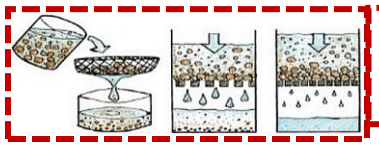
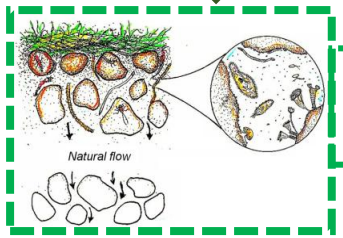
Slow Sand Filter is Ecological Purification System.

Part 5.

EPS 2025-OBW
Nov. Part 5:41-48
8 slides



Slow Sand Filtration

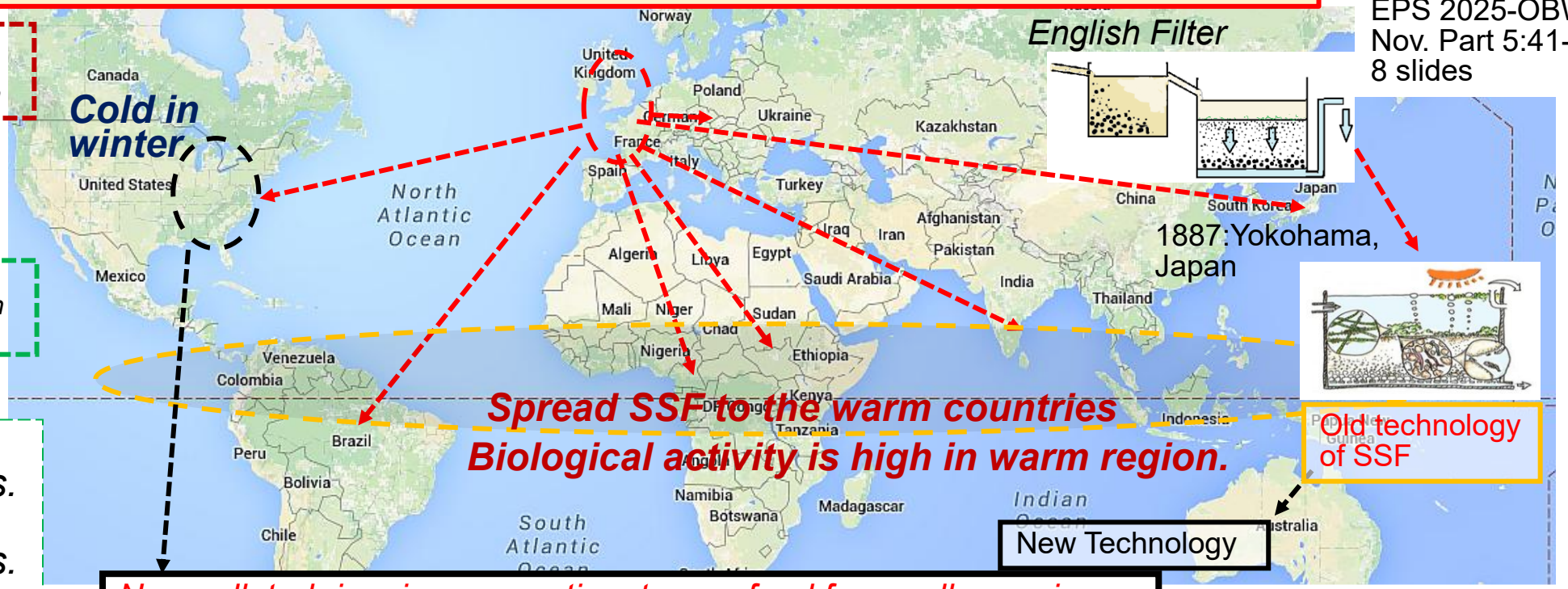


Ecological Purification System

***Slow** means gentle for small organisms.*
***Sand** is just habitat for small organisms.*
***Food Chain** is the key.*

Key is Gentle for Small Organisms.

Non-polluted water contains fine SS and poor food for small organisms in continent rivers in USA.

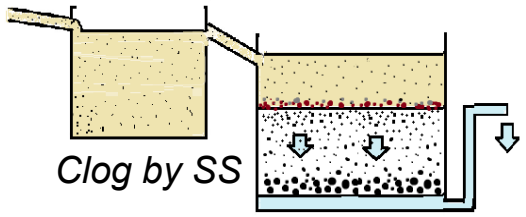


Non-polluted river in new continent: poor food for small organisms
1882: NJ, USA, Coagulation treatment : Origin of Rapid sand filter
1910: NJ, USA, Chlorine treatment Completion of **American Filter**

Rapid Sand Filter is chemical treatment.

Fine much suspended solid

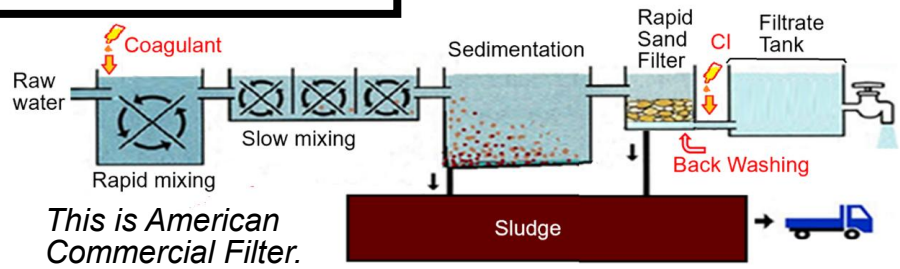
*Biological **activity** is weak in winter.*



Clog by SS

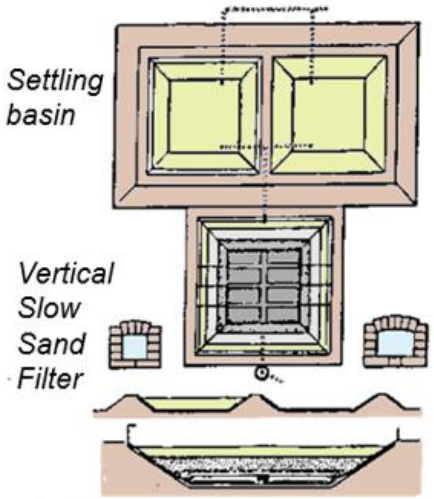
Does not settle.

Filter easy to brock by suspended solid.



This is American Commercial Filter.

People loves new technology. → RSF spread to the world.

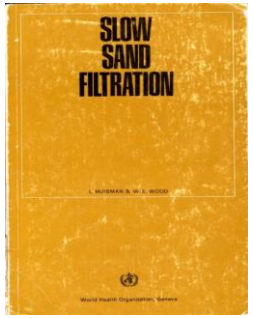


The filter rate was 2-3 m/d (10cm/h).

38 cm	Water depth
61 cm	sand layer
61 cm	gravel layer

*Simpson filter in 1827 is **38 cm**.*

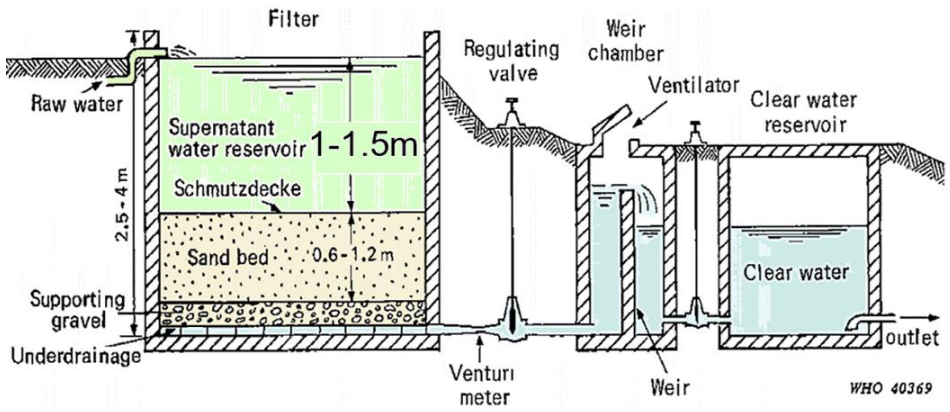
Shallow depth



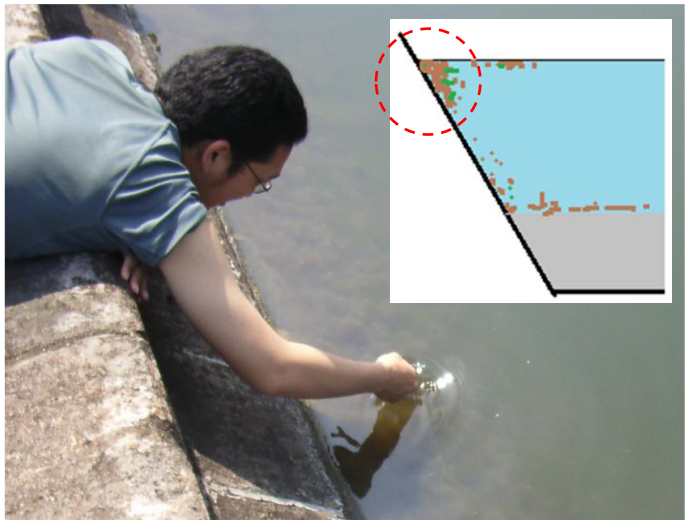
Huisman & Wood 1974: WHO manual of Slow Sand Filtration for safe drinking water

*WHO manual 1974 Water depth is **1-1.5 m**.* ***Deep depth***

Huisman & Wood didn't notice the role of algae.



Algae grow well on the shallow river bed even in cold winter.

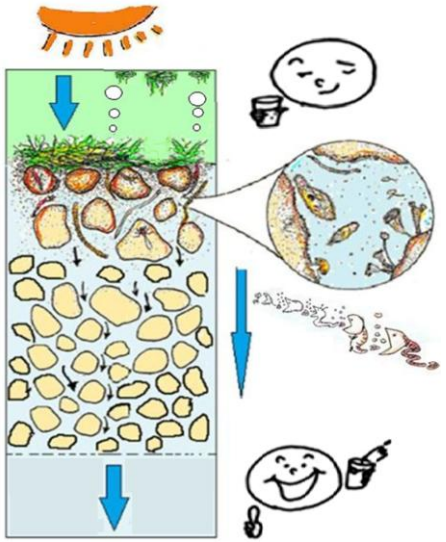


Algae grow well on the shallow slope of a slow sand filter.

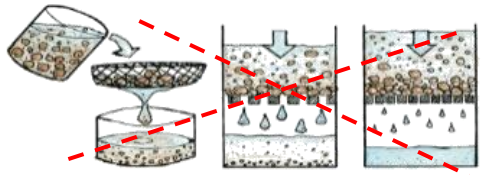
Shallow depth activates algal photosynthesis and other biological activity.

