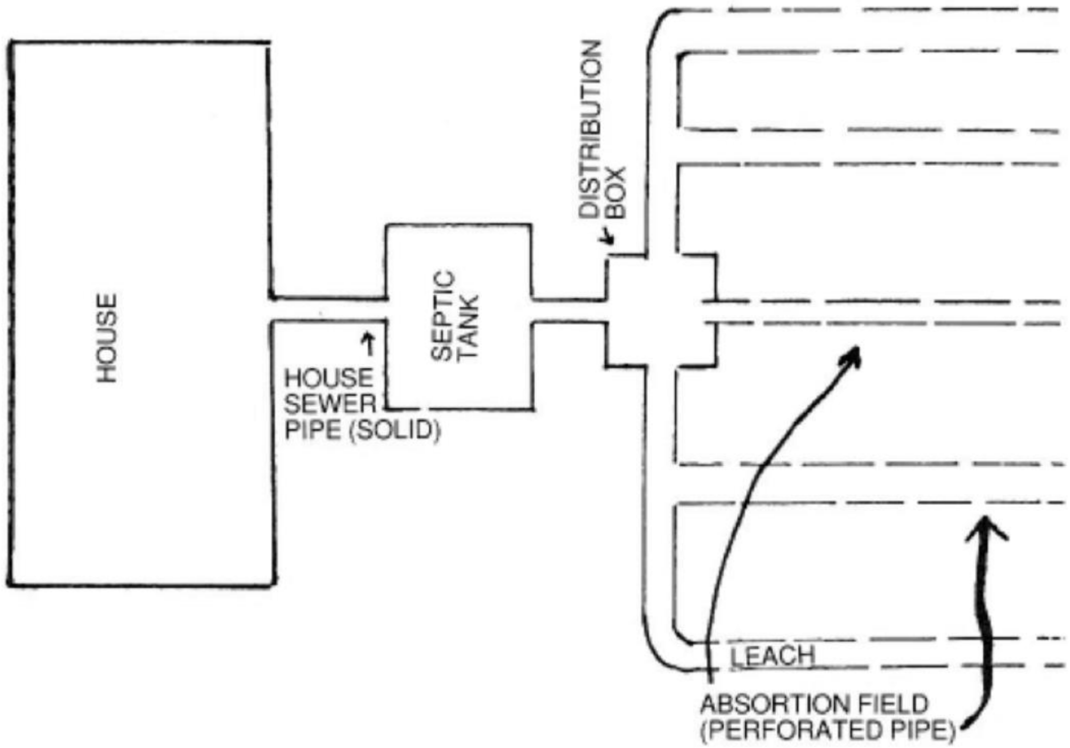


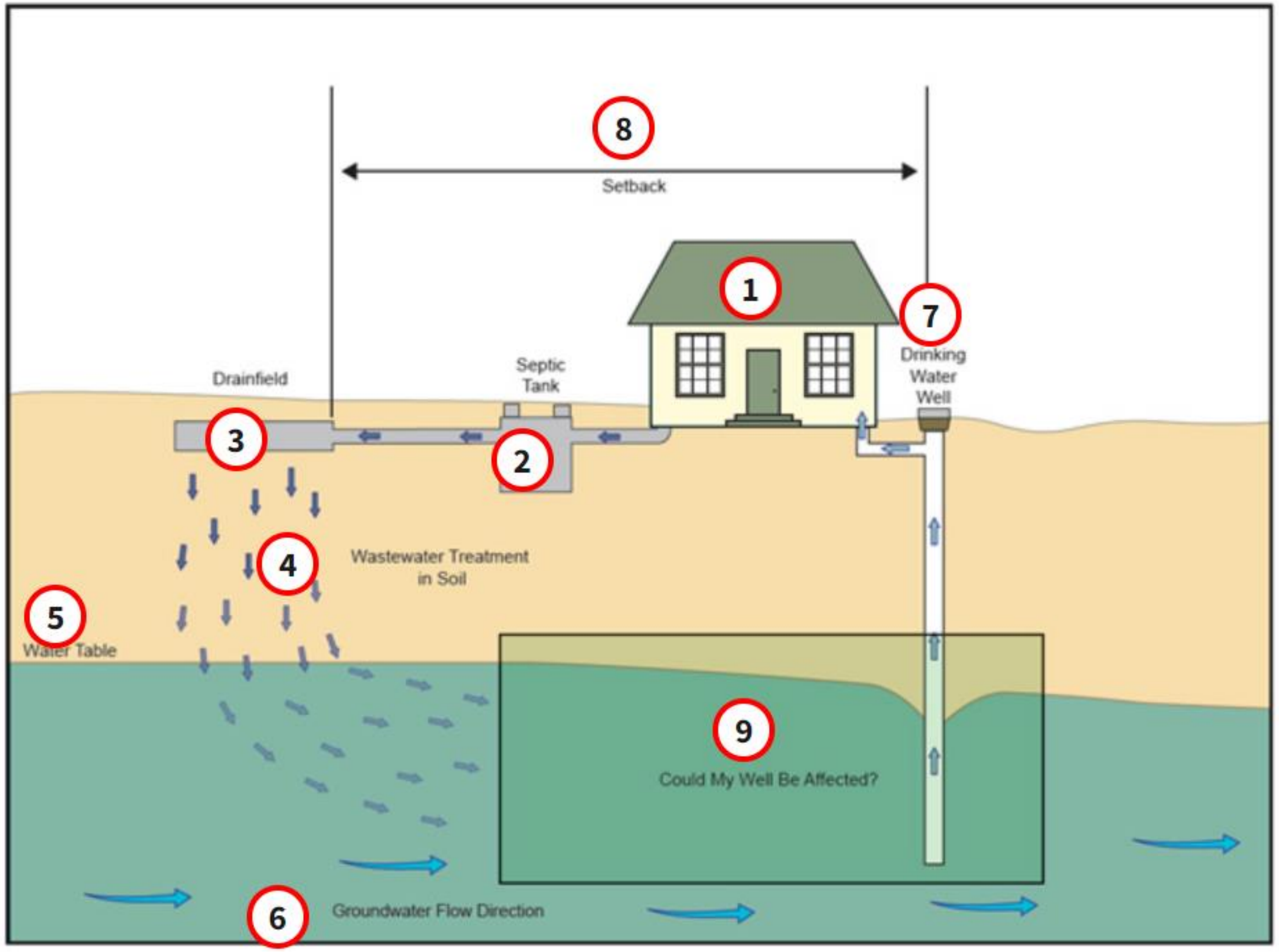
Poll #1



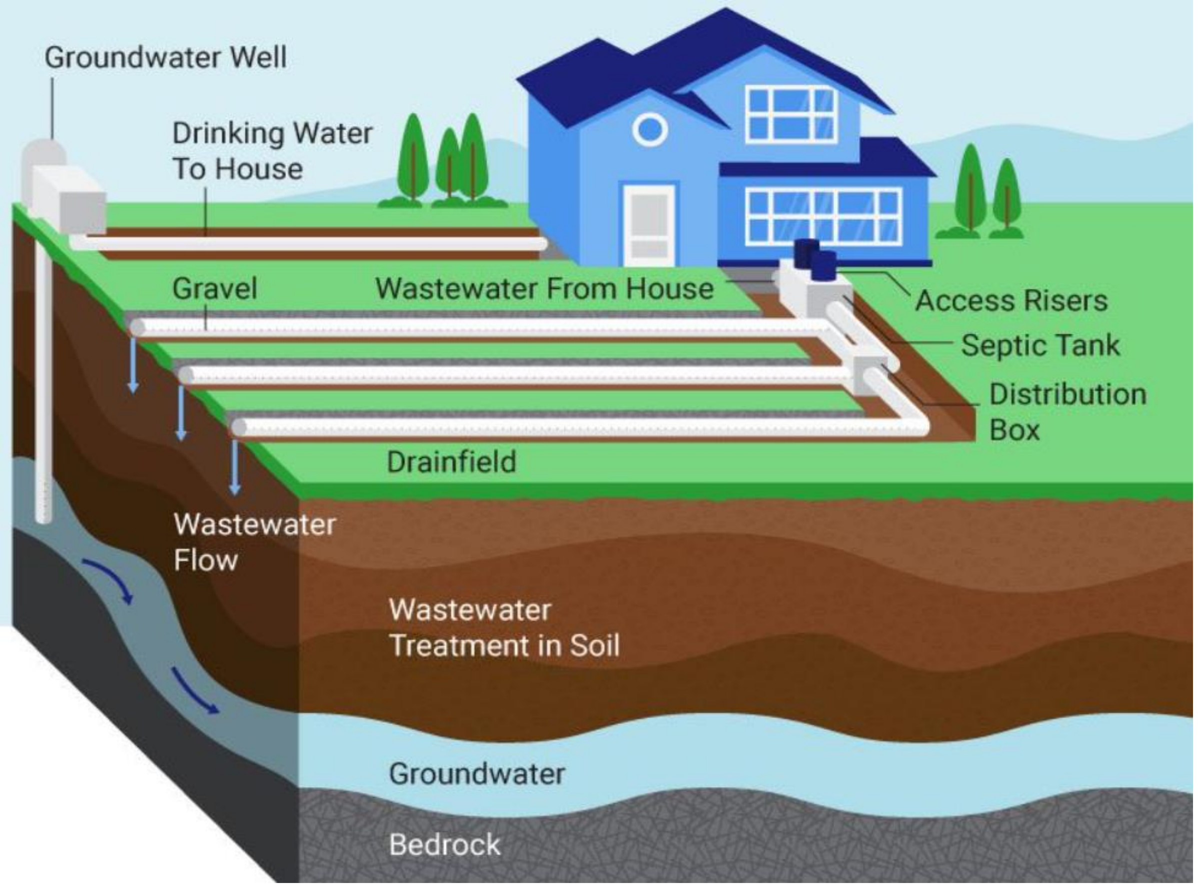


Septic System Plan

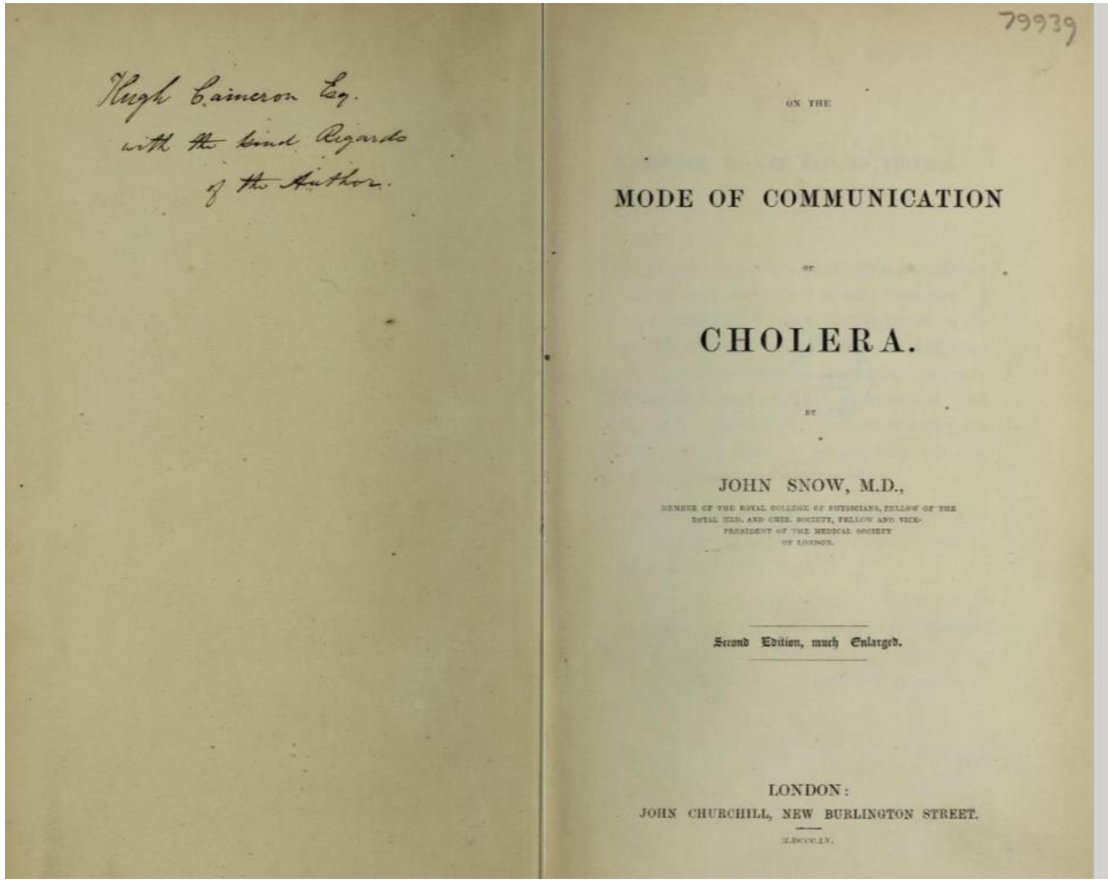




CDC found that out of 172 cases of groundwater contamination with a known source, 67% were due to either a failing septic or improperly designed well.



John Snow and the 1854 Cholera outbreak



Hugh Cameron Esq.
with the kind Regards
of the Author.

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ON THE

MODE OF COMMUNICATION

OF

CHOLERA.

BY

JOHN SNOW, M.D.,

Second Edition, much Enlarged.

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JOHN CHURCHILL, NEW BURLINGTON STREET.