No growth on the deep filter bed.

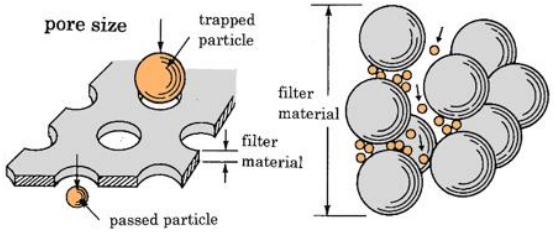
Algae grow well in shallow model.



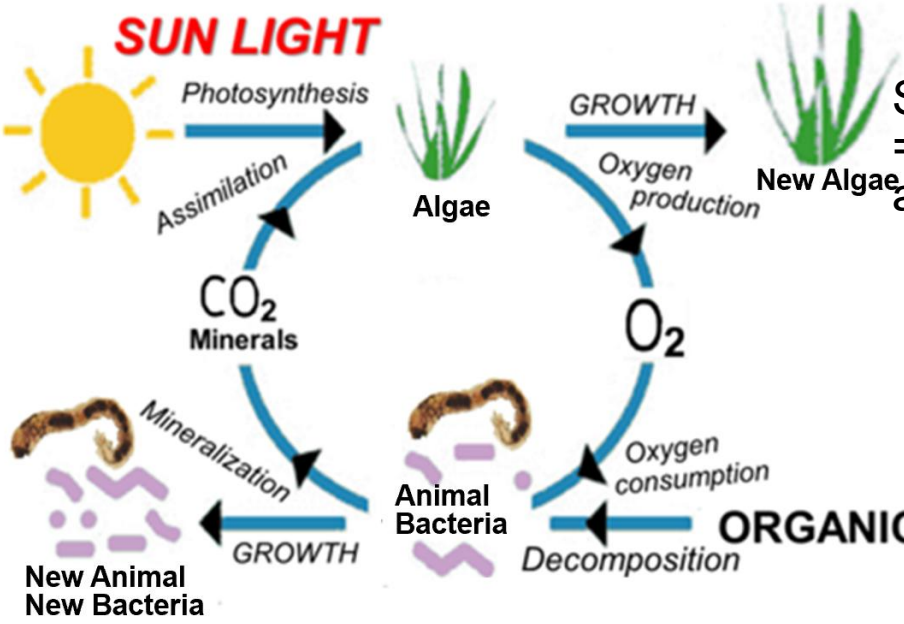
Shallow depth is the key.



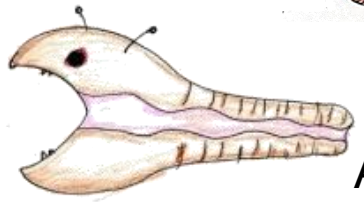
SSF is not mechanical filter.

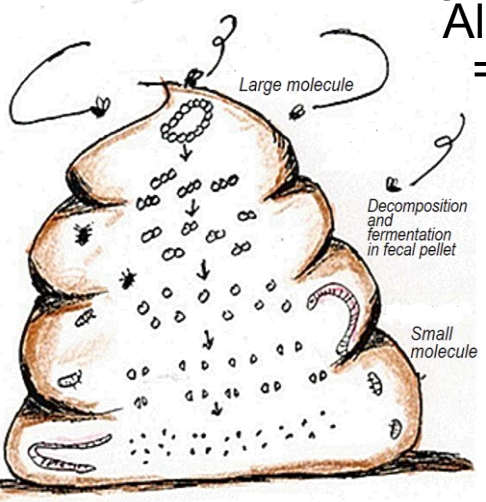


This is not mechanical reduction.

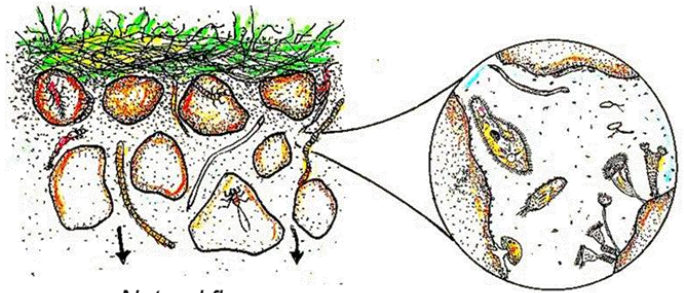


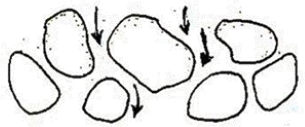
Shallow depth =better for algal growth





Algae=food for small animal
Algal growth : photosynthesis
=oxygen production
=aerobic condition
=gentle for animal activity



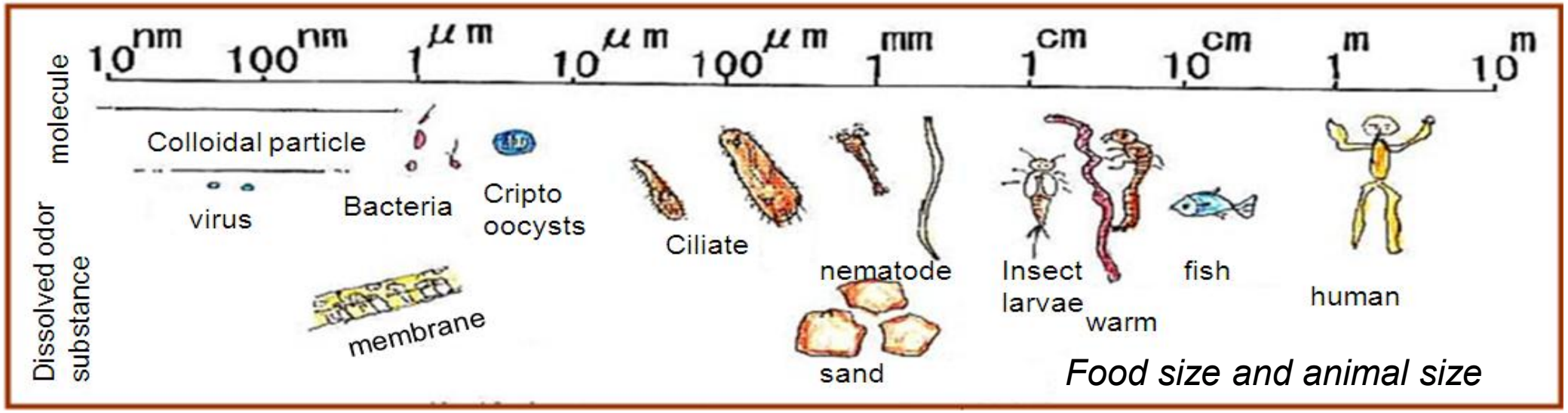


Large molecules are broken to small molecules under anaerobic condition in fecal pellets.

Key is Food Chain.

This is an Ecological Purification System.

Food chain among small animals is the key for purification system.



Food size and animal size

Hungry creatures are important to trap any particles under gentle condition.

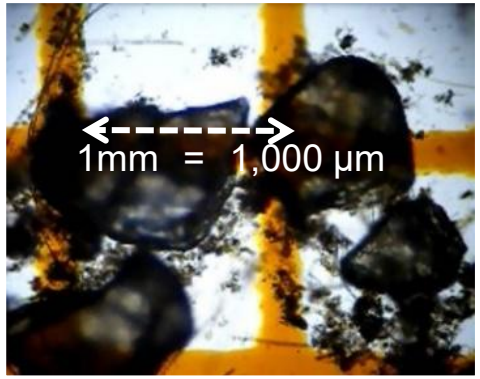
Short time work

Passing time of food in body is also very short.

Long term action

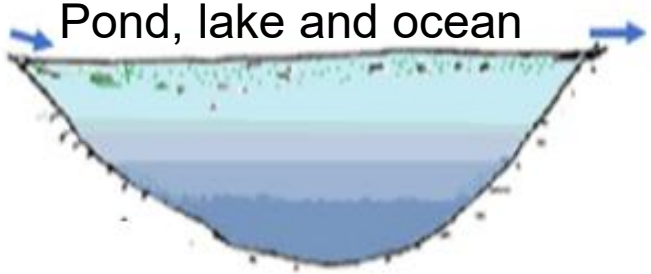
Complete decomposition (mineralization) in the faecal pellet.

Anaerobic condition inside of fecal pellet.



Different type of algae grow in different water environment.

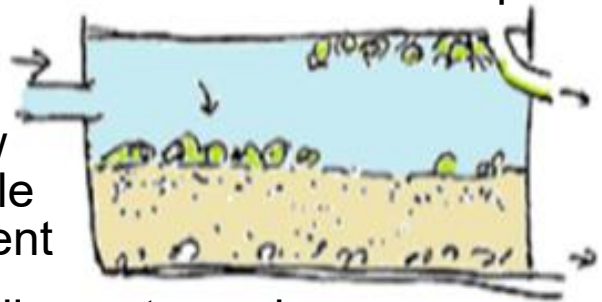
Pond, lake and ocean



Stagnant water

There is down ward current from surface in slow sand filter pond.

Slow gentle current

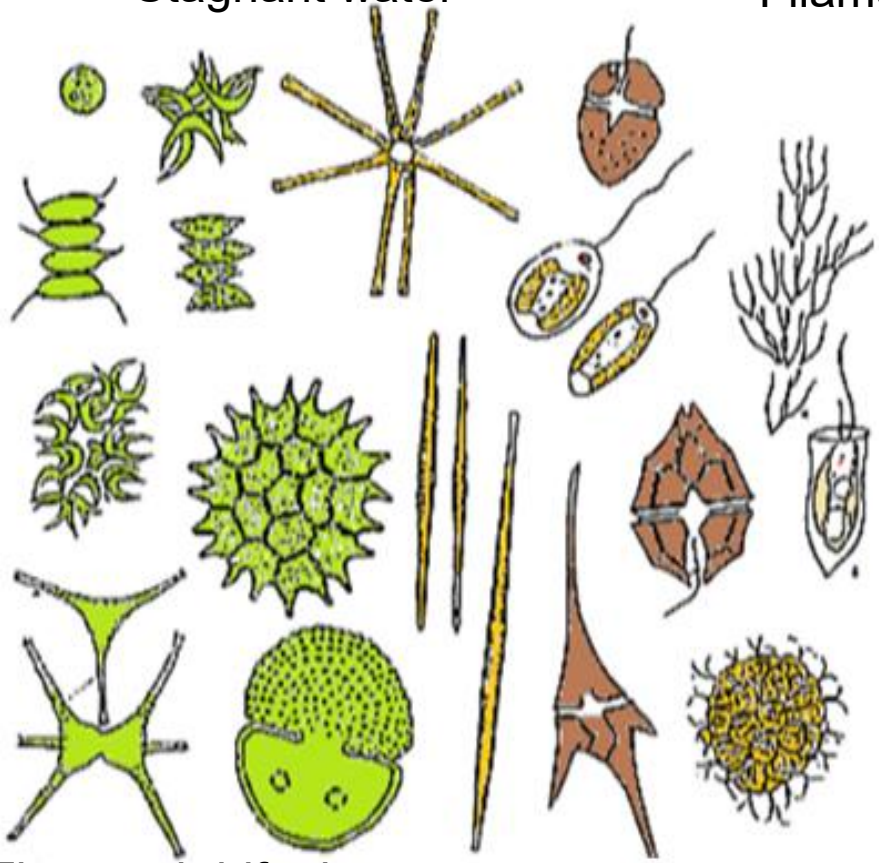


Filamentous algae can grow.

Stream, river

Horizontal running water

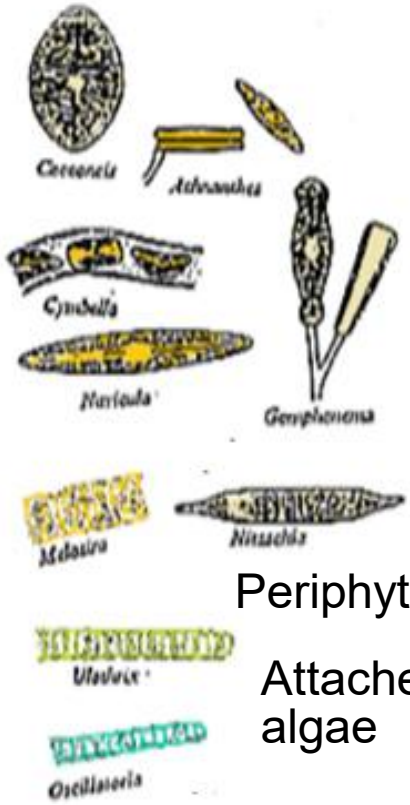
Occasional storms and rapid currents.



Float and drift algae
Phytoplankton

Flagellated algae

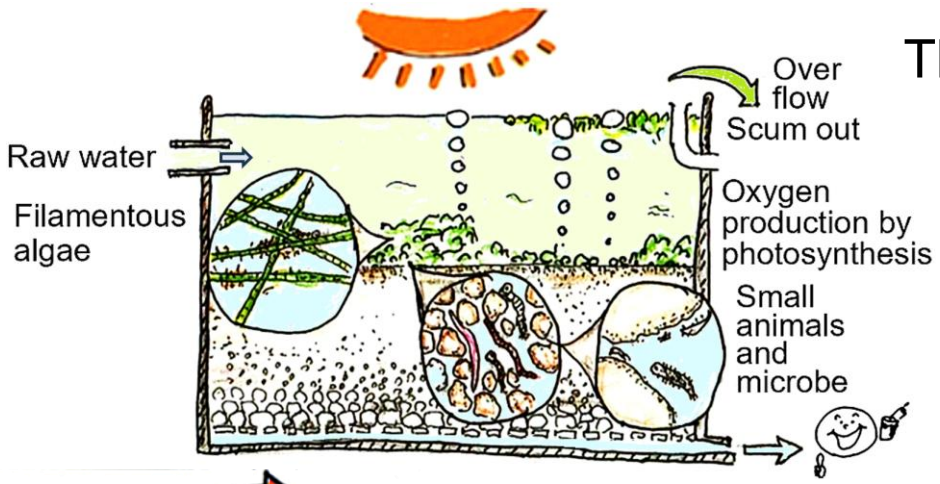
Filamentous algae



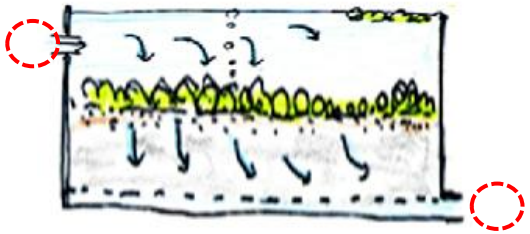
Periphyton

Attached algae

Aerobic condition is essential for biological community.



There is down ward current.

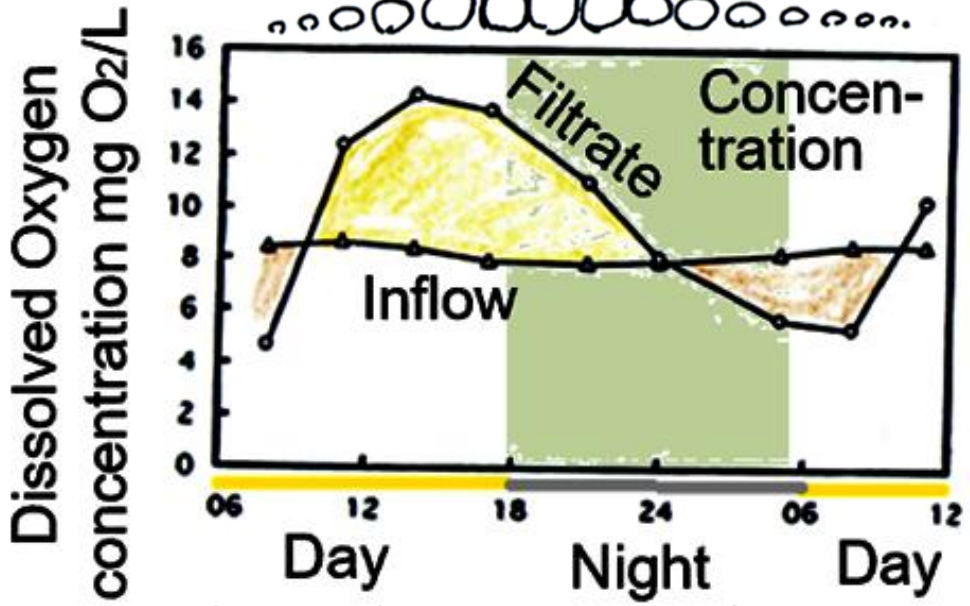


Diurnal change of dissolved oxygen (DO) was measured.

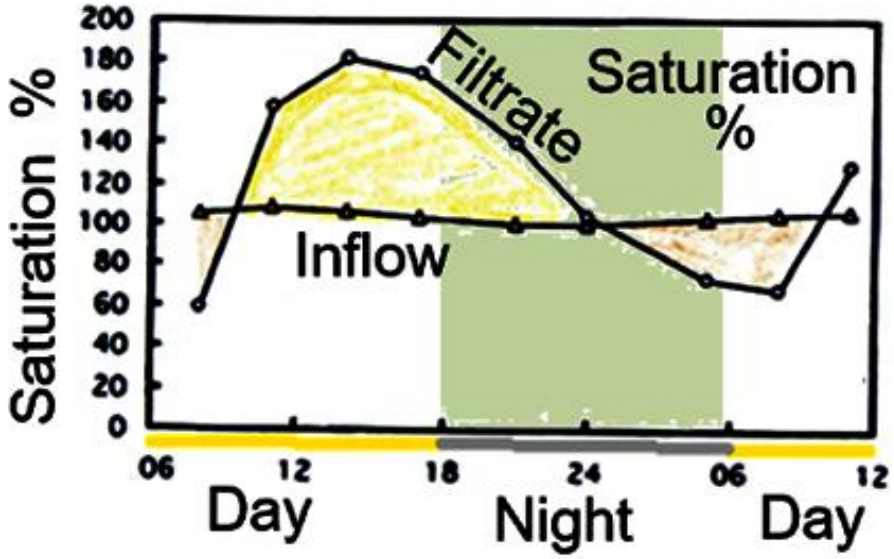
$CO_2 + H_2O \rightleftharpoons CH_2O + O_2$

20% 40% 20%

Partial pressure of oxygen in bubbles was also measured.



Soon after sun rise, DO in filtrate was rapidly increased.



Even after sunset, DO in filtrate was super saturated condition.

Shallow depth is key.

Algal photosynthesis accelerates purification process by small communities and keeps aerobic condition even in night time.

We presented role of algae in SSF at International conference in Spain in 1992.

https://www.tandfonline.com/doi/abs/10.1080/03680770.1992.11900544?journalCode=tinw19

https://www.tandfonline.com/doi/abs/10.1080/03680770.1992.11900545?journalCode=tinw19

We visited to Thames Water company on 19th of August, 1992. We explained about role of algae in SSF.

After our visit, I investigated the seasonal change of algae in Thames filters in London from 1994 to 1996, 30 years ago.

Nutrient rich Thames water

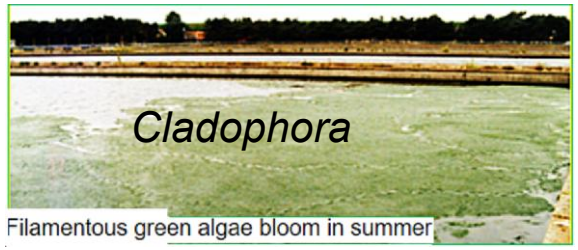
Ashford Common WTP

Biological roughing filter without chemical.

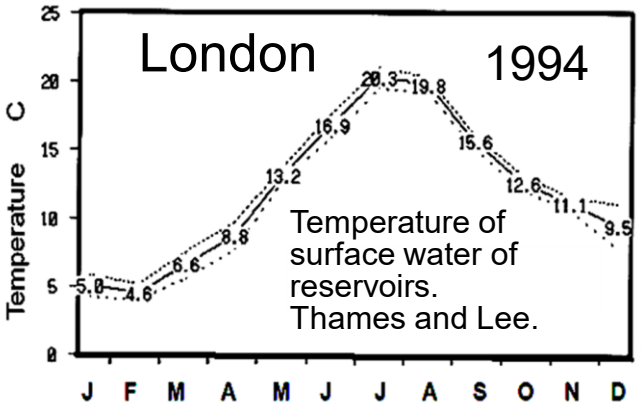
Cupper Mills WTP

100mx35m 32 Filters

100mx34m 34 Filters

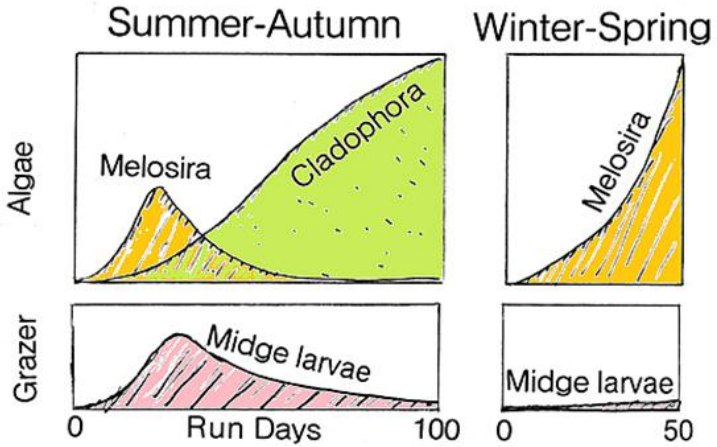


Filamentous green algae bloom in summer



Filamentous diatom in winter

Green algae in summer and diatom in winter in Thames filters.