GREAT MARLBOROUGH STREET
WORK HOUSE
PUMP
PUMP
PUMP
PORTLAND MEWS
BREWERY
PETER STREET
GREAT PULTENEY STREET

Treatment goals

Onsite wastewater treatment

- Anaerobic process to reduce solids in septic tank
- Aerobic and anaerobic microorganism consume effluent BOD in microbial mat.
- Other processes at work in microbial mat are filtration and adsorption

Conventional wastewater treatment

Aerobic treatment process to consume BOD which results in a biomass

- Remove BOD, TSS and nutrients from wastewater
- Final effluent is disinfected
- Must meet permit requirements before discharging to receiving water

Treatment effectiveness of onsite WW

Water Quality Parameter	% Removal In A Septic Tank	% Removal In A Leach Field
BOD (Biochemical Oxygen Demand)	15% to 50%	75% to 90%
TSS (Total Suspended Solids)	25% to 45%	75% to 90%
Settleable Solids	> 90%	75% to 90%
Enteric Bacteria	10% to 40%	80% to 90%
Enteroviruses	No Significant Reductions	generally high but variable
Protozoa	No Significant Reductions	generally high but variable

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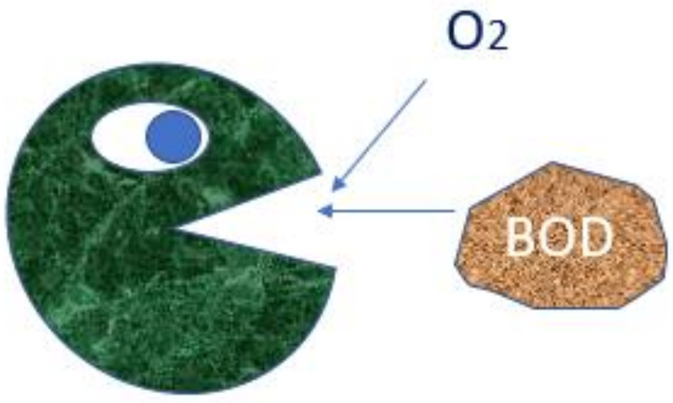
Biochemical Oxygen Demand (BOD)

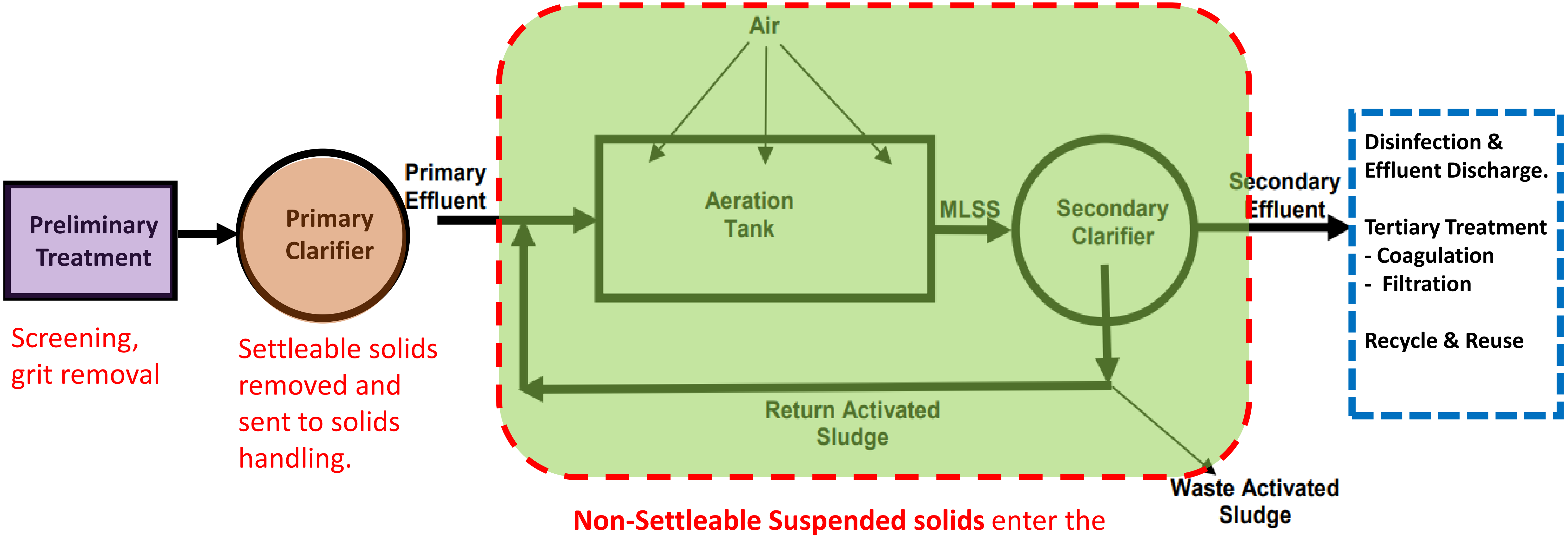
- Indicates the strength of the waste stream in mg/L. BOD is the food that microorganisms consume during the wastewater treatment process.

- Determined in a 5-day test that measures how much oxygen is required by bacteria in order to metabolize wastes.



Microorganisms require oxygen to metabolize waste.

The activated sludge process



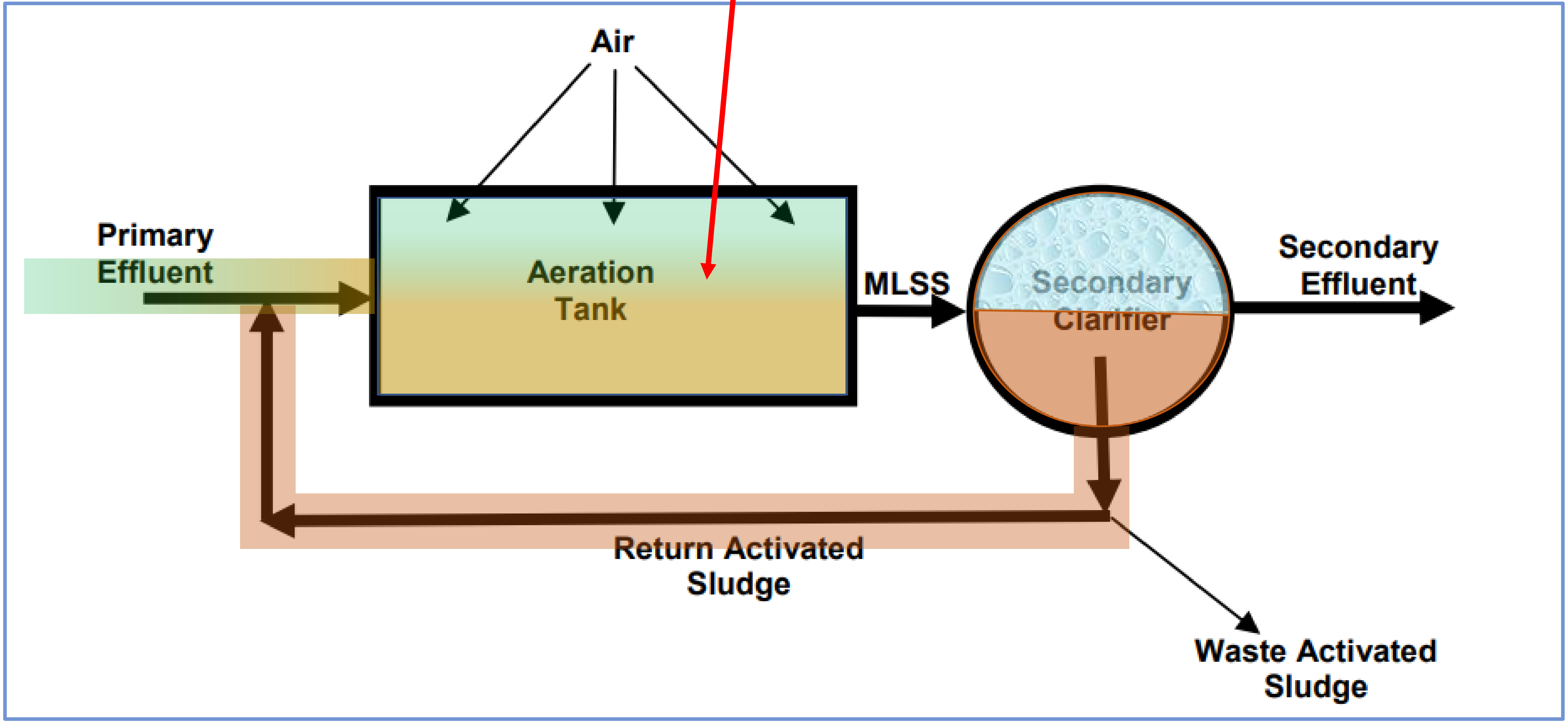
Screening, grit removal

Settleable solids removed and sent to solids handling.

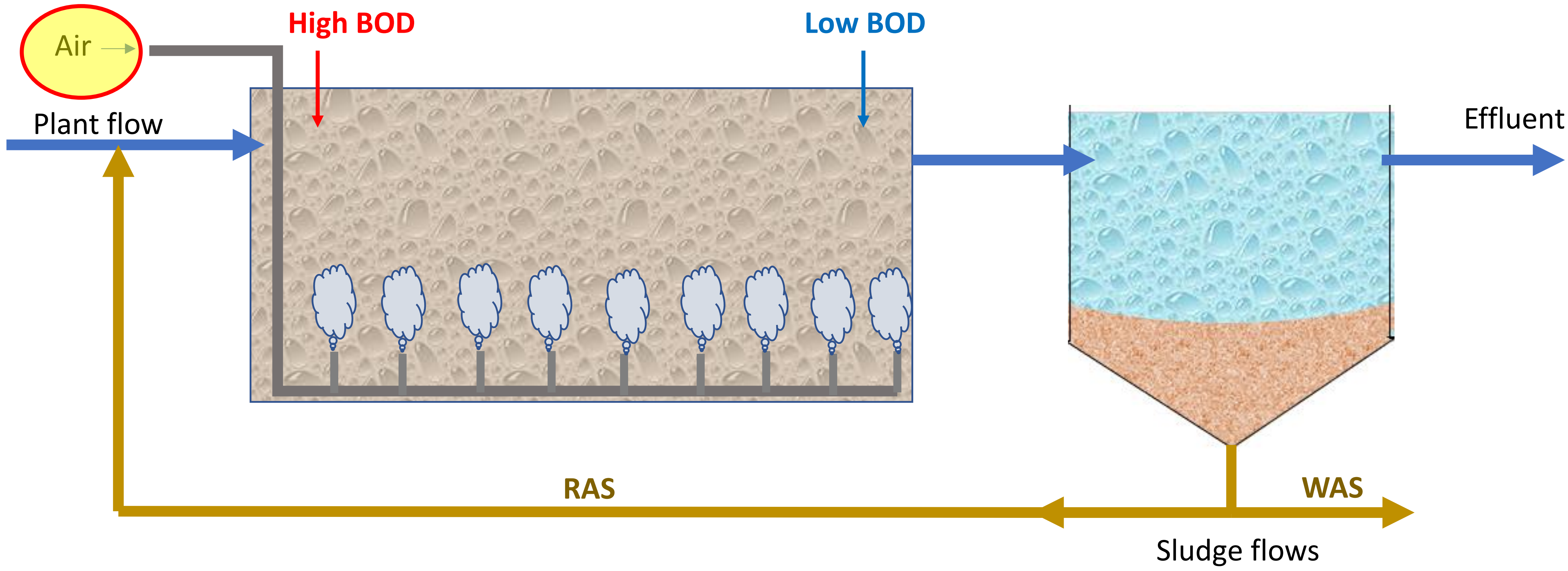
Non-Settleable Suspended solids enter the activated sludge process. Waste is converted to cellular biomass.

The activated sludge process

Mixed Liquor: Incoming wastewater is combined with sludge from the secondary clarifier.



Conventional activated sludge layout



Main points to notice:

1) Continuous process. 2) Treatment progresses through the aeration basin. 3) Solids remain in system longer than the water.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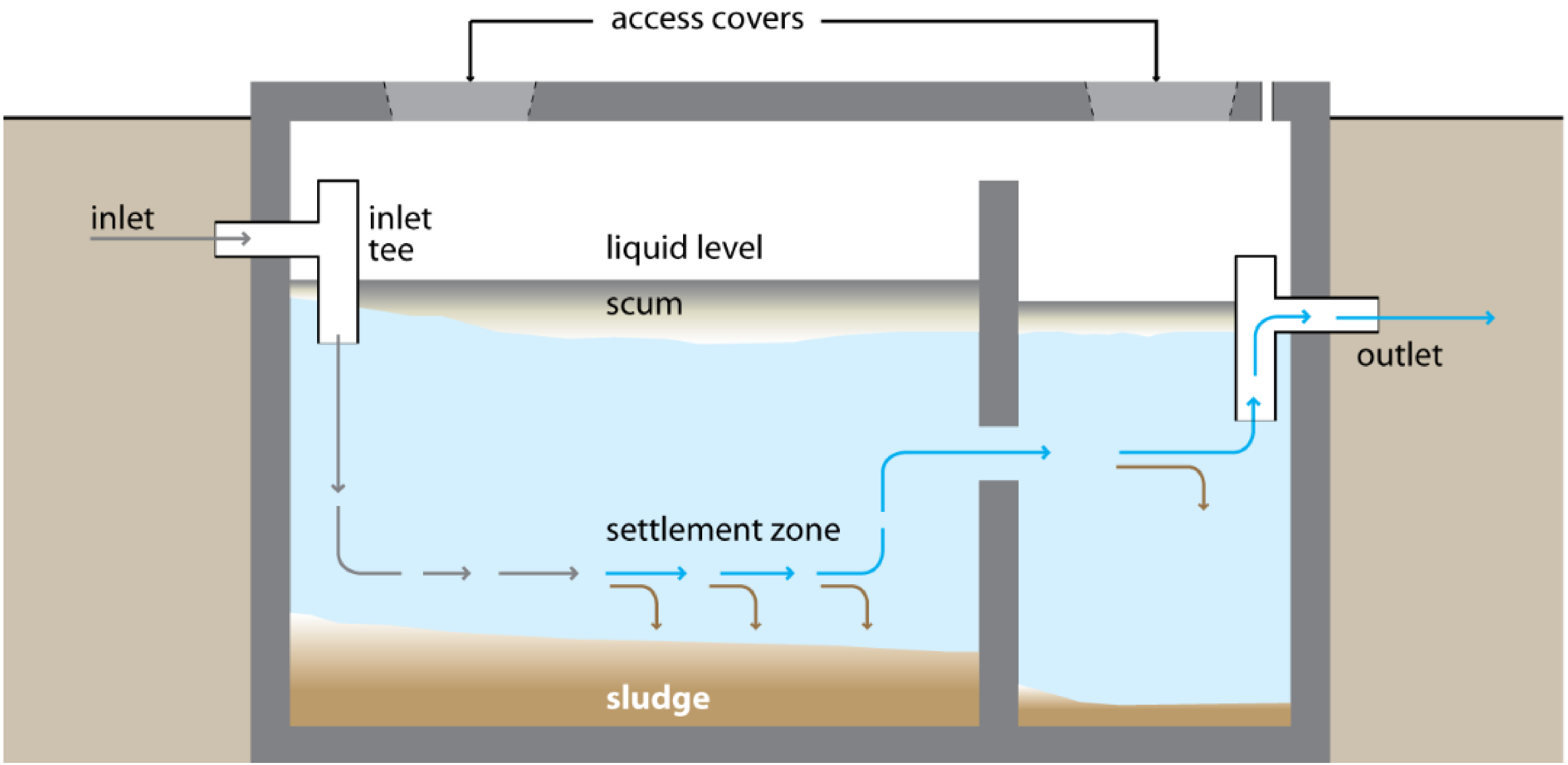
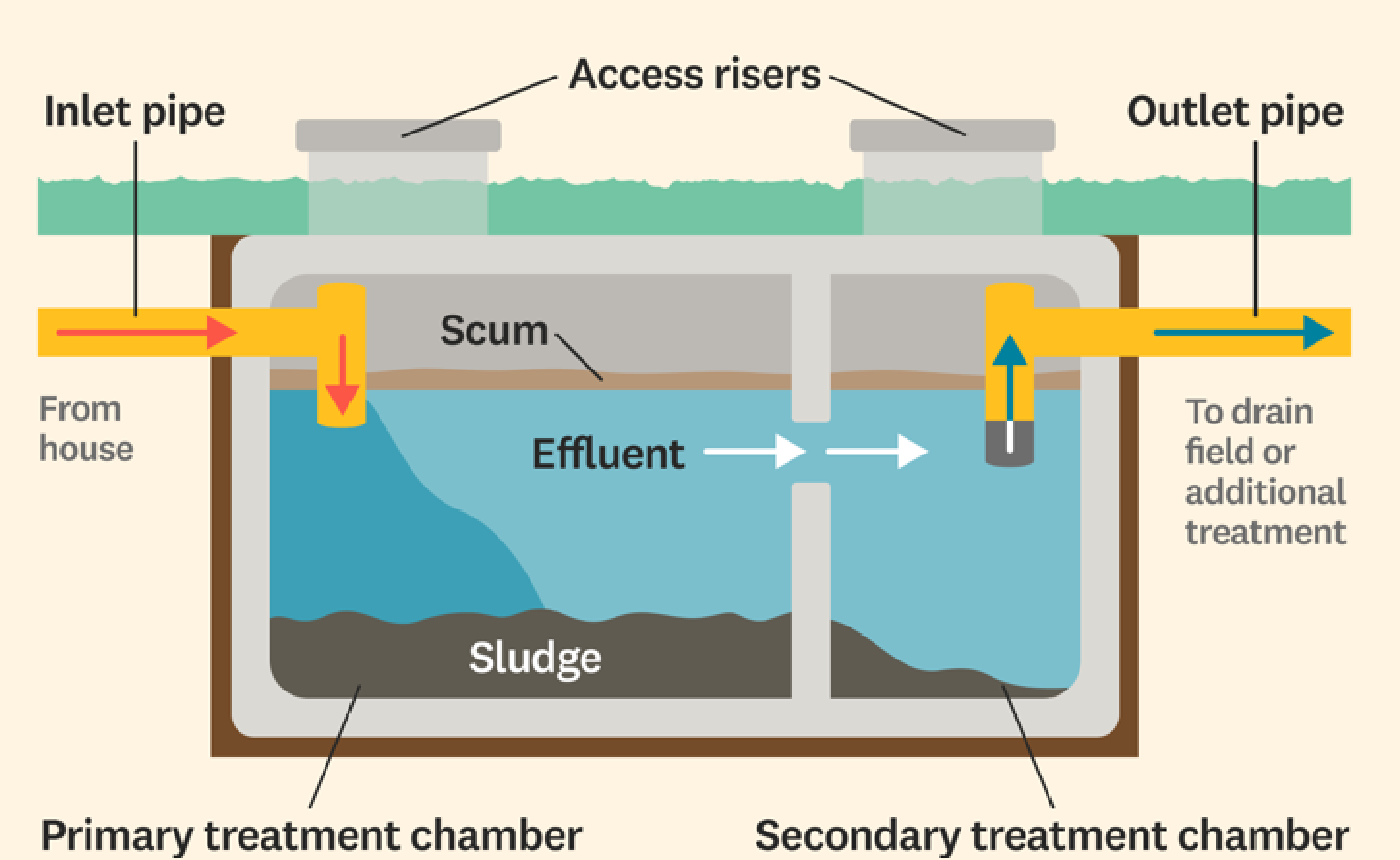
LONDON:
JOHN CHURCHILL, NEW BURLINGTON STREET.