Diatom to Green algae in summer is due to grazing activity.

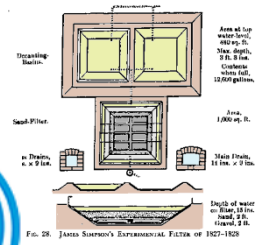
About higher flow rate of Thames filters

Since your visit (Aug. 1992) we have added DO and turbidity monitoring on the outlet of all SSFs.

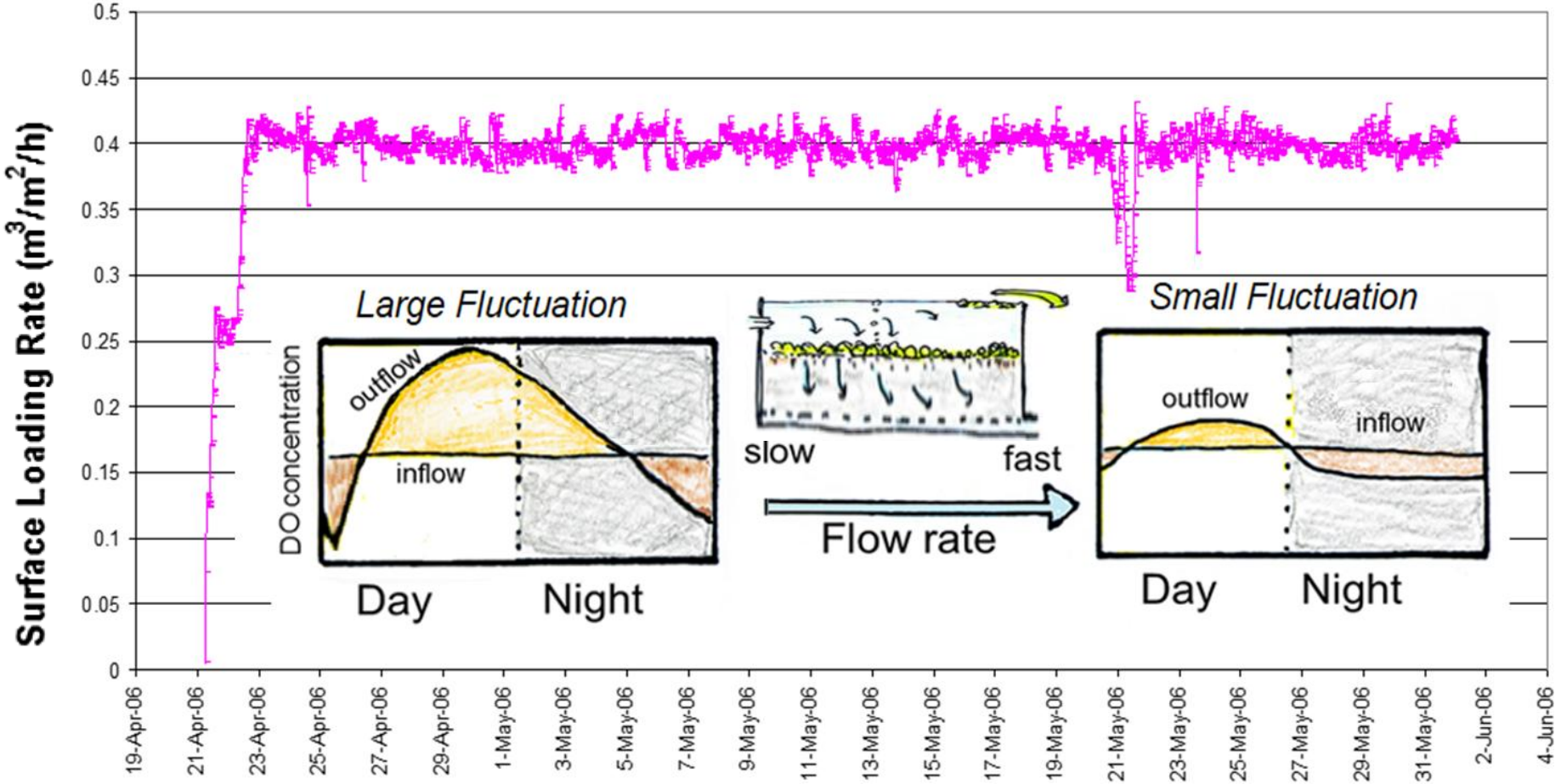
Thames Water's asset standard says we can operate up to **0.5 m/h** (**12 m/d**), but in reality, we are usually in region of 0.25 to 0.35 m/h, but we can reach 0.4 m/h occasionally if we have to. We do have keep a careful eye on dissolved oxygen (DO).

2025/03/18

Dr. Michael Chipps
Principal Research Scientist



Surface Loading Rates for a SSF at Ashford Common during April and May 2006



Aerobic condition is essential for hetero-tropic organisms in the sand layer.

The filter rate was 2-3 m/d (10cm/h).

38cm water depth

200yrs ago

4.8 m/d (20 cm/h)
World wide English Standard Filter rate

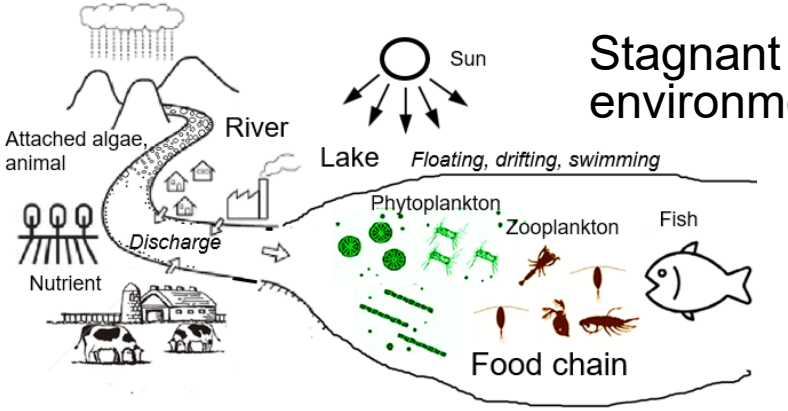
The filter rate of 0.4 m/h (9.6 m/d) is adopted in Thames filter plants in London to escape oxygen drop in filtrate during the night time.

Faster flow rate is better for small organisms in the filter.

Hungry condition is normal.
Living things are always ready to grow.

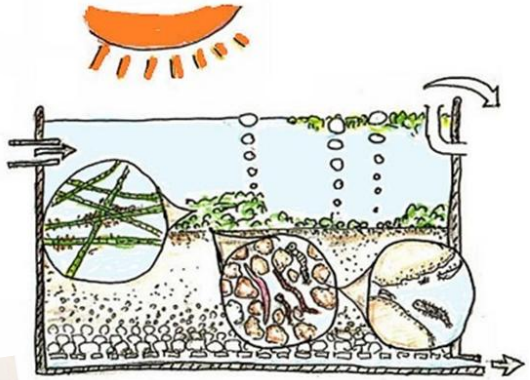
Part 6.

EPS 2025-OBW
Nov. Part 6:49-56
8 slides



Stagnant environment

Running environment



In places where the environment changes, biological communities suited to the new environment become active.

Living things are always ready to grow.

The boundary between river and lake or land and lake.

There is a transition site. Suitable organisms grow at new environment.

All living things are in a hungry condition, always waiting for an opportunity to reproduce.

1974, Broa (Lobo), São Carlos, São Paulo, Brazil

Broa reservoir

Clean delicious spring water

Clear subsurface water in a river bed

Dirty materials are broken passing through the soil or sand layer by biological activity.

Dissolved Oxygen is important.

Covered filter: Iizuna, Nagano, Japan from 1974(S49).

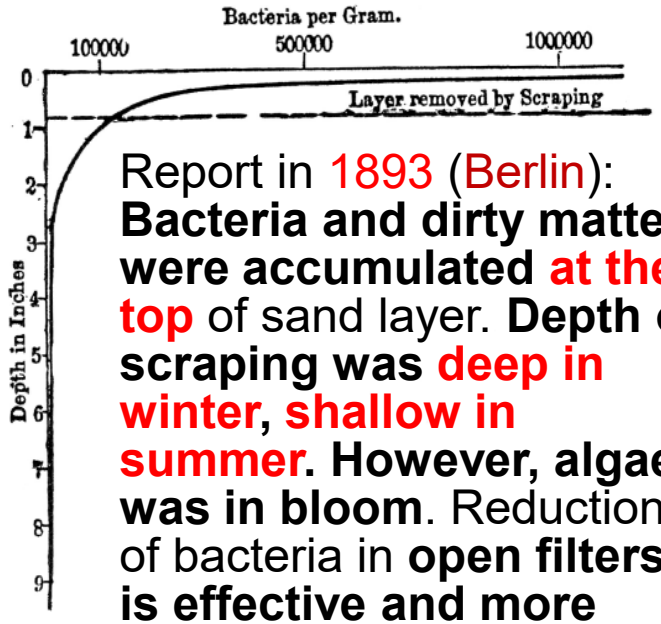
Made windows for solar radiation.

Biological activity was increased. Filter resistance was decreased.

Covered filter from 1849, at Albany, NY, US
Microscopic organisms play an active role in the covered filter.

Covered filter: Otaru, Hokkaido, Japan from 1927

I remember the explanation of Baker's book "The Quest for pure water" in 1949.



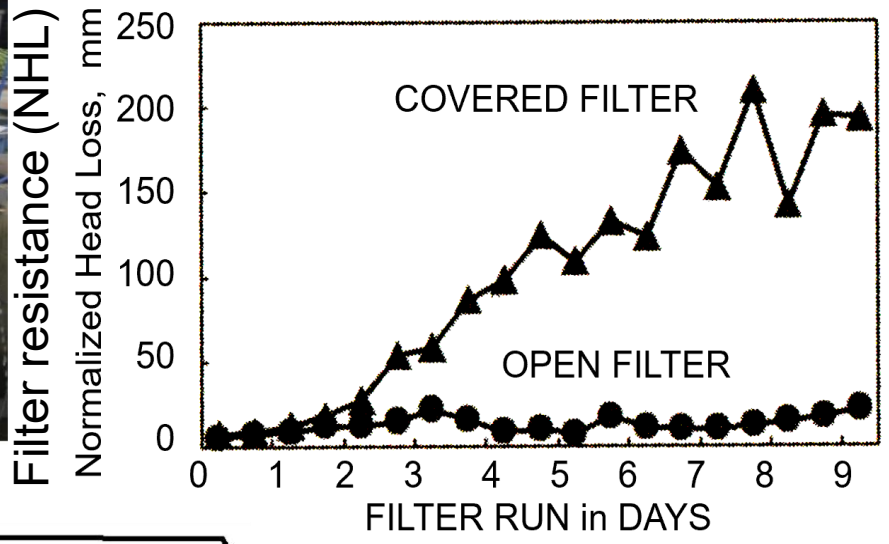
Report in 1893 (Berlin): **Bacteria and dirty matter were accumulated at the top** of sand layer. **Depth of scraping was deep in winter, shallow in summer. However, algae was in bloom**. Reduction of bacteria in **open filters is effective and more clear filtrate** water in comparison with open and covered filters during 20 years.

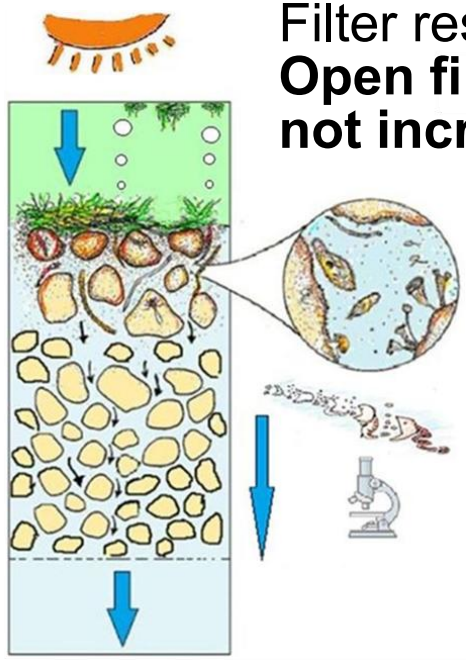
Filter resistance of **Open filter did not increase.**

This means performance is due to biological activity.

Effect of open filter and covered filter.

Ueda, Nagano is cool region. Water temperature is about 20 C even in summer.

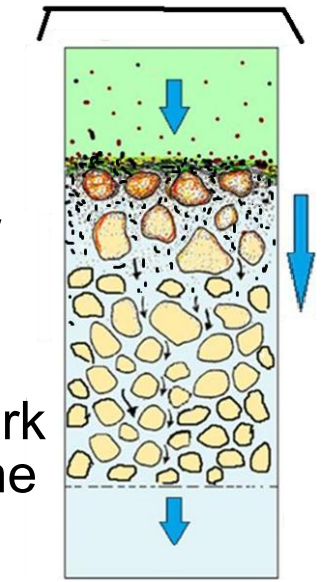




Filter resistance of **Open filter did not increase.**

Algae grow well.

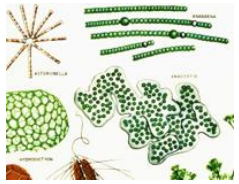
Grazing animals work well near the surface.



Filter resistance of **Covered filter increased** almost every day.

There is no growth of algae and is little food for grazing animals.

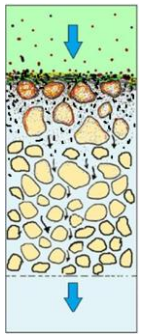
SS accumulated on the sand surface and resistance gradually increased.

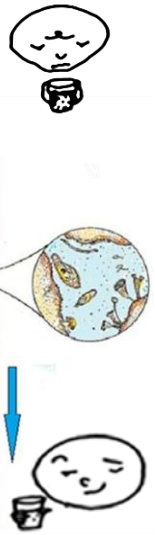



Algae had been trouble for the rapid sand filter in US. Taste and odor algae, filter clogging algae are big trouble in water supplies in US.

They believed SSF removed turbid particles with fine sand.

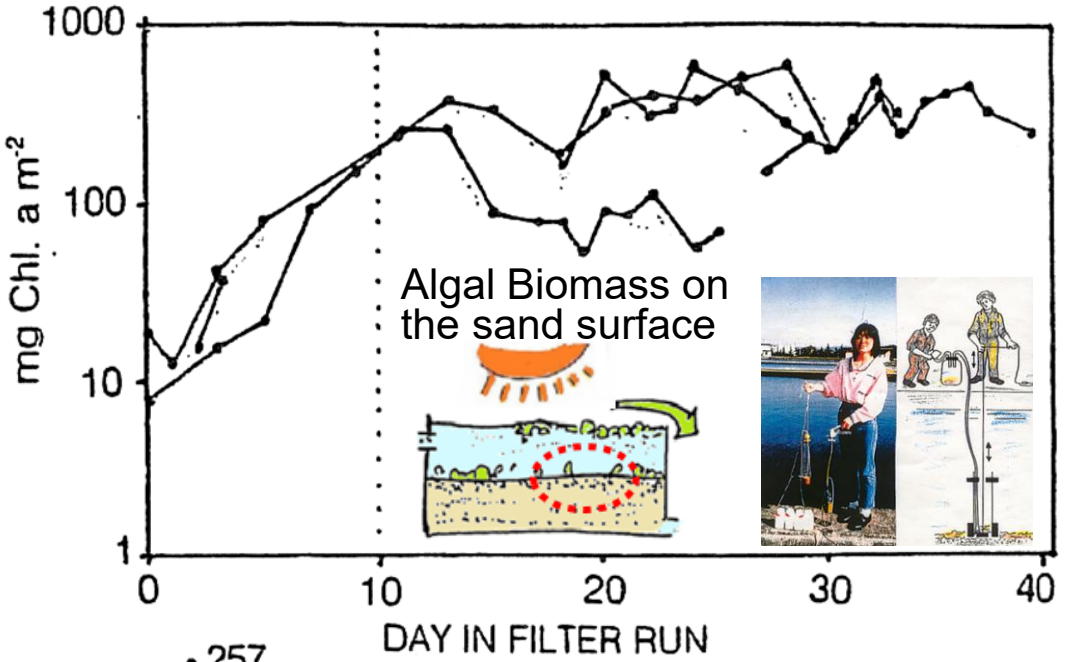
However, dissolved odor substances pass through.



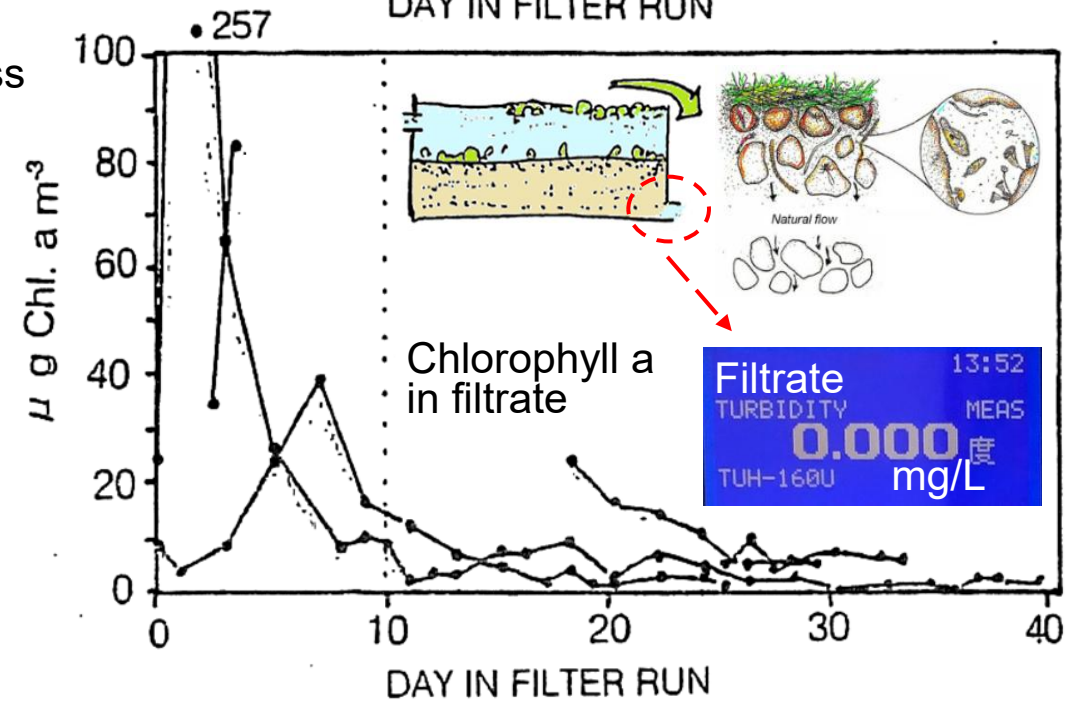


Filtrate is purified by biological communities.

I confirmed the effect of algal growth on the filter bed during filter run.



Algal Biomass on the sand surface



Chlorophyll a in filtrate

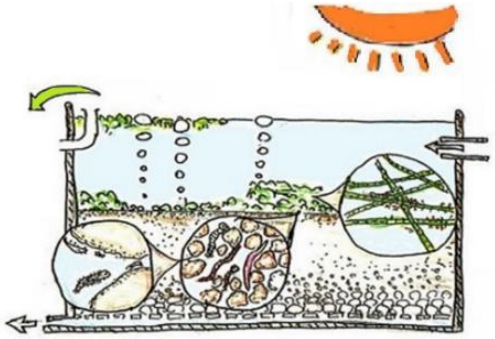
Algae grow well in summer. Continuous culture system of filamentous Algae becomes after 10 days.

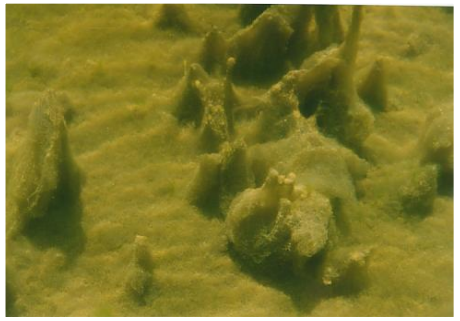
Scrapping of surface mud is not necessary in warm summer.

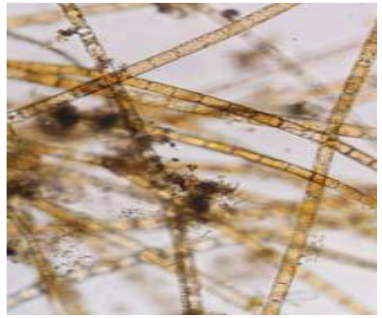
Filtrate water became clear water in 10 days. Grazing animal community grew well within 10 days.