M.DCCC.LV.

Physical removal processes – floatation and sedimentation



Anaerobic treatment



Anaerobic bacteria do not require oxygen and use sulfur compounds for respiration.

Anaerobic treatment is slower, but results in less biomass when run to completion.

Source of biogas and compost.

Anaerobic decomposition steps

Hydrolysis - organic materials are broken down into ammonia and other small molecules and become soluble. Water functions to weaken the chemical bonds.

Fermentation - Volatile fatty acids are produced from the products of hydrolysis

Gas production - Gases are produced/released carbon dioxide, hydrogen, hydrogen sulfide, nitrogen, and methane.

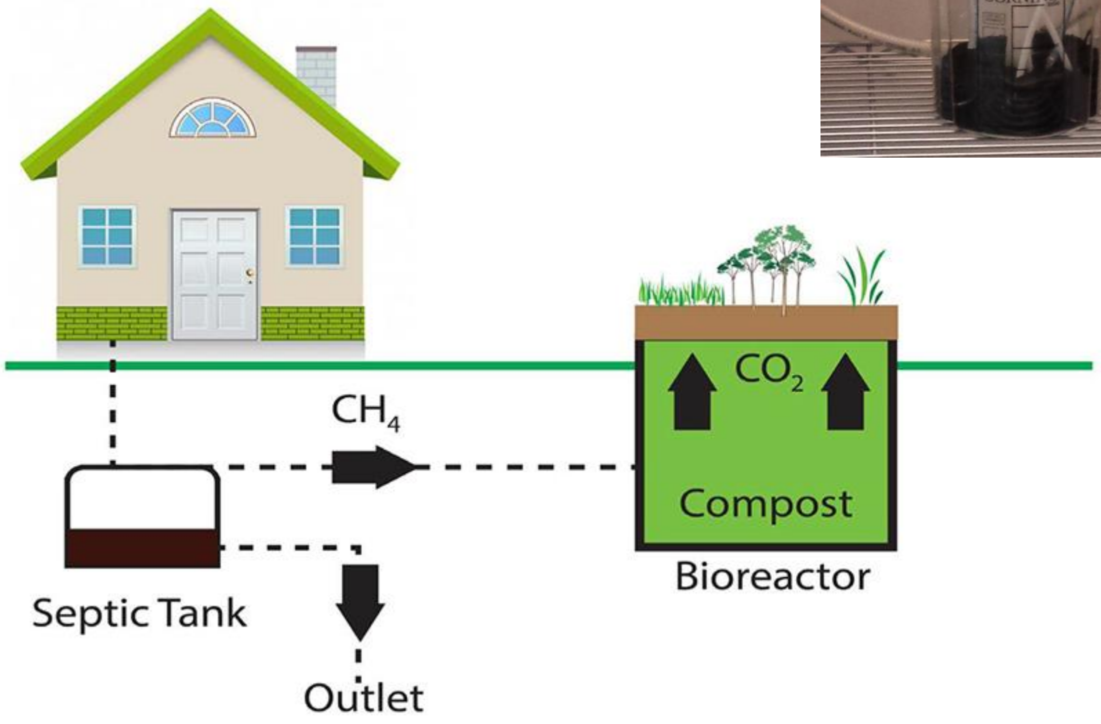
A large portion of solids (60% to 80%) is converted to gas in anaerobic decomposition when it is run to completion.

Reducing methane from anaerobic decomposition

Utah State University Study

On-site (septic) systems are estimated by the EPA to make up 76% of wastewater sector methane emissions in the US, trapping heat in the atmosphere over 20 times more effectively than carbon dioxide and contributing to poor air quality

- Methane produced in septic tanks was collected and treated in a compost biofilter system.
- Methane is converted to carbon dioxide by reacting with the compose.
- Carbon dioxide is used by the plants growing on the compost.



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Biomat

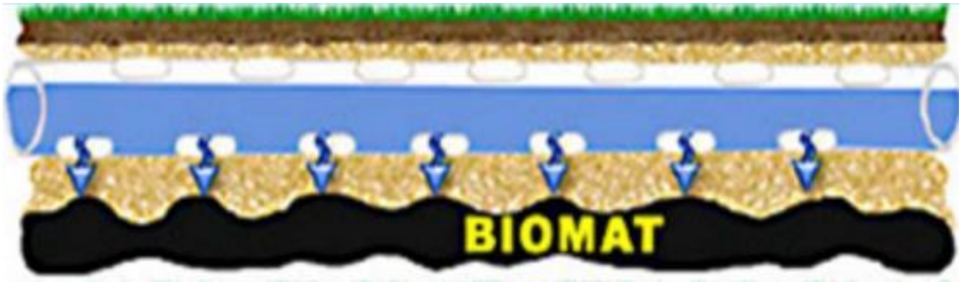
Extends ½" to 6" into soil

Formed from a zoological film

Aerobic bacteria dominate near the surface of the biomat

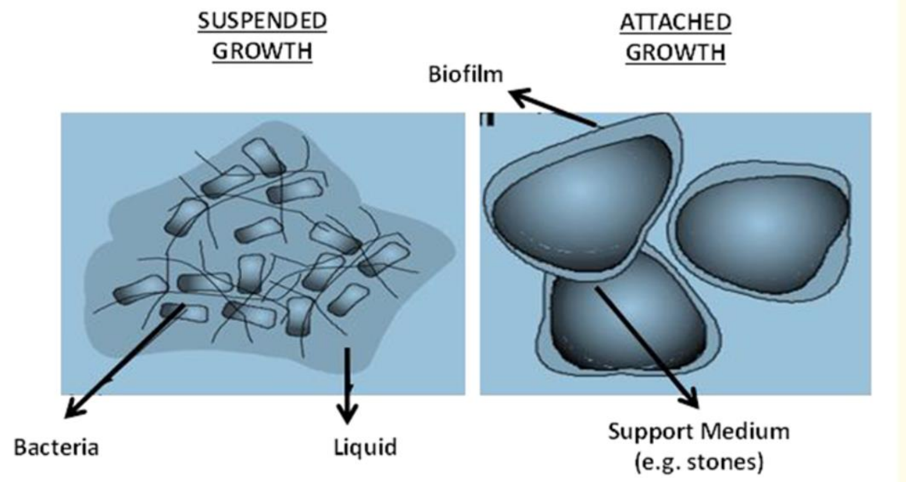
Anaerobic bacteria dominate in the interior of the biomat

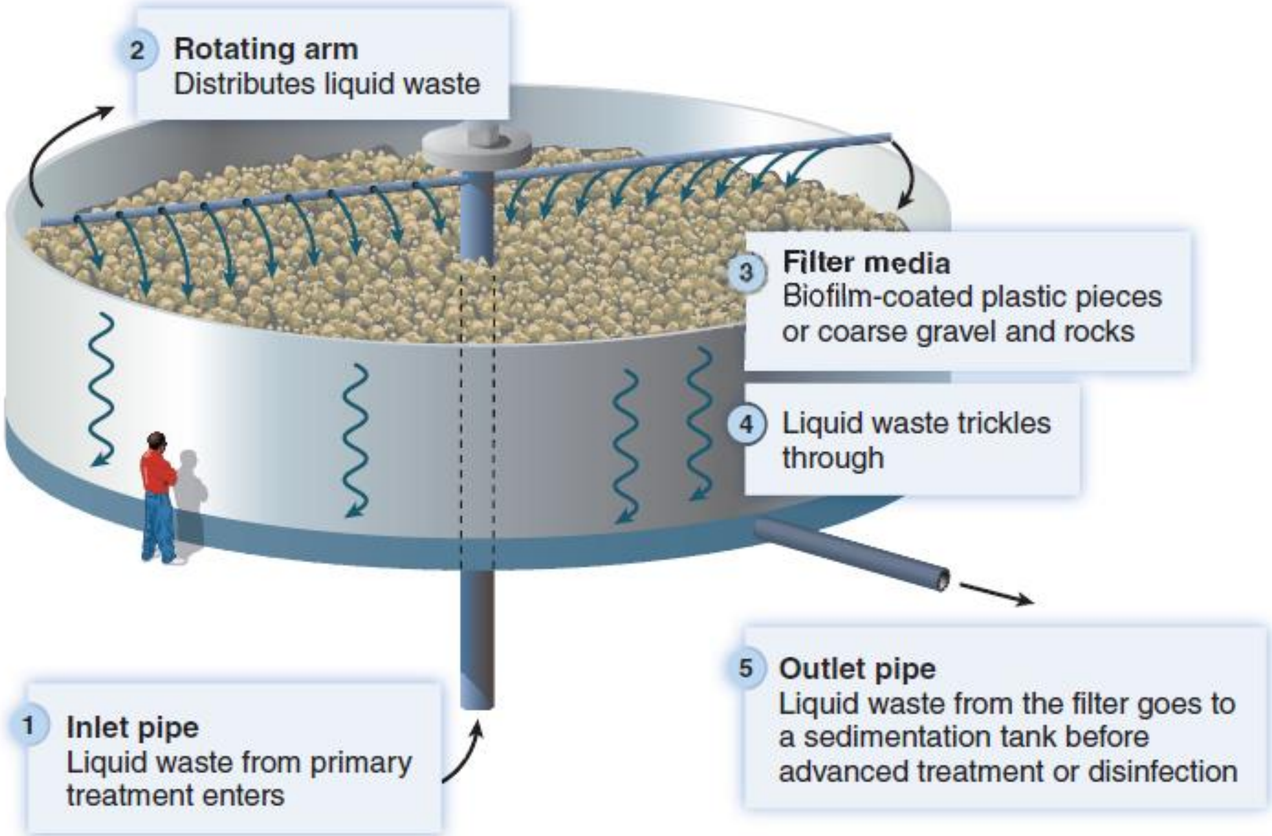
Biomat is self cleaning – during low flows (no food) microbes consume themselves and each other.