Japanese standard filtrate is 2 degrees (mg/L).

Super clean filtrate.

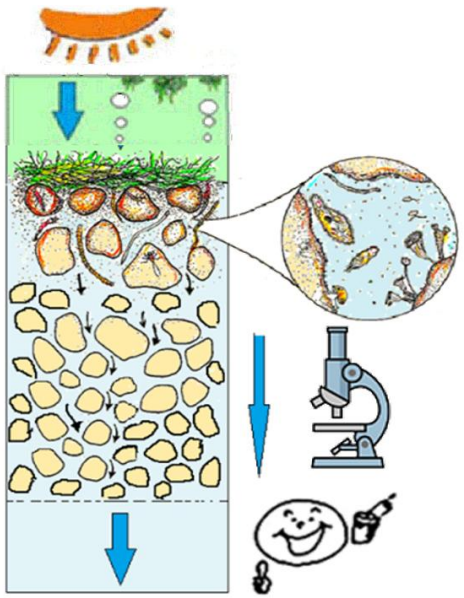






The filamentous diatom *Melosira* grows predominately and develops into a cotton-like shape on the sand surface.

The algae mat floats along with the inflowing turbidity due to the buoyancy of oxygen bubbles caused by photosynthesis. Outflow from overflow pipe. It becomes a continuous culture system. It also serves as an automatic garbage collector.

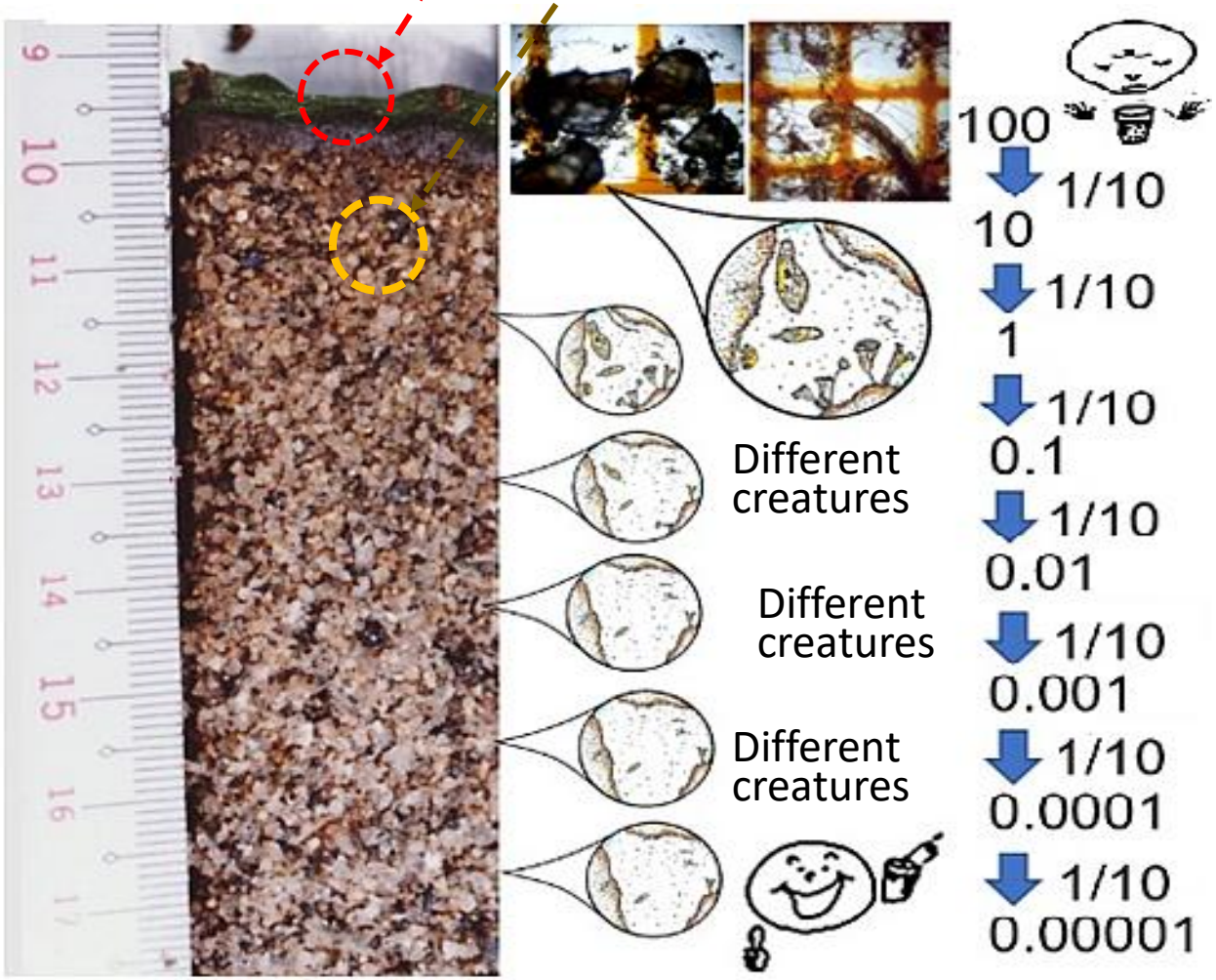


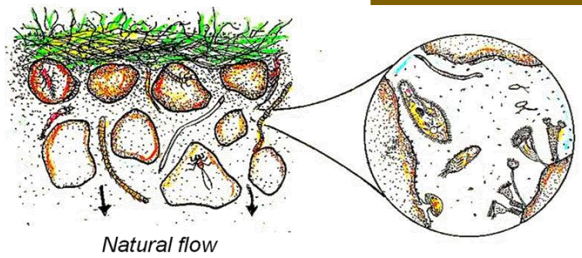
The sand in water is clean and uncontaminated.
⇒The sand gets dirty because the water is pulled down.

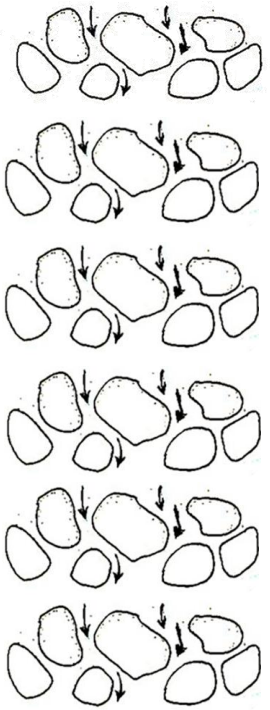
The sand layer is similar to the forest soil profile. Food for organisms comes from the surface.

Organisms living on the surface and beneath it are not the same.
Different creatures are active. Creatures that are suitable for that food will be active.

Vertical flow from top to bottom.
The most important thing is that the sand does not move.





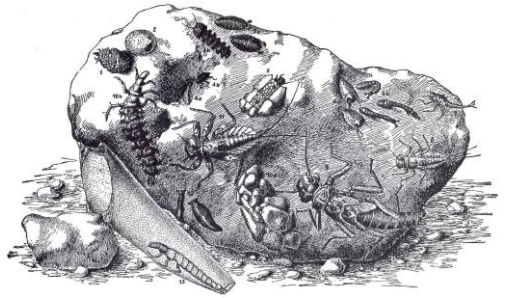


Microscopic organisms that attach to the sand surface can play an active role with peace of mind.

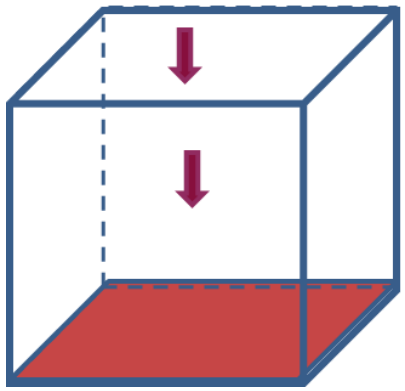
Completely decompose things that can be biodegraded.

Most of small organisms live on the surface of substrata (sand particle) under slow current condition.

They live at the top of sand layer where food comes. They are always waiting for food. They are always hungry.

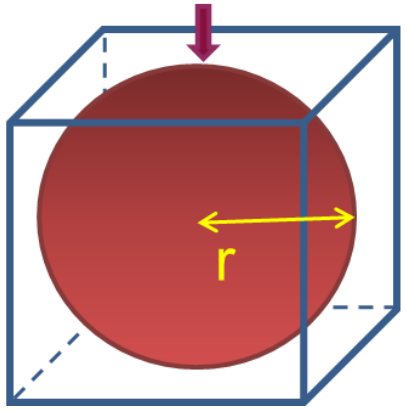


Large surface area is better. Small sand is better.



1

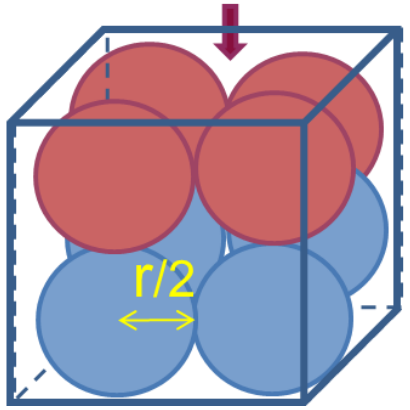
Bottom surface area



radius = 0.5
Surface area
= 4 x π x r x r

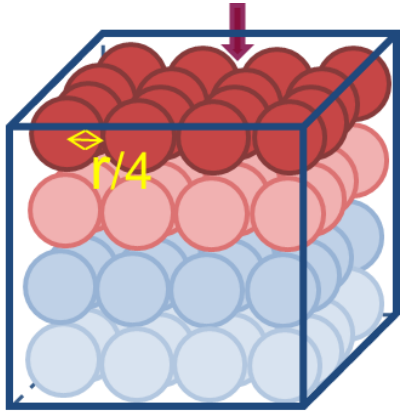
1 ----------> ***= 3.14***

Surface area of a ball is 3.14 times than flat area.



radius = 0.25
Surface area of one ball
= 0.785
8 balls in box = ***6.28***
Total area of top 4 balls

= 3.14 ----------> ***= 3.14***

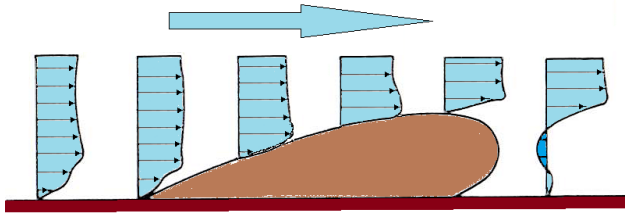


radius= 0.125
One ball area
= 0.196
64 balls in box =***12.56***
Total area of top 16 balls

Total surface area of top layer of balls is always same of 3.14 times than flat area. Smaller ball makes larger area.

And, total volume of balls is always same of 52 % (porosity : 48%) in a box.

Viscosity relates to temperature

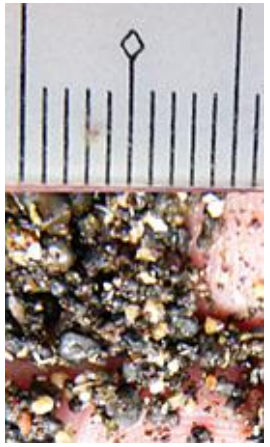


Filter resistance increases toward smaller size of particle.

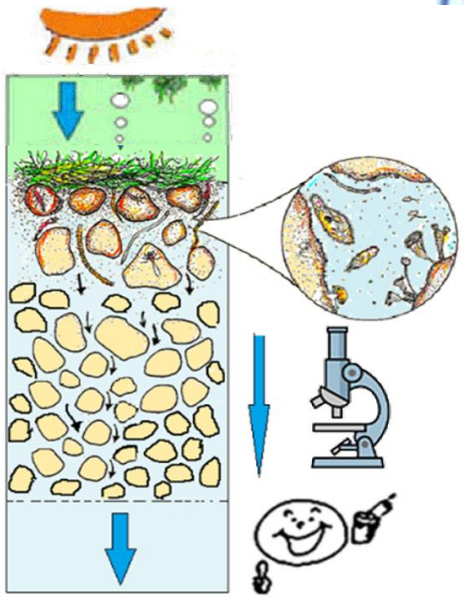
Too small particle becomes a flat surface.

Points: shallow depth, enough radiation on the bottom, rapid growth, even large size of sand.

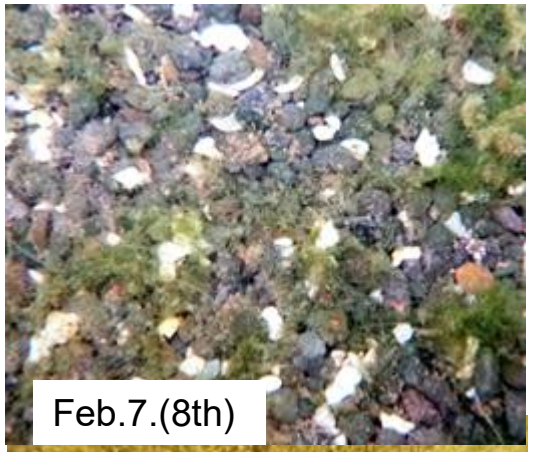
We confirmed the performance using a bucket model in Samoa, tropical island.



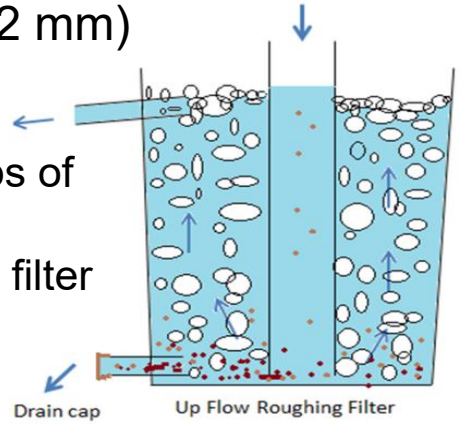
Sand washed and separated with mosquito mesh (1-2 mm)



Shallow depth: Algae grow well.

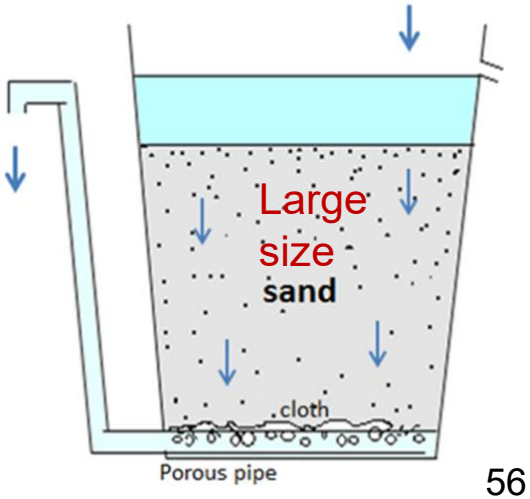


Two steps of up-flow roughing filter



Filter rates **5m/d, 10m/d, 20m/d**

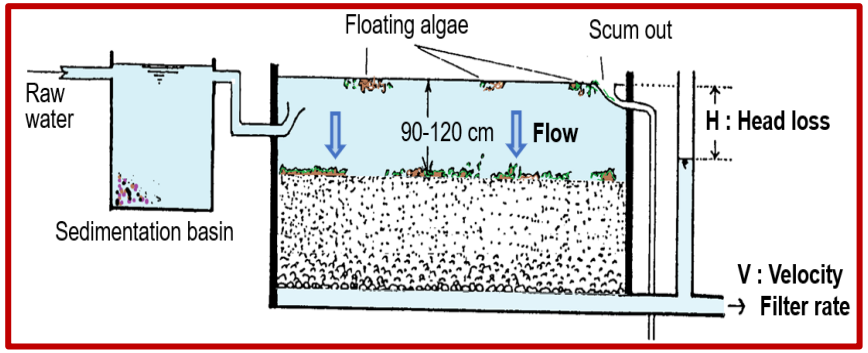
All good quality of filtrates.

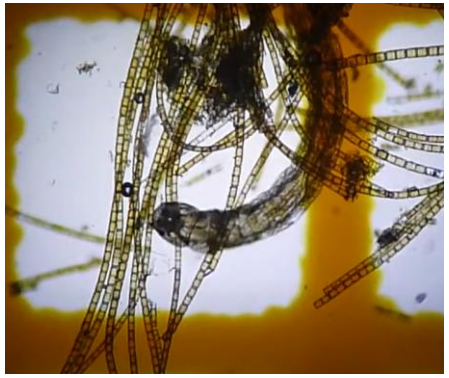


Filter Clog relates to Biological Activity. Filter Resistance relates to Temperature.

Part 7.

EPS 2025-OBW
Nov. Part 7:57-65
9 slides

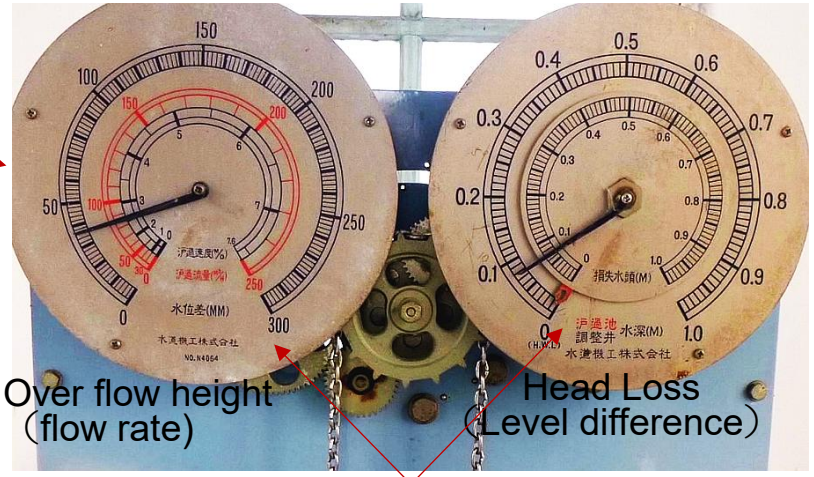




Slow Sand Filter Plant (EPS) in Ueda, and NHL (youtube.com) 4 min

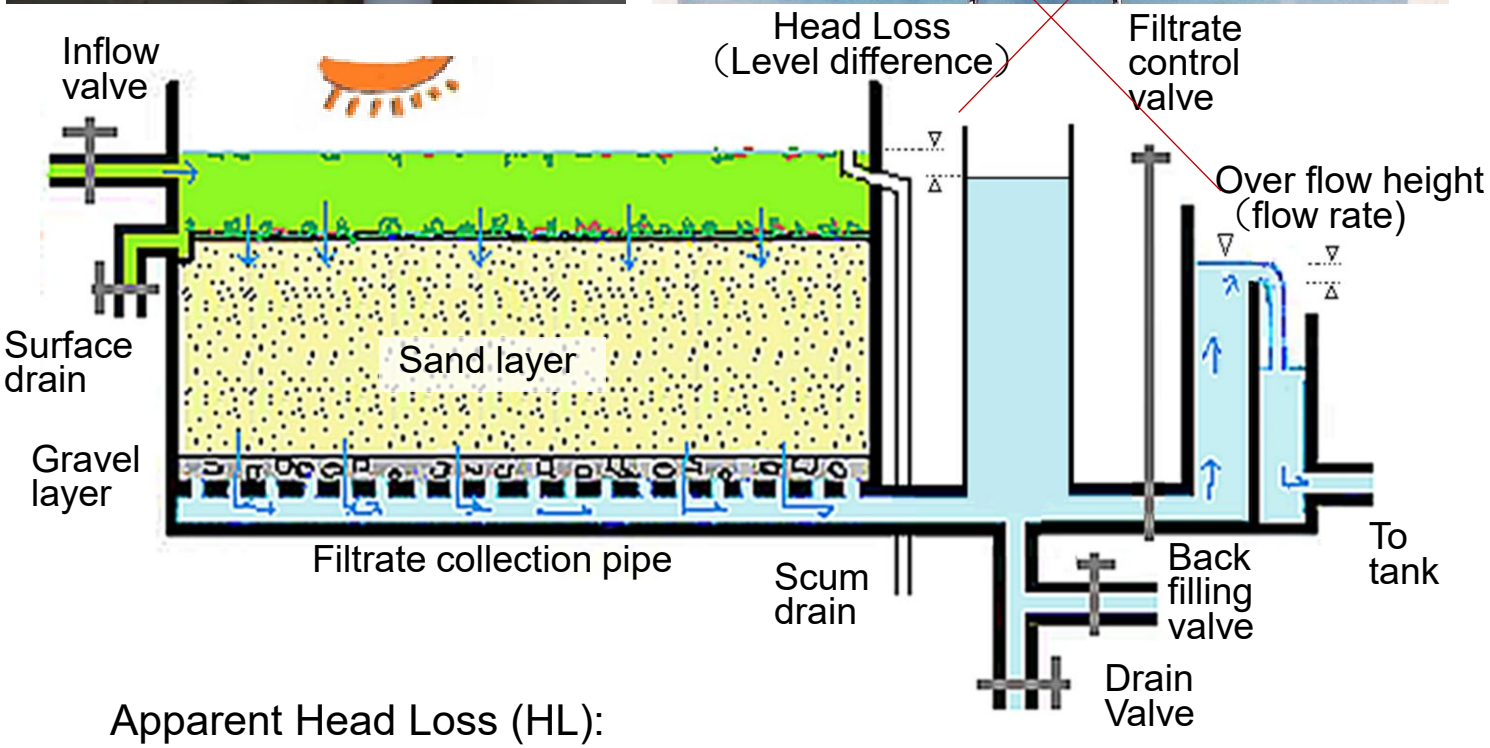
https://www.youtube.com/watch?v=1ixdARf3Tk0&t=15s

Filter resistance : Actual head loss is not an index of filter resistance as it is.