Attached growth

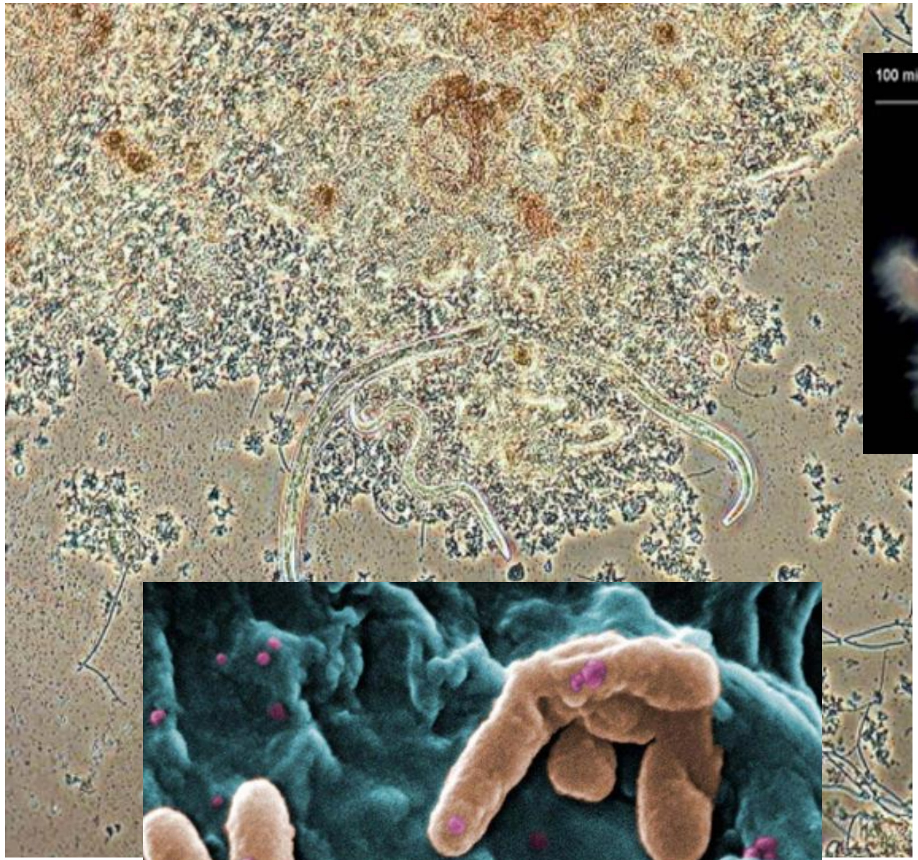
- Onsite Drainfield
- Trickling filter

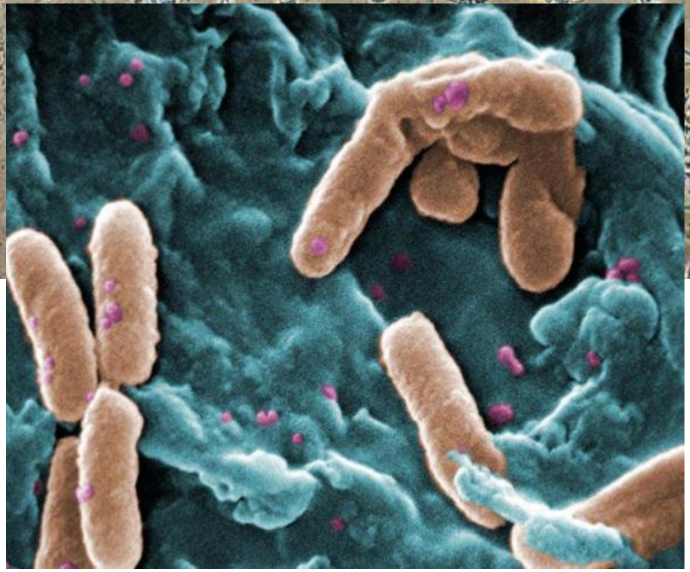




Microbes in onsite systems

- Bacteria
- Fungi
- Algae
- Protozoa
- Rotifers
- Nematodes





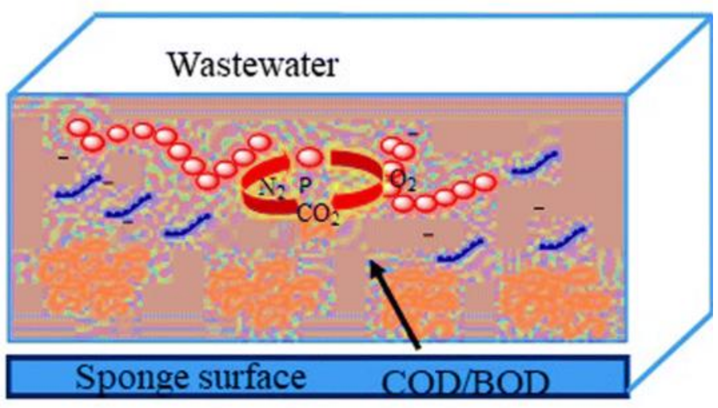
Biological processes in biofilms

Biodegradation – bacteria and fungi break down organic chemicals into smaller components with enzymes.

Bioaccumulation – microbes assimilate organic chemicals into their cells

Biosorption - a physiochemical process that occurs naturally in a biofilm which allows it to passively bind contaminants onto its cellular structure

Biomineralization - bacteria convert organic substances to inorganic derivatives and can lead to mineral frameworks within biofilms



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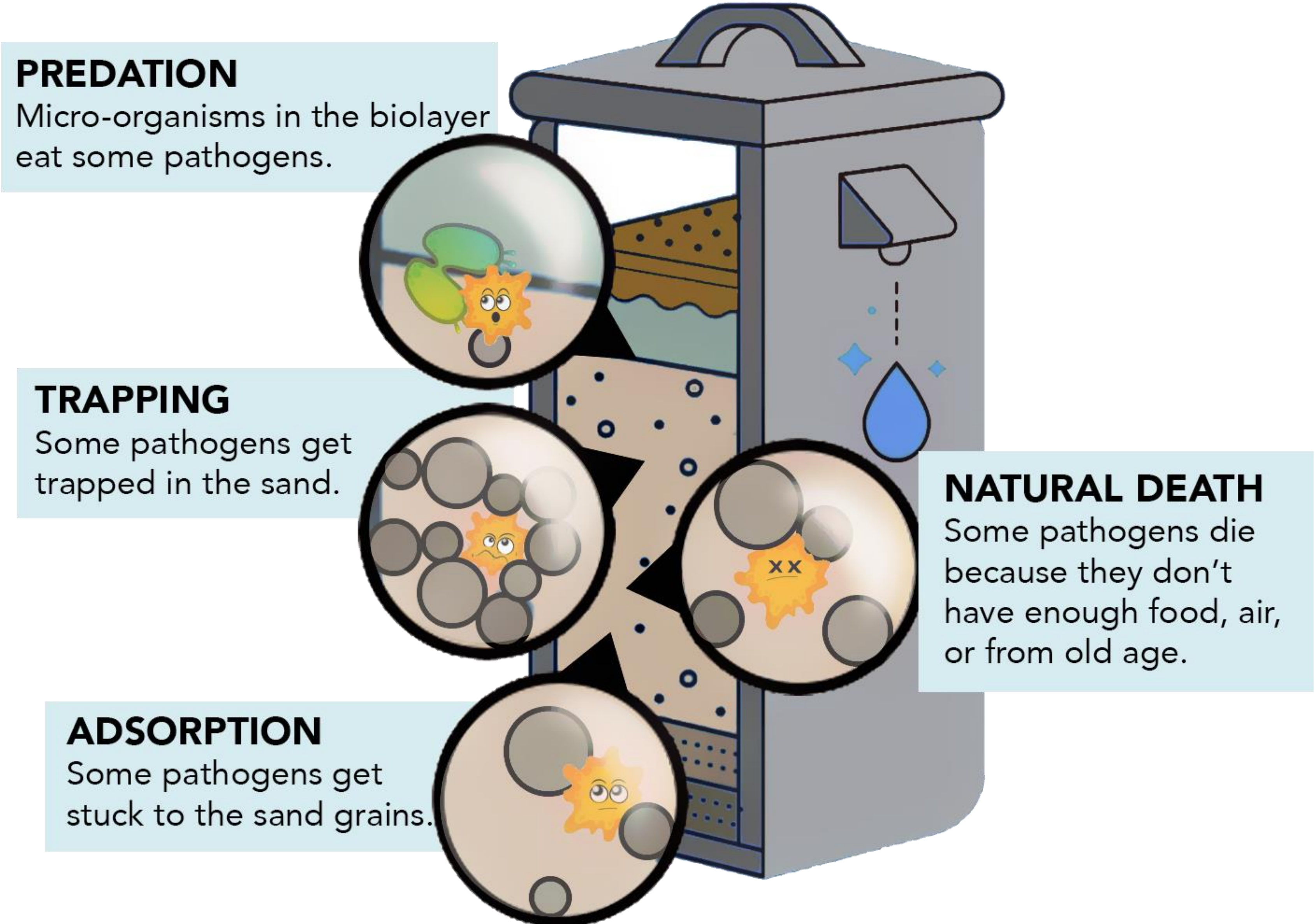
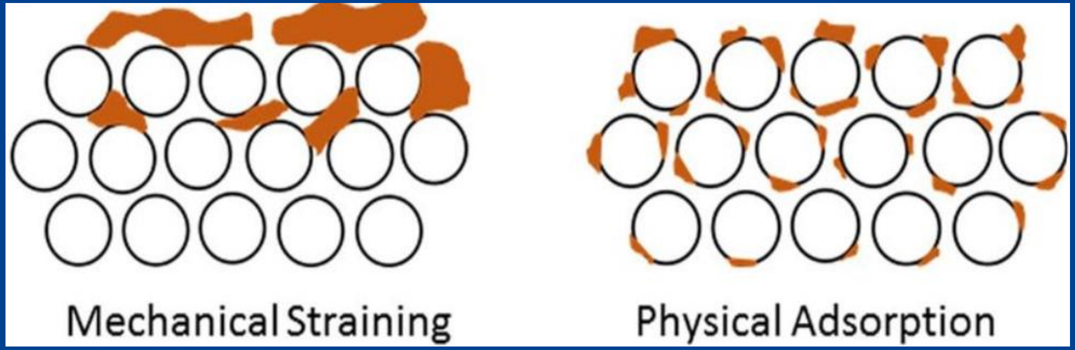
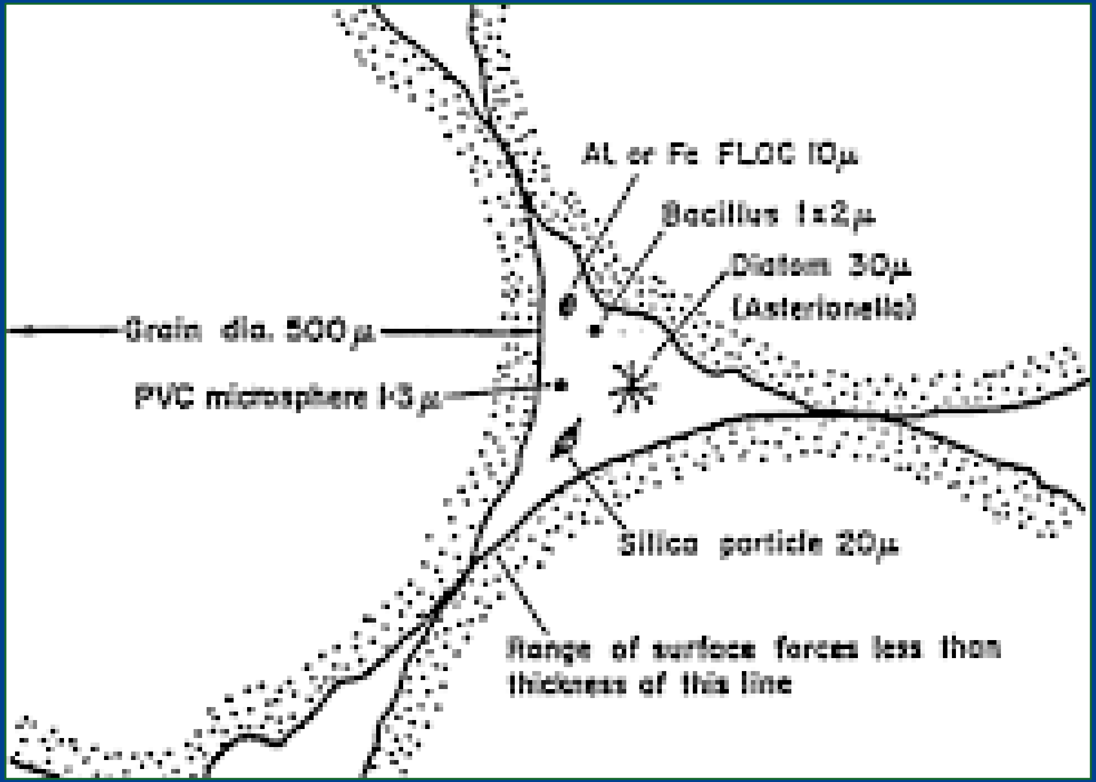
Biomat pathogen removal processes



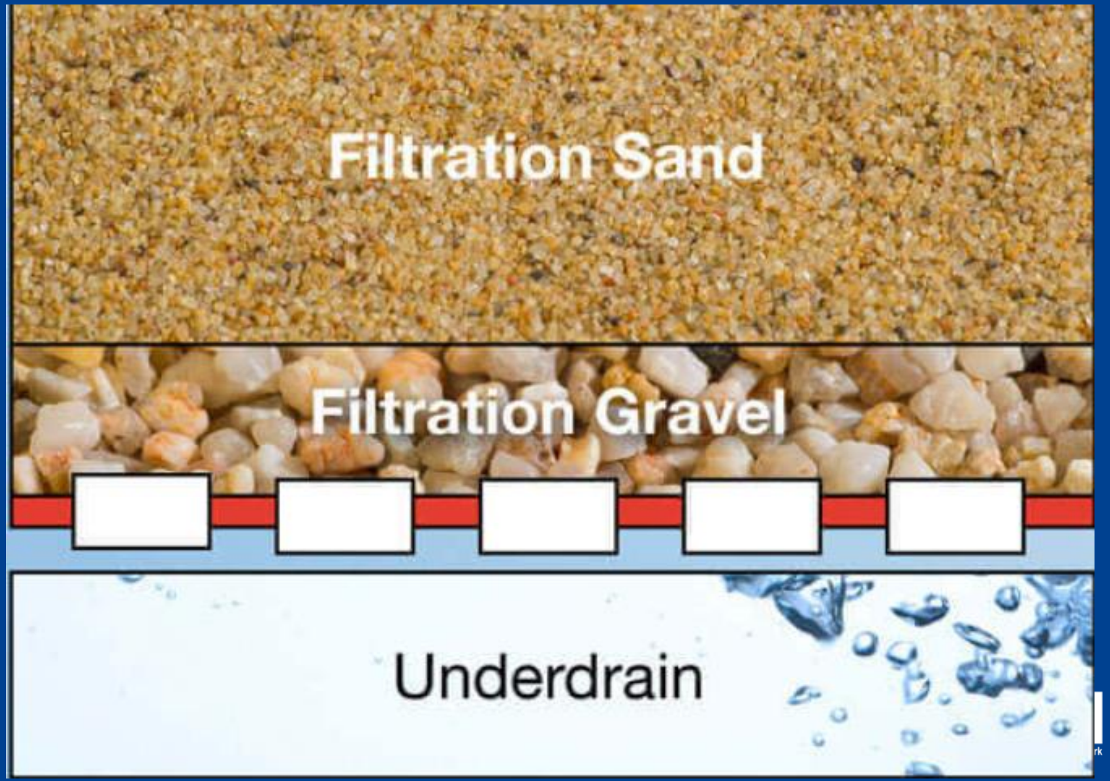
Filtration



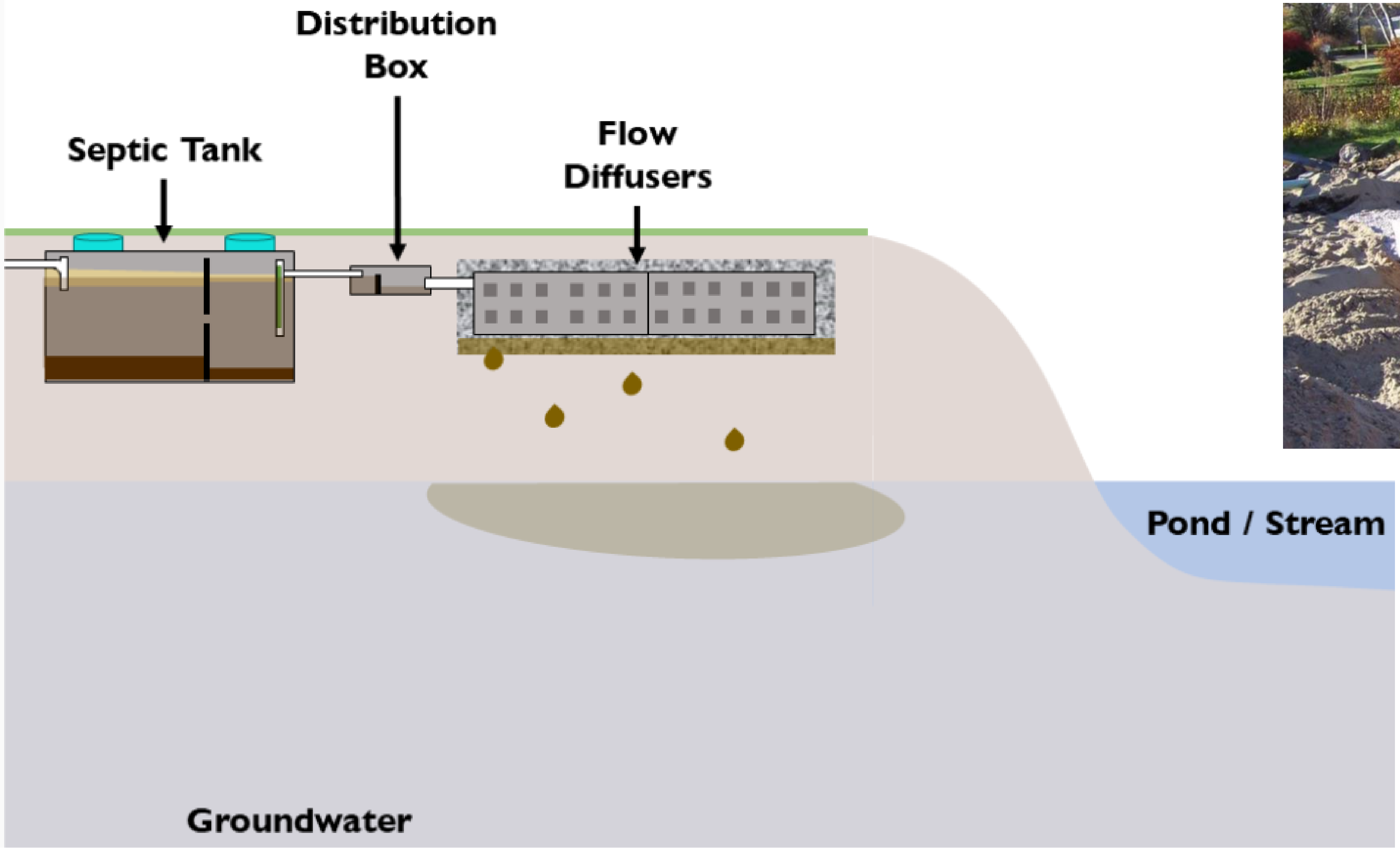
Small particles trapped



Typical sand filter



Flow diffusers



System sizing concepts

Drainfield sizing concepts

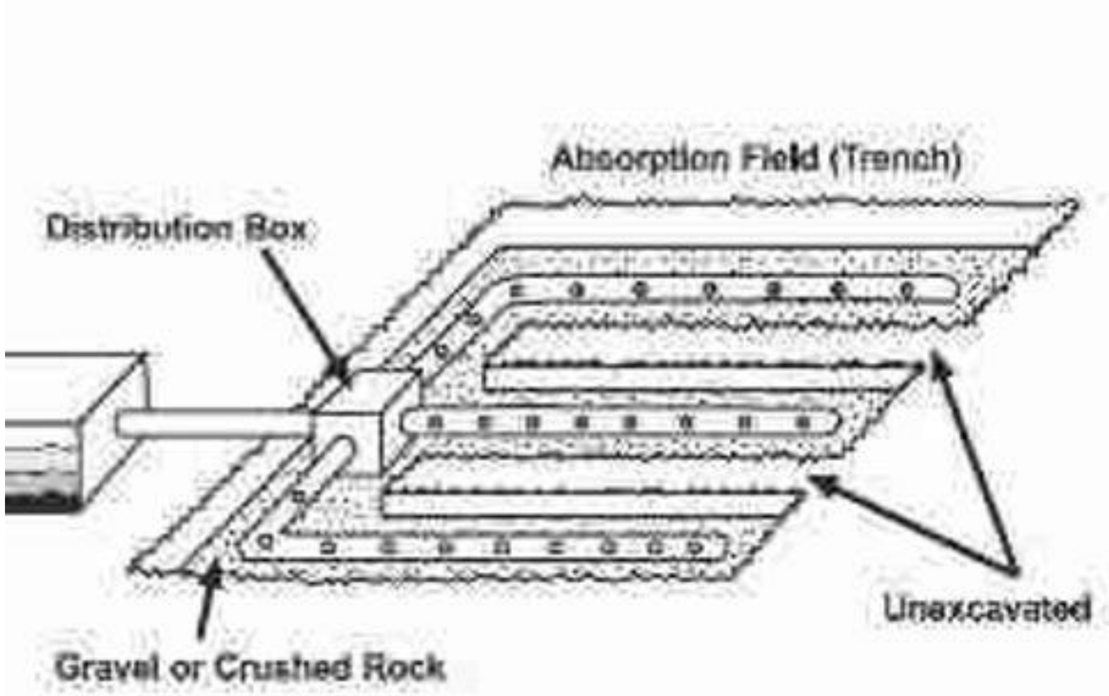
Soil with percolation rate of one inch in 1-5 minutes requires about 125 feet of drainfield trench for a typical two-bedroom home.

A percolation rate of 46-60 minutes per inch, would require about 333 linear feet

Tank sizing concepts

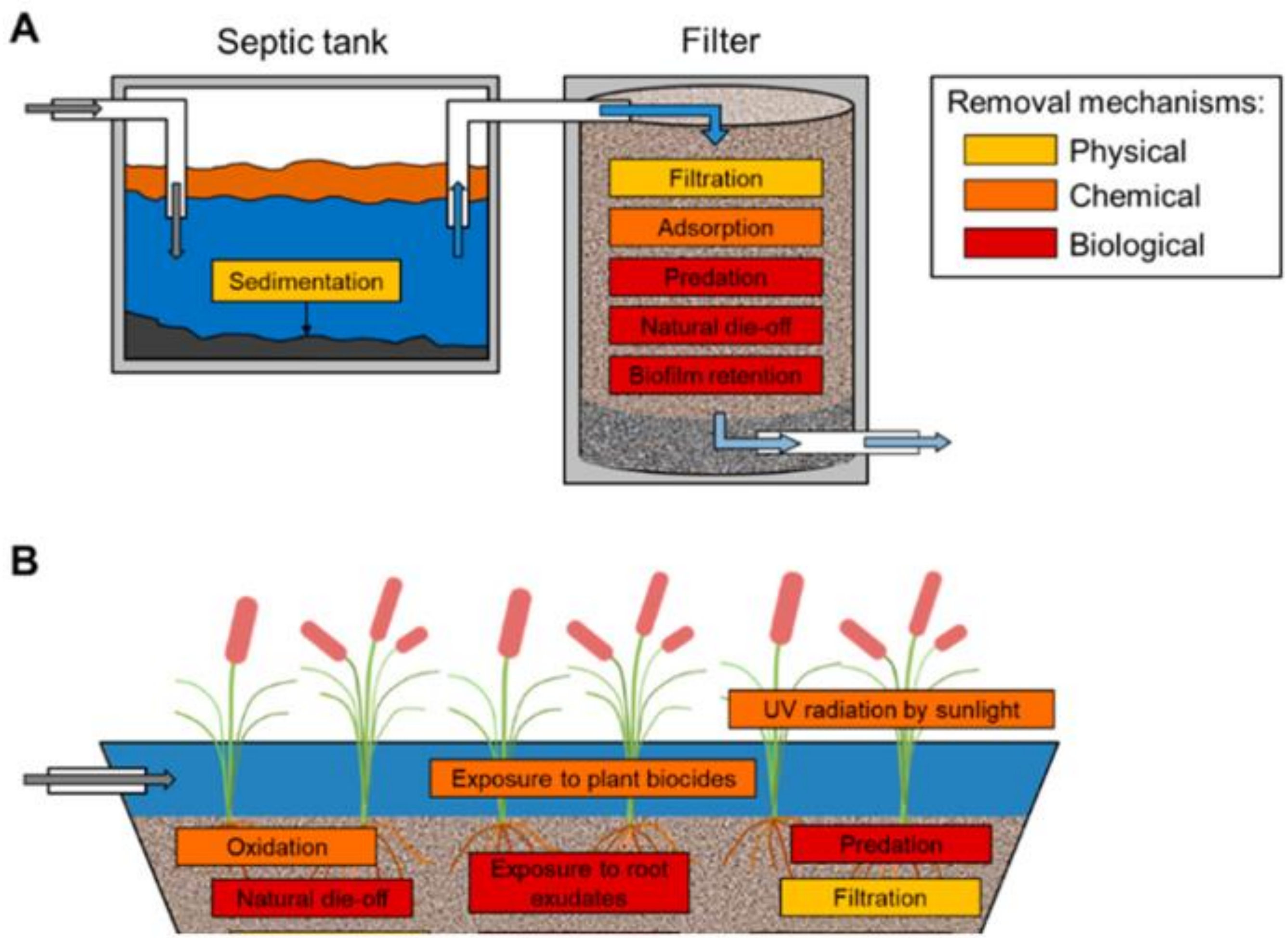
The average adult discharges about 90 gallons of solid waste into the septic tank each year, reduced 60% to about 54 gallons.

Tank is pumped when it reaches about 30% solids.



Poll 2: What is your current role?

a) Utility operator or manager
b) Community representative or local official
c) Regulator, state or federal government official
d) Consultant or TA provider
e) Something else? Add a comment



Removal of fecal coliform

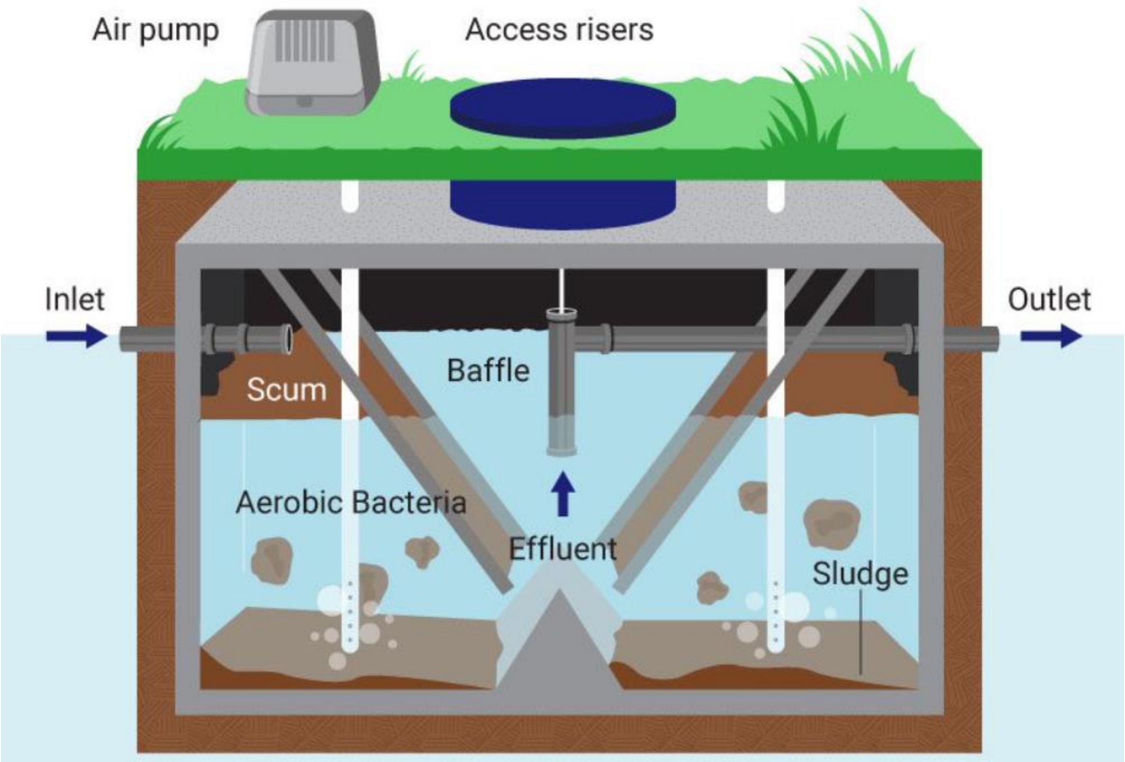
- Basic septic and drainfield (20.5%)
- Biofilter (63.8%)
- Wetlands (51.7%)

Filtration improved removal of other types of pathogens through straining, adsorption, and supported biofilm growth

Wetlands uptake nutrients and help to remove pharmaceuticals and heavy metals as well as nitrogen and phosphorus.

https://www.mdpi.com/2073-4441/13/9/1190

Aerobic treatment systems (ATS)



Benefits

- Can protect for environmentally sensitive areas.
- Much greater reduction in BOD and pathogens
- Can improve treatment in poor soils
- Less extensive drainfield required

Disadvantages

- Aeration is required which involves energy usage and the complexity of additional components to inspect/maintain.
- Not necessary in areas where soil conditions are suitable for regular onsite systems.

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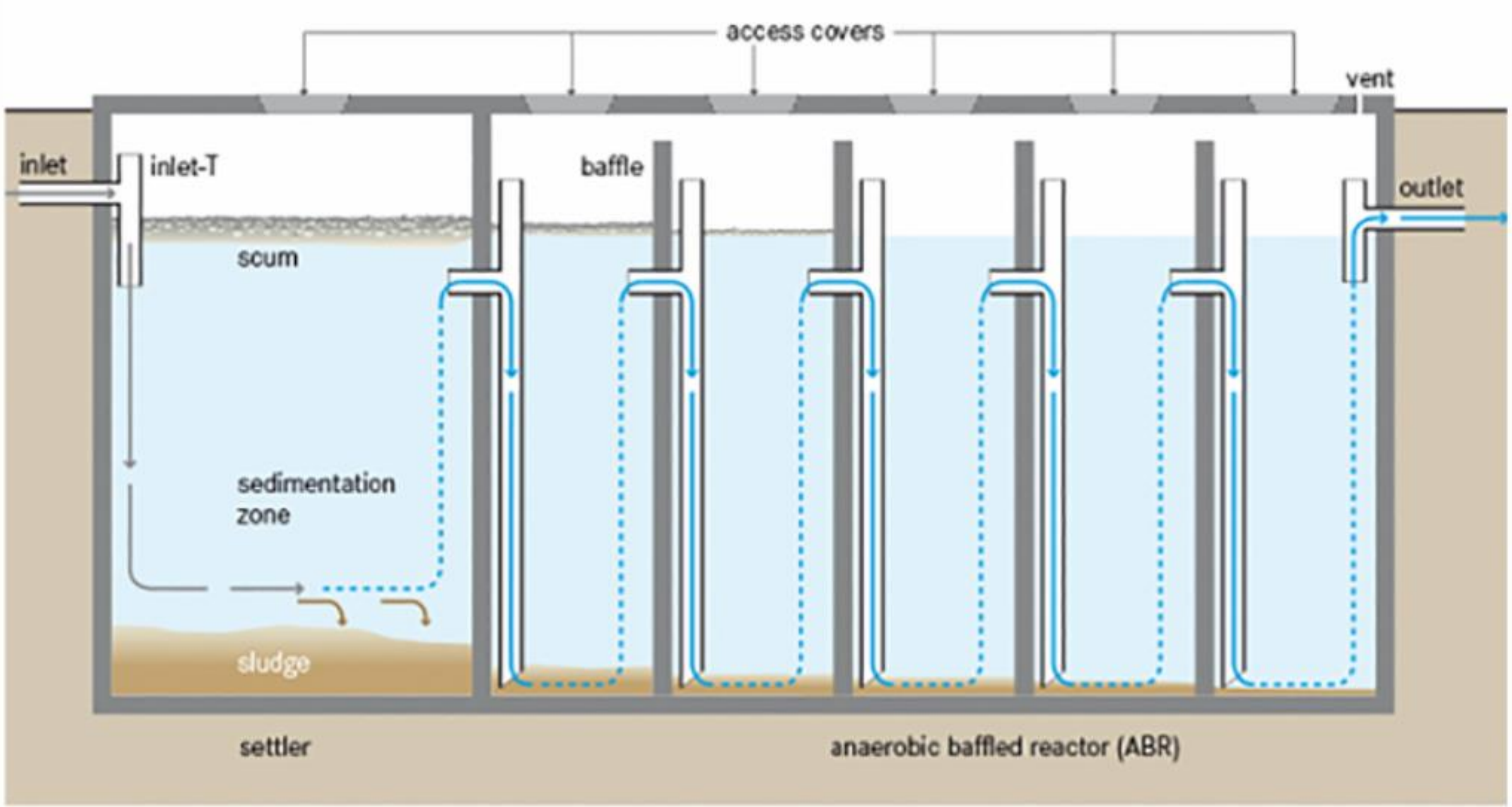
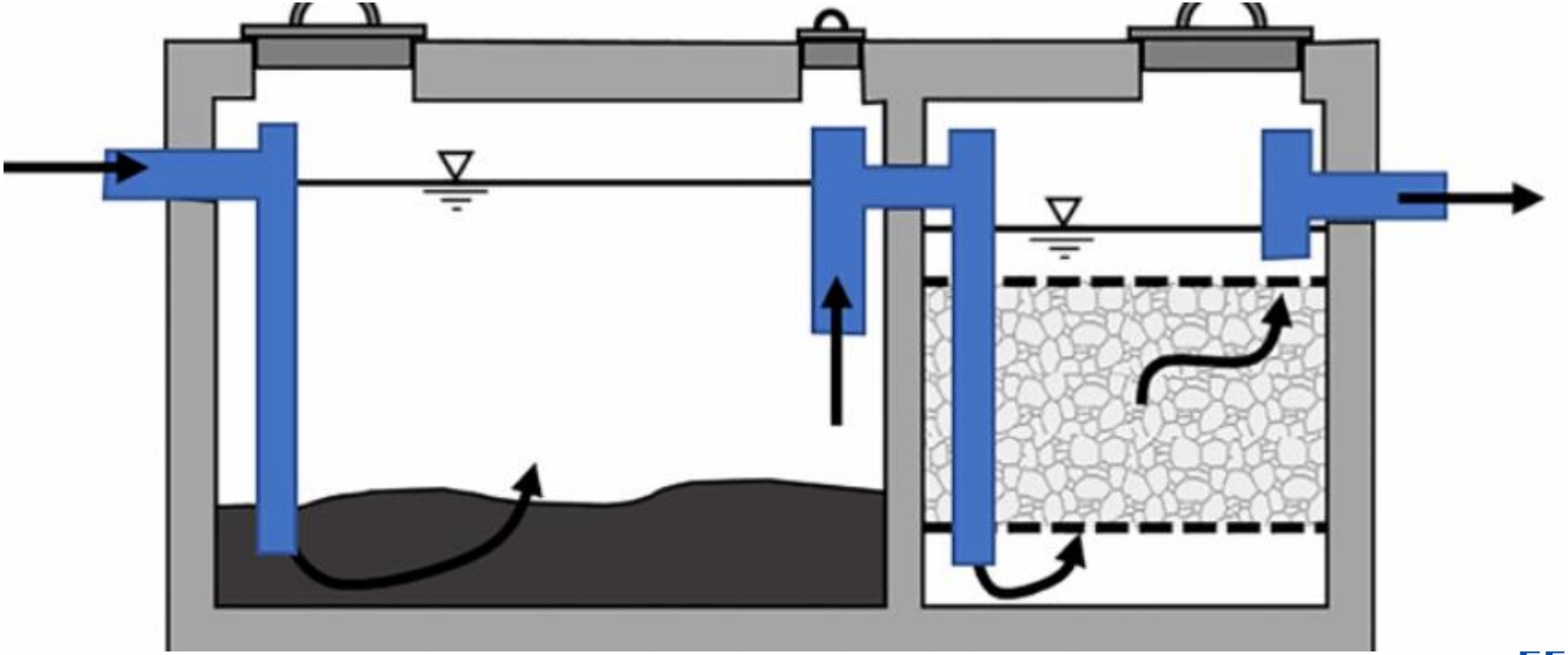
Anaerobic baffled reactor



Upflow biofilter septic tank - anaerobic



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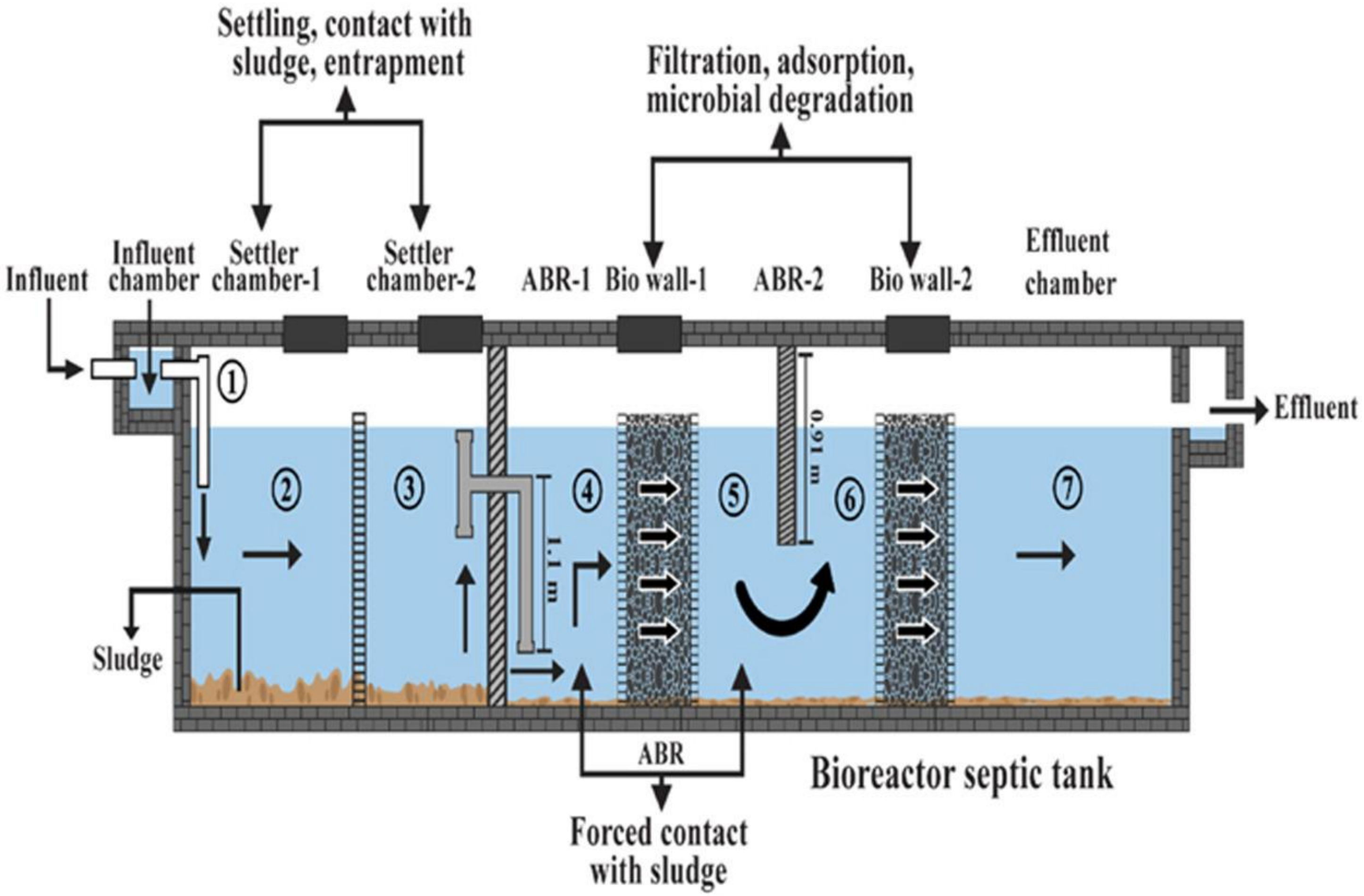
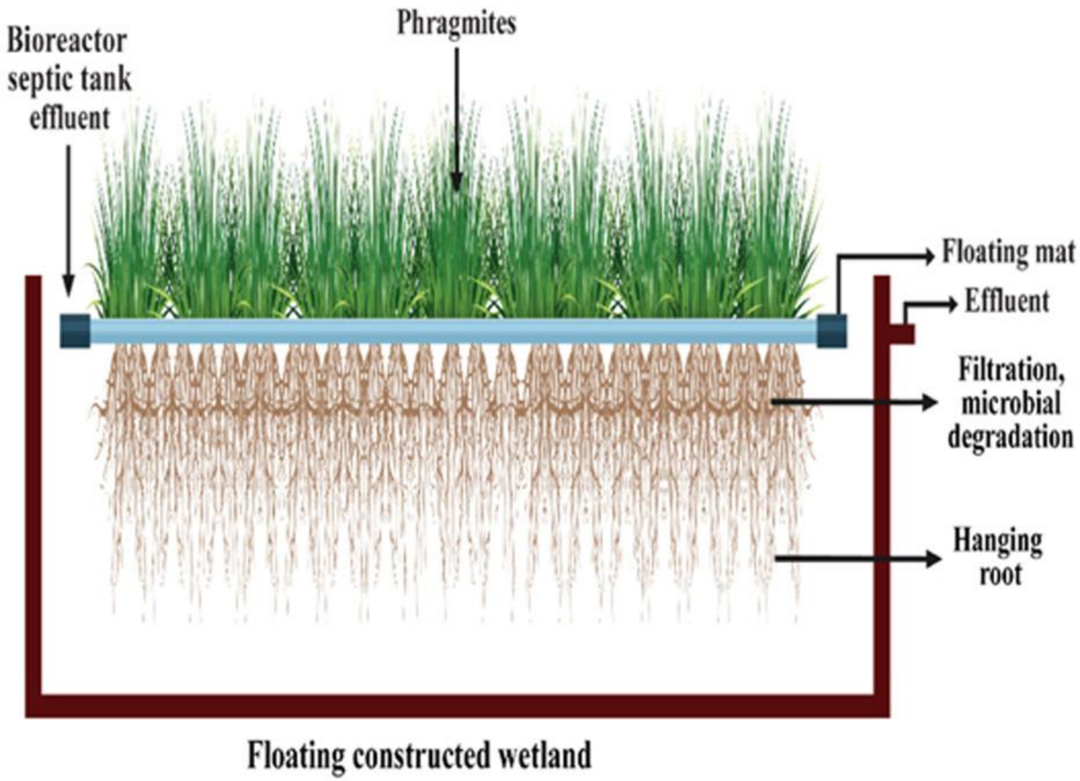
Septic with sludge (anaerobic) recirculation and wetland





https://www.sciencedirect.com/science/article/abs/pii/S2213343721005832

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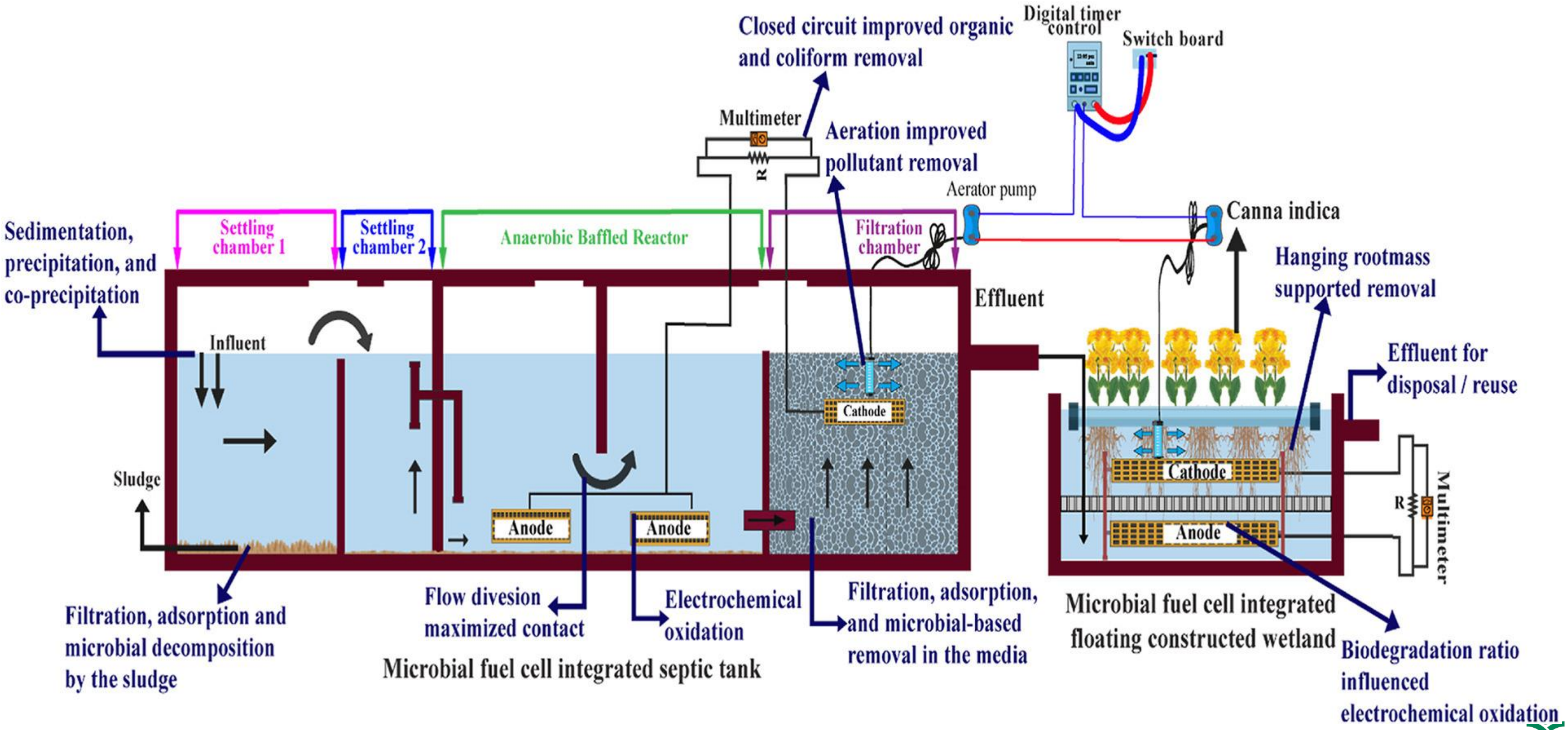
Septic with aerobic, filtration, wetland treatment and bioenergy



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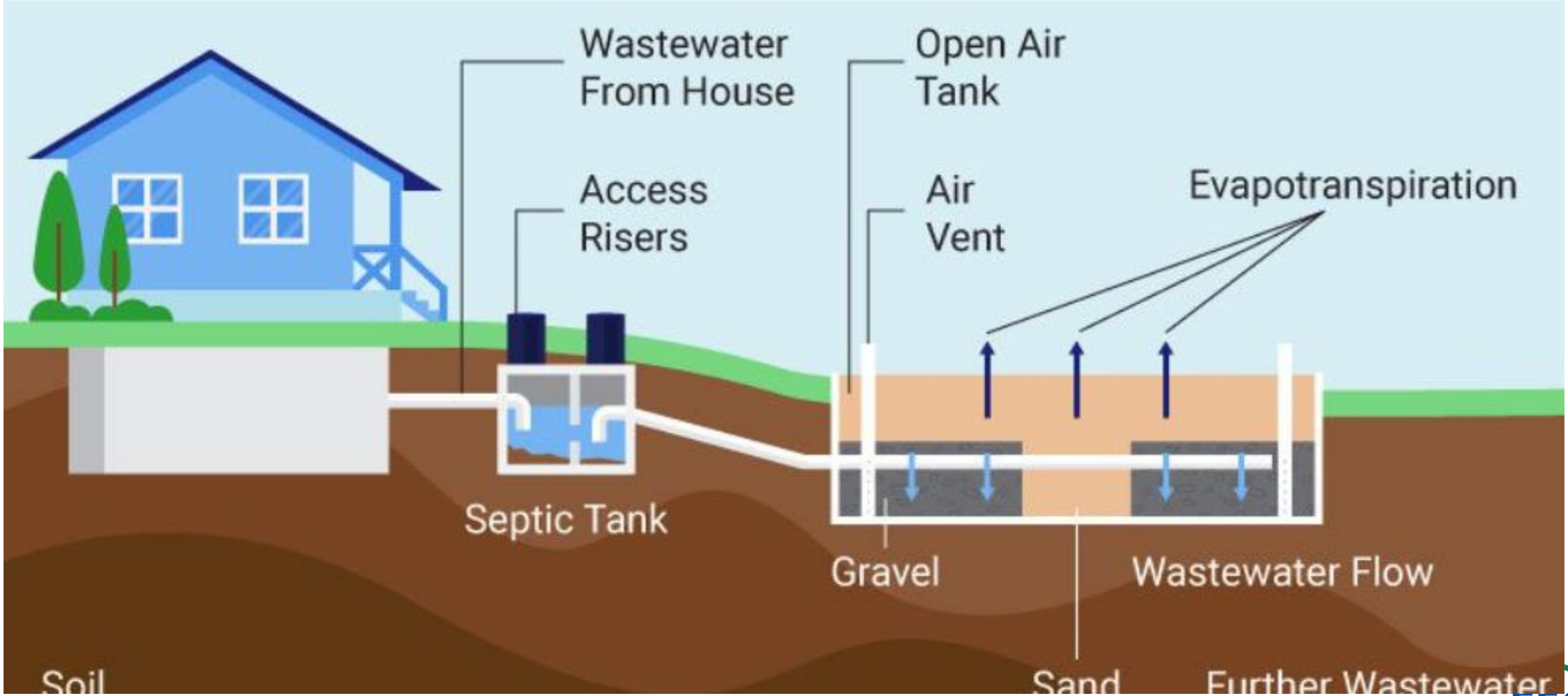
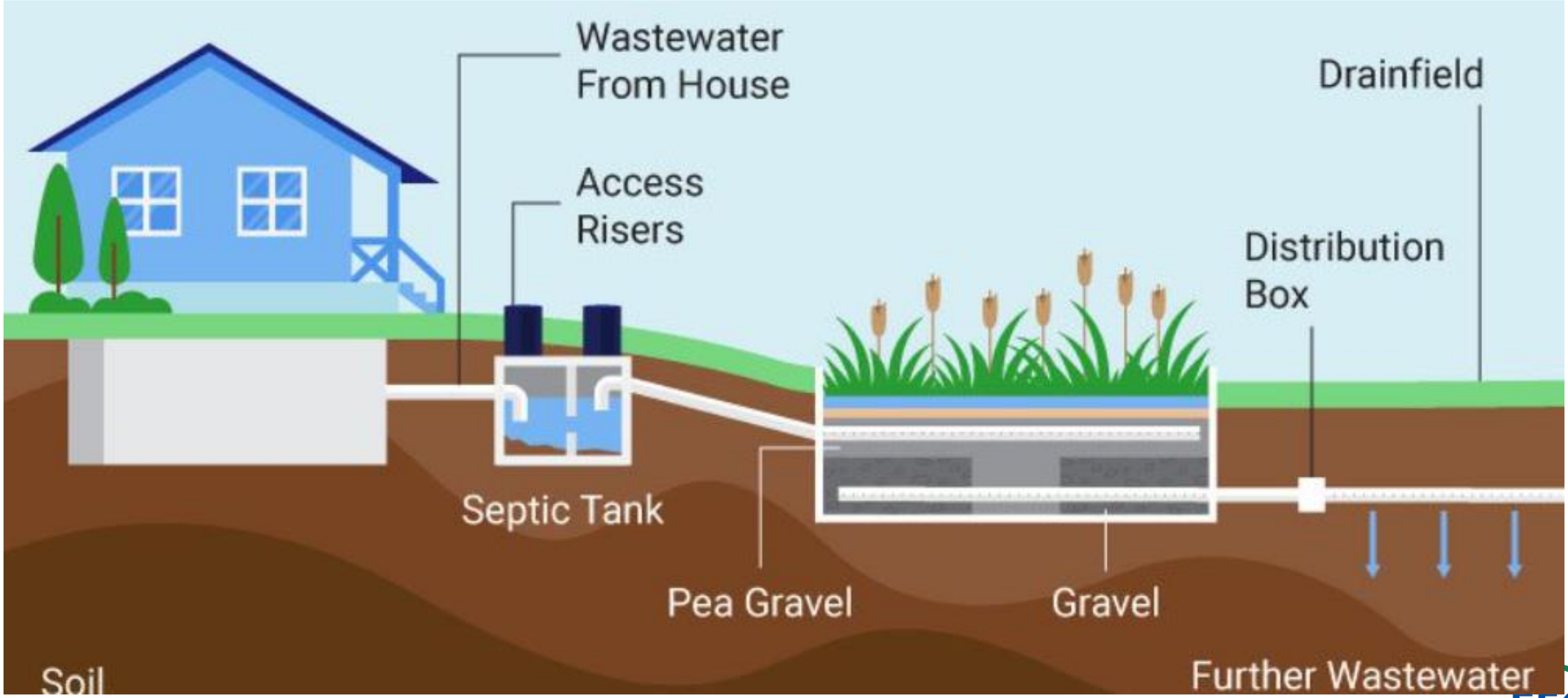
Evapotranspiration system



Constructed wetland system



Constructed wetland examples

Wetland removal performance

Parameters	Unit	Standard*	Average concentration			Overall removal (%)
			Influent	Effluent		
				CW unit 1	CW unit 2	
BOD	mg/L	≤ 20	96	12	3	97
COD	mg/L	≤ 120	260	47	21	92
SS	mg/L	≤ 50	100	12	5	95
TKN	mg/L	≤ 100	30	16	4	86
NH_3-N	mg/L	N.A.	18	12	3	84
NO_3-N	mg/L	N.A.	0.1	1.2	6.5	**
TP	mg/L	N.A.	6.8	3.1	2.2	87

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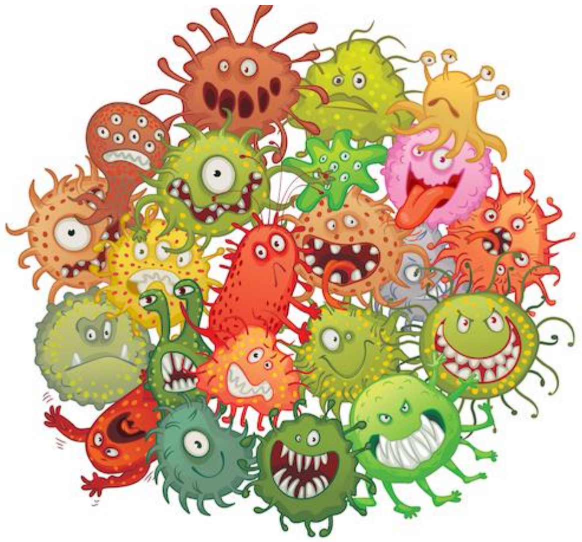
Adding specialized bacteria and microbes

Does bioremediation work?

- Bioremediation is used to clean up groundwater contamination such as petroleum plumes – these are custom developed bacteria from a lab.
- Microbial seeding is often used in the start-up of activated sludge plants, and when there has been a toxic load or washout that has occurred.

Is bioremediation useful or necessary in septic systems?

- In most cases bioremediation is not necessary or recommended. Household waste already contains a very high concentration of microbes.
- Adding bacteria could upset the natural microbial balance
- Usually good initial construction and regular pumping are the best strategies.



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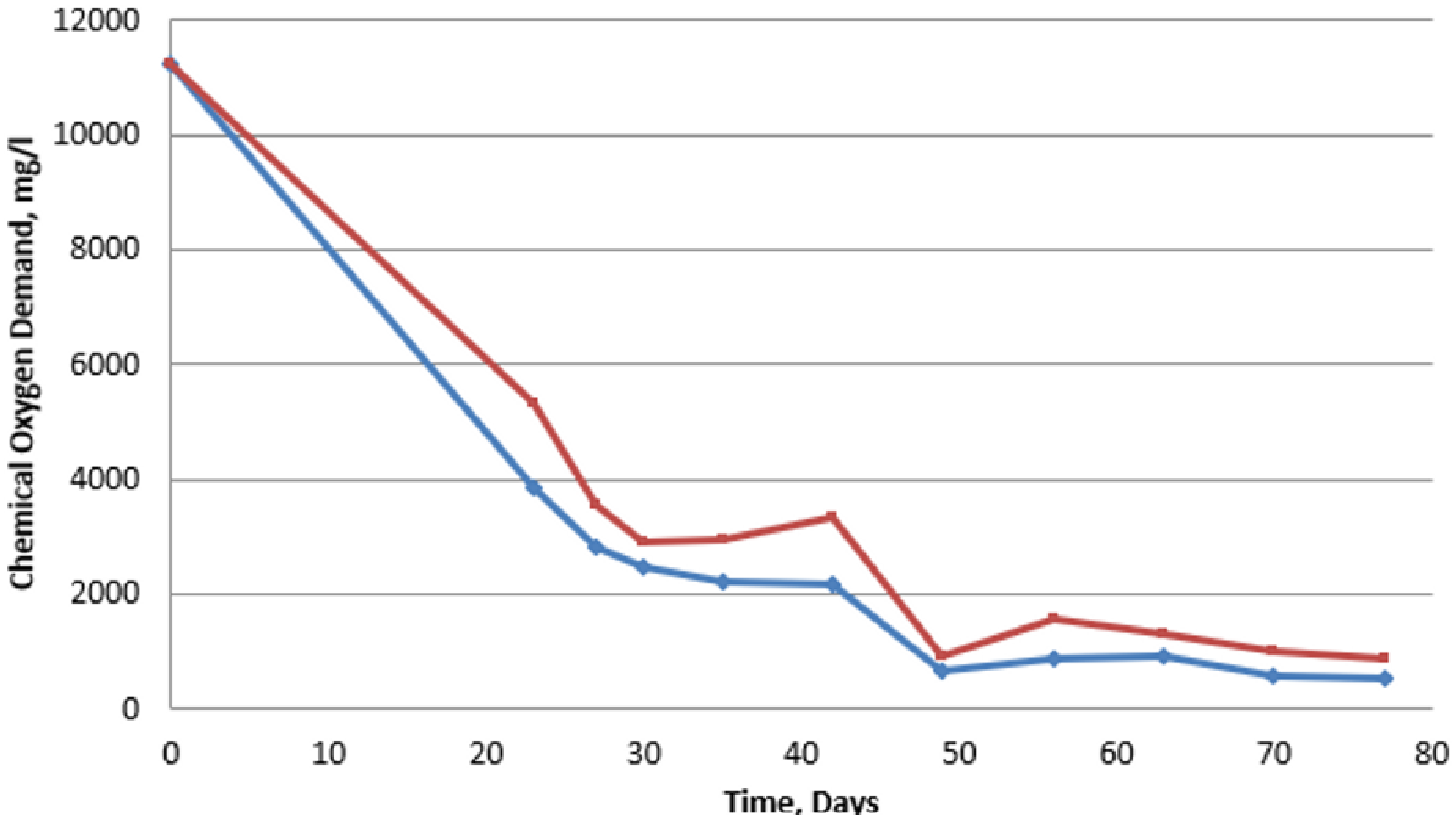
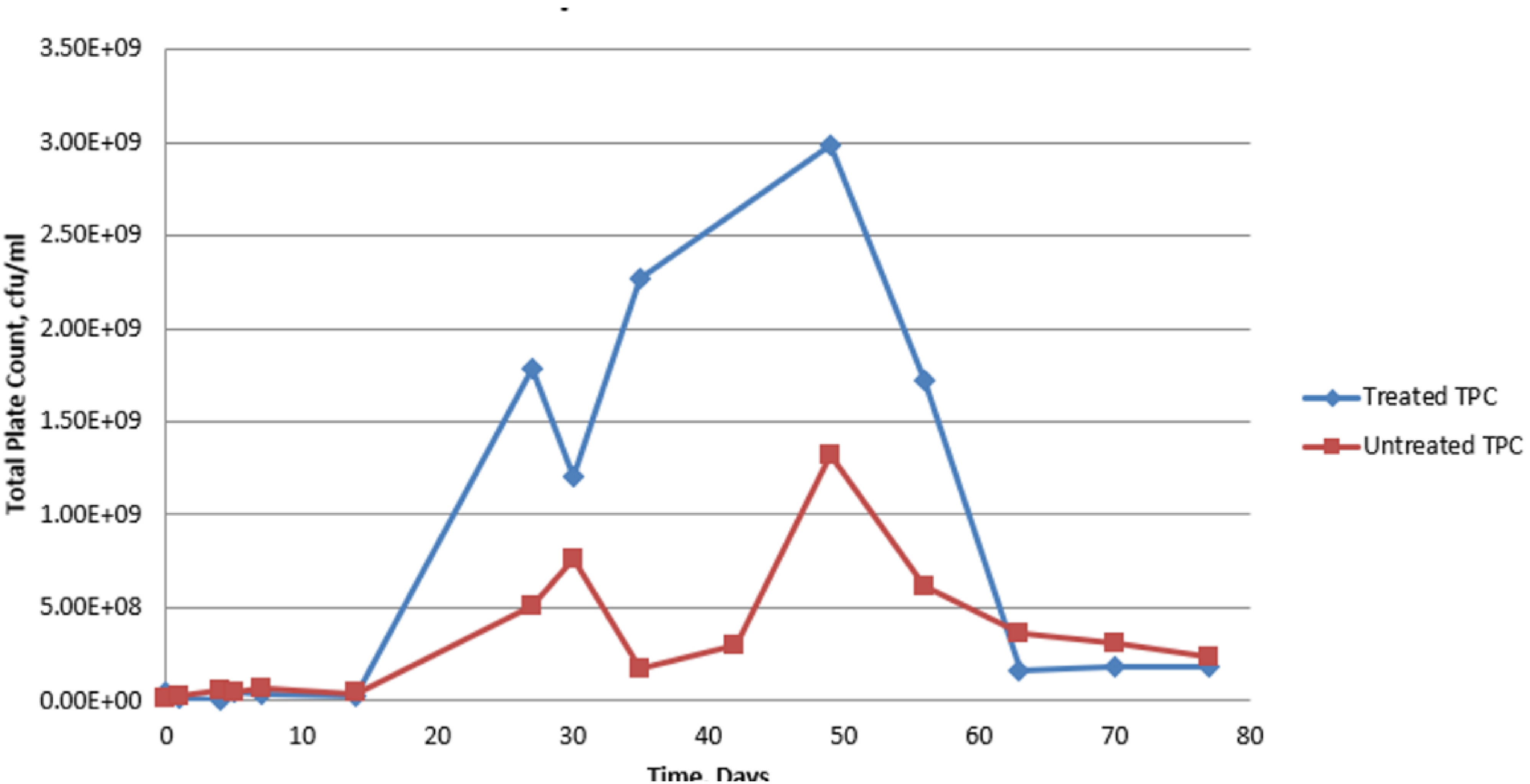
Treatment effectiveness with and without bioremediation



Bioremediation and naturally occurring bacteria



Factors that inhibit drainfield performance

- Grease and oil can coat the biomat decreasing performance of microbes.
- Failure to pump the septic when needed can result in solids clogging of the drainfield and disrupt percolation.
- Adding solids from sink garbage disposals will quickly lead to solids accumulation and drainfield clogging

Results:

1. Decreased treatment
2. Decrease percolation and ponding
3. Aerobic processes are interrupted by being saturated.
4. Sewer backups into home indicate a potential total failure of the onsite system

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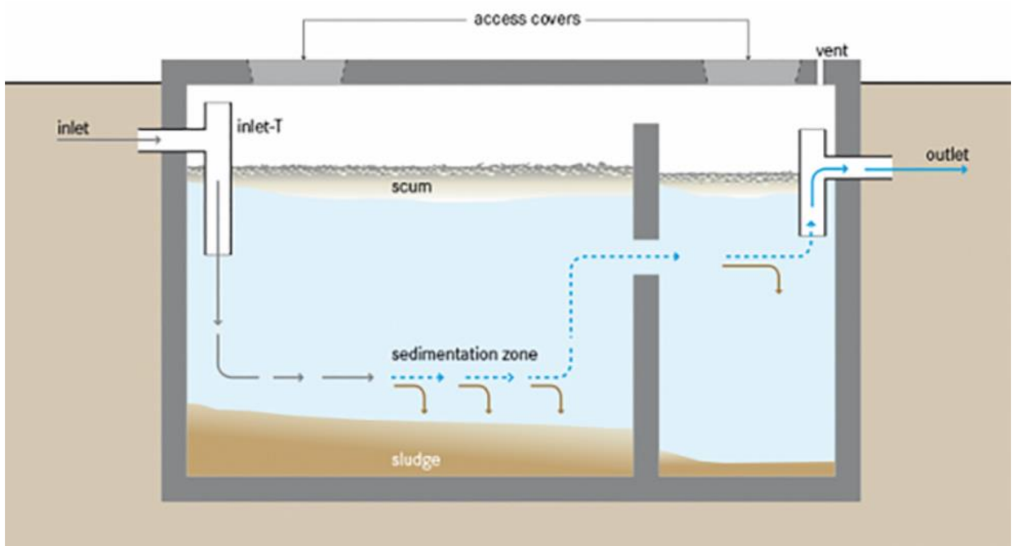
No scum layer

Solids with less density than water float to the top.

A scum layer should develop after 6 months of operation

Scum layer is ideally at least 1-inch thick

Solids removal is accomplished by floatation and sedimentation – the middle zone is clarified effluent.



Causes

- Effluent baffle missing
- High flows or turbulence
- Emulsifiers – overuse of phosphate-based cleaners, fabric softeners and degreasers
- Brine from water softeners

Toxins and disinfectants should also be used with caution since they can damage beneficial microbes.

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Failure to pump when needed

1. Solids enter and clog the drainfield
2. Treatment effectiveness is reduced (because there is less hydraulic retention time due to a smaller effluent zone).
3. High costs to repair or replace drainfield
4. Harmful gases and aerosols are produced
   - Methane
   - Hydrogen sulfide
   - Airborne bacteria and pathogens

SEPTIC TANK PUMPING FREQUENCY (IN YEARS)

Septic Tank Size	Household Size – Number of Occupants									
	1	2	3	4	5	6	7	8	9	10
1000 gallon	12	5½	3½	2½	2	1½	1	1	1	1
1250 gallon	15½	7½	4½	3	2½	2	1½	1	1	1
1500 gallon	19	9	6	4	3	2½	2	2	1½	1
2000 gallon	25	12	8	6	4½	3½	3	2½	2	2

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Pumping frequency based on inspection

- Measure the thickness of the scum and sludge layers each year.
- Pump when the total thickness of the solids layers are 30% of the total depth.
- Estimate solids accumulation per year

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Poll 3

Which of the following is the greatest need in regard to septic systems?

a) Protecting water from contamination through proper maintenance

b) Educating the public about proper septic maintenance

c) Adding functionality to improve of onsite wastewater systems

d) Reducing greenhouse gas emissions and energy usage

e) Something else? Add a comment.

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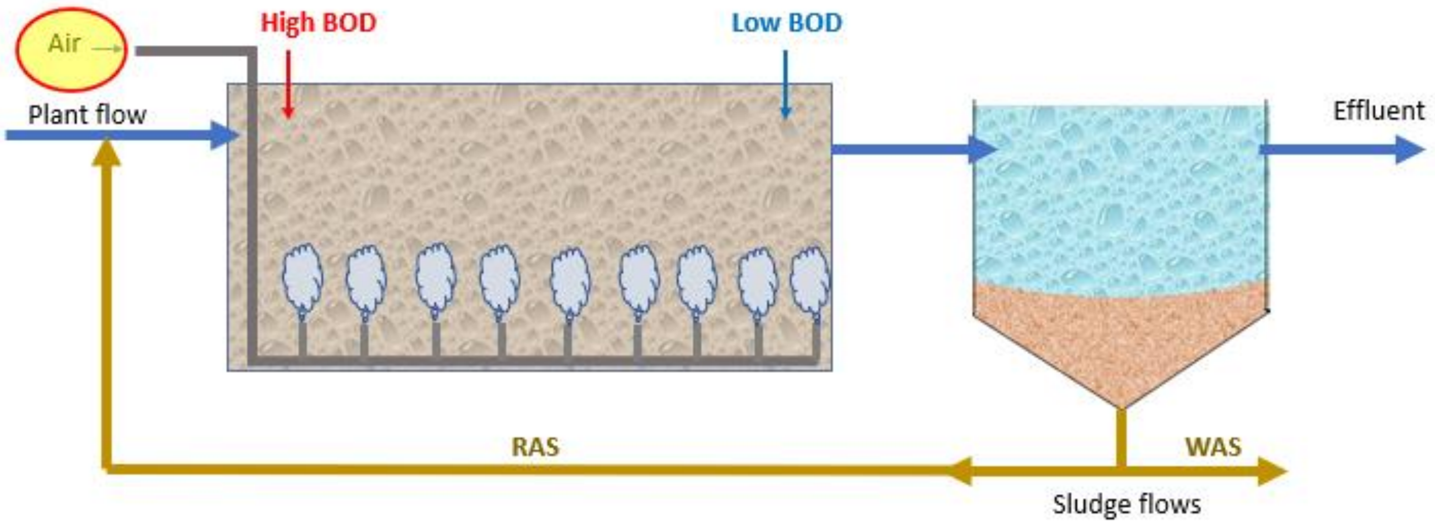
What we covered

- Biological, chemical, and physical processes in onsite wastewater
- System alternatives and studies to improve operation.
- Root cause factors for onsite problems
- Analogies to conventional treatment processes



What can we conclude?

1. **Establish** a regular inspection schedule
2. **Be proactive** in providing pumping and maintenance
3. **Designs** using proper standards to properly size and choose the correct type of system will result in success.
4. **The goal of treatment** is protection of water sources and human health by removing pathogens and waste from effluent.

Thank you for participating

Share 1 thing you enjoyed learning about today in the chat

We’re now open for questions

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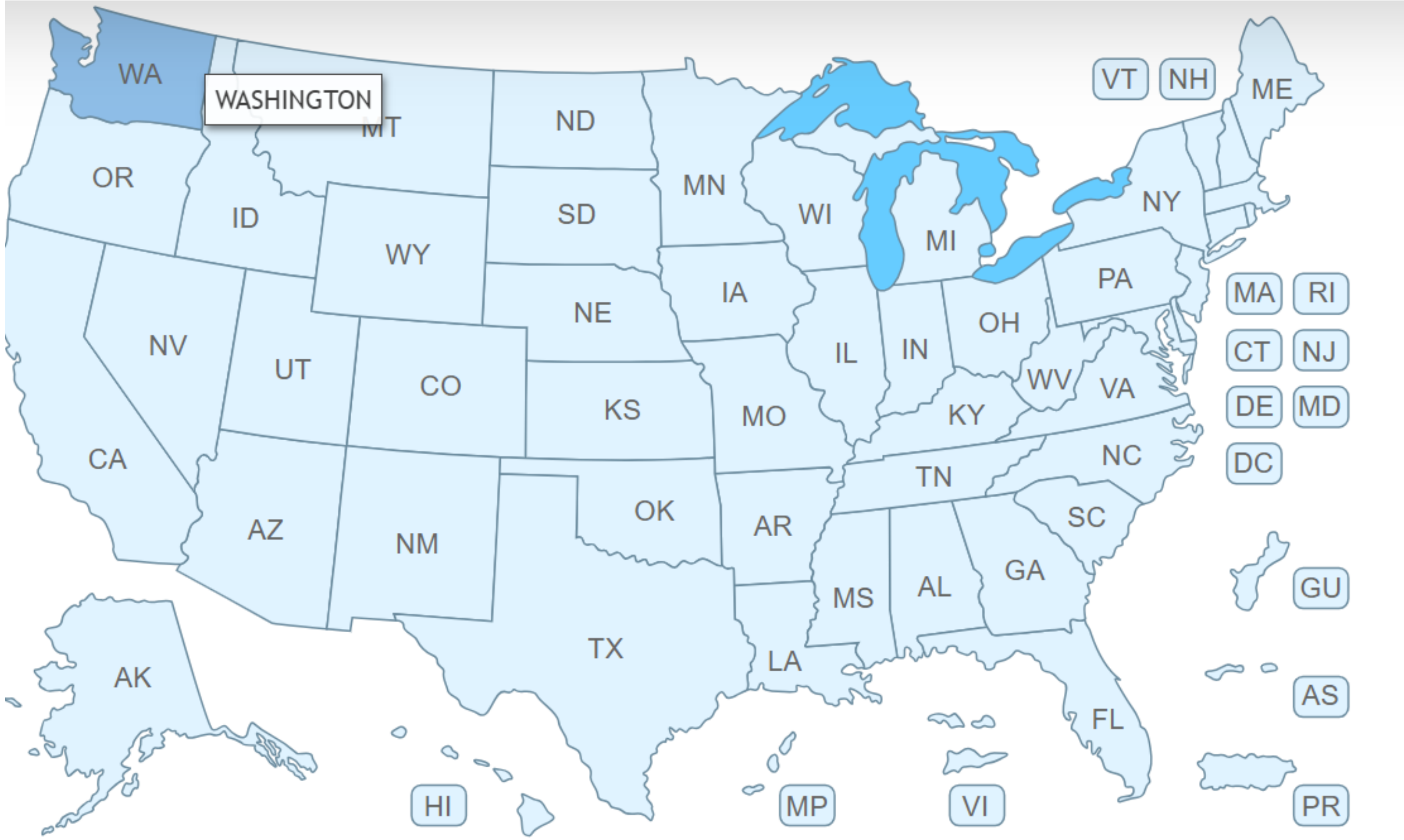
Funding guide



What comments/questions do you have?

Great Lakes Environmental Infrastructure Center

https://gleic.org/

National EFC Network

www.efcnetwork.org

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https://www.epa.gov/sites/default/files/2015-06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf

USEPA Decentralized Wastewater Technology Fact Sheet: Aerobic Treatment Units.
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