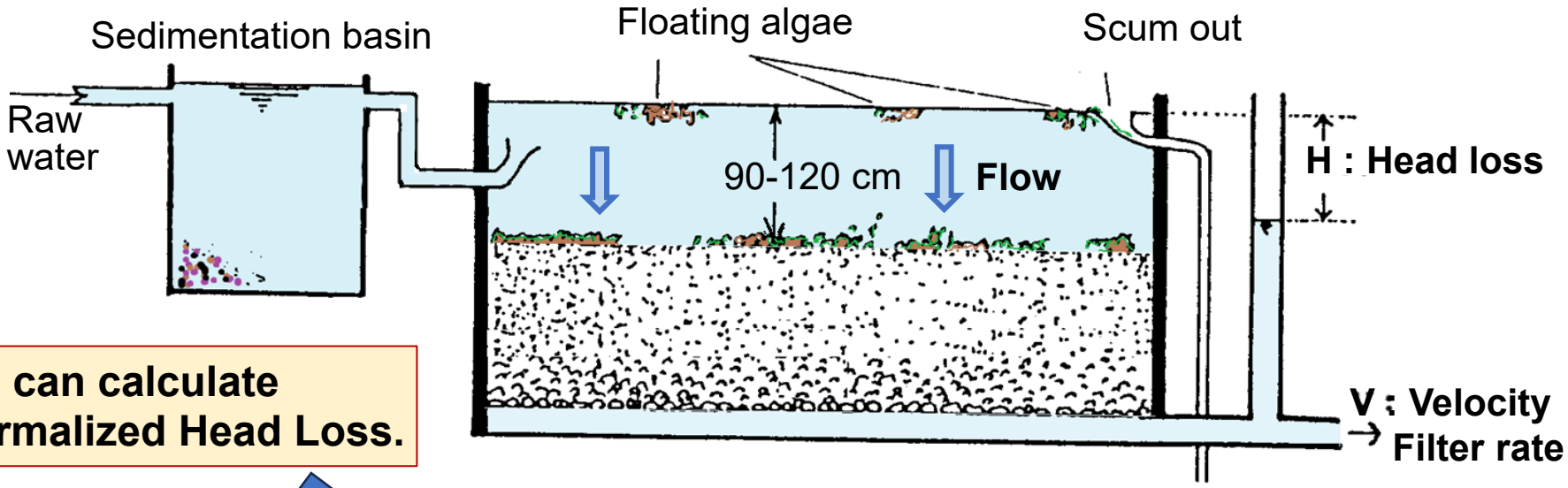
Head Loss relates to flow rate.

Head Loss is proportional to flow rate.



Apparent Head Loss (HL):
=This value is not an index of filtration resistance as it is.
Calculate HL when filtered at standard filtration rate.
= Normalized Head Loss

Clog indicator: Head Loss (Filter Resistance) is proportional to flow rate.



We can calculate Normalized Head Loss.

Over flow height (flow rate)

Head Loss (Level difference)

Actual velocity rate

Actual Head loss

Clog indicator: Actual **Head loss** （H : cm）

Actual Head loss (H : cm) is proportional to **actual velocity rate** (V : cm/h or m/d). H = k x V

Normal velocity rate (Vn) is 20cm/h (or 4.8 m/d).

NHL (Normalized Head Loss：Hn) at Normal velocity rate (Vn：20 cm/h or 4.8 m/d)

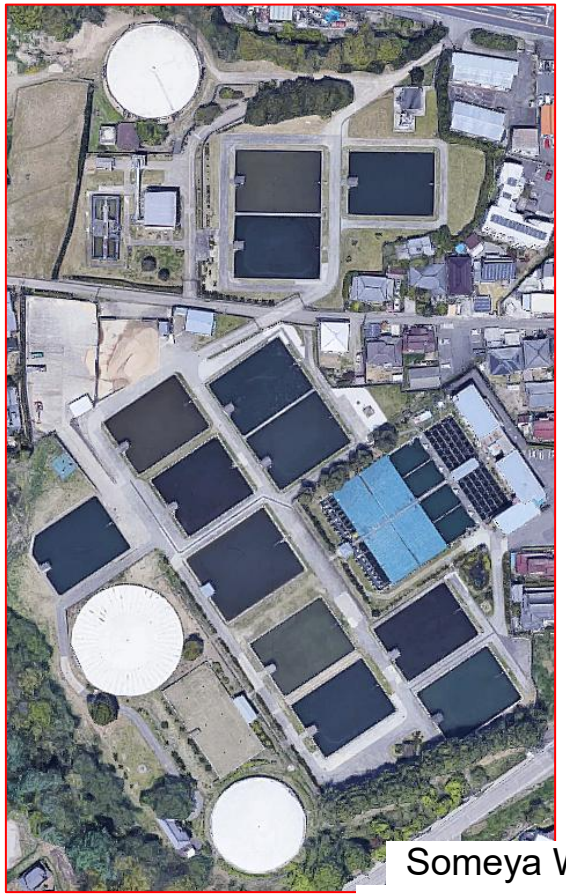
NHL (Hn) at Normal velocity rate (Vn) can be calculated by the Actual head loss (H) and the observed actual velocity rate (V : cm/h or m/d).

Hn=k x Vn （Hn ÷ Vn = k）, H = k x V （H ÷ V = k）

Hn ÷ Vn = H ÷ V

NHL(Normalized head loss: Hn)：Hn=(H x Vn) ÷ V

Someya WTP in Ueda, Nagano founded in 1923.



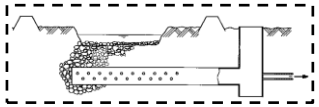
Original 3 filters was constructed in 1923

Someya WTP

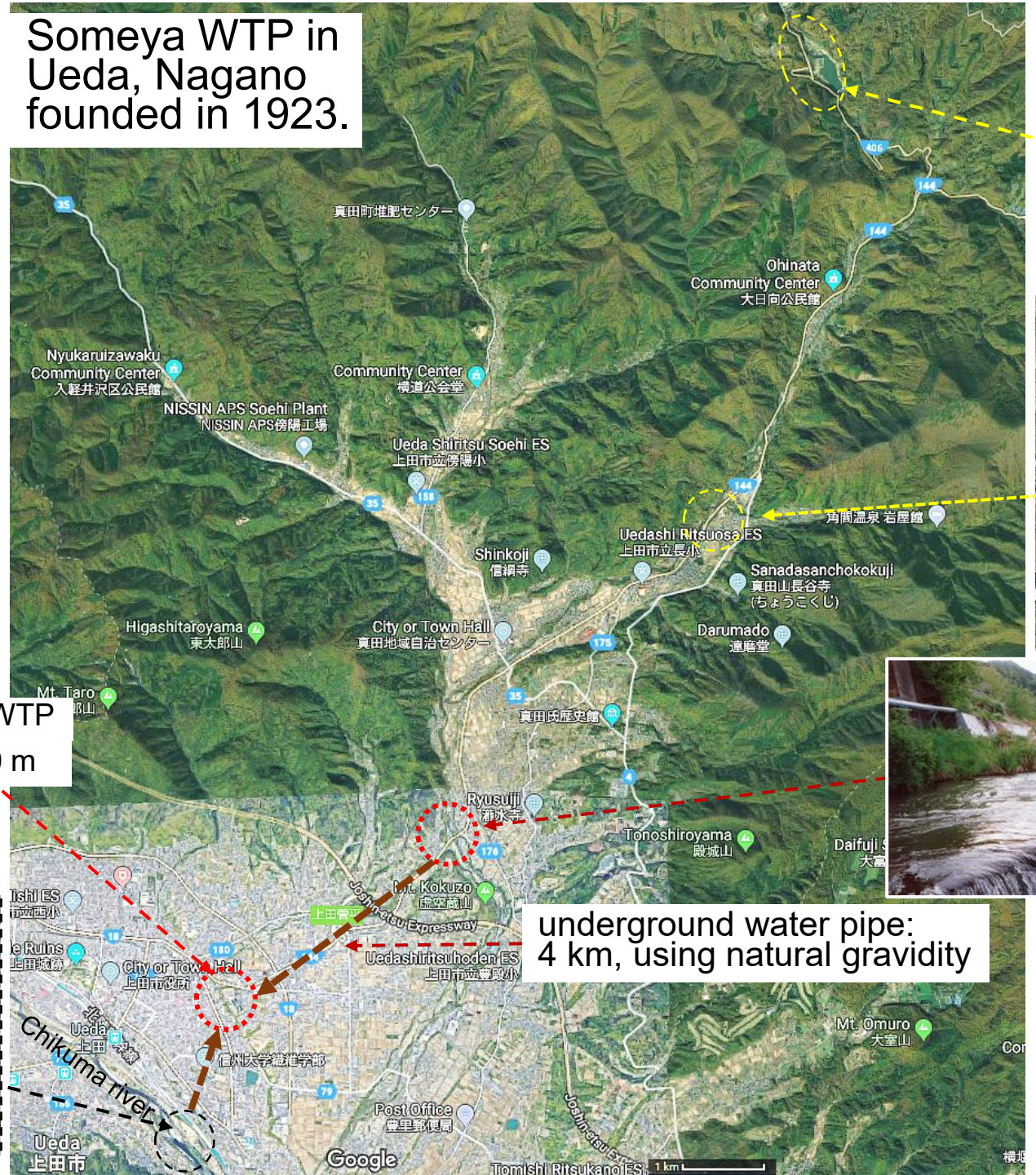
Altitude 500 m

Original intake of subsurface water in 1923, pump up to WTP.

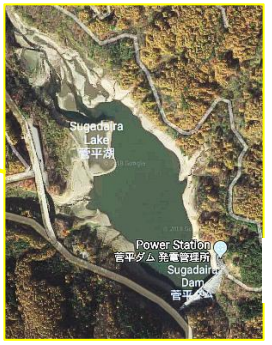
Pump up



Altitude 450 m



underground water pipe:
4 km, using natural gravidity



Sugadaira reservoir Construct in1968

Altitude 1,140 m

Ishifune WTP In 1969

Altitude 700 m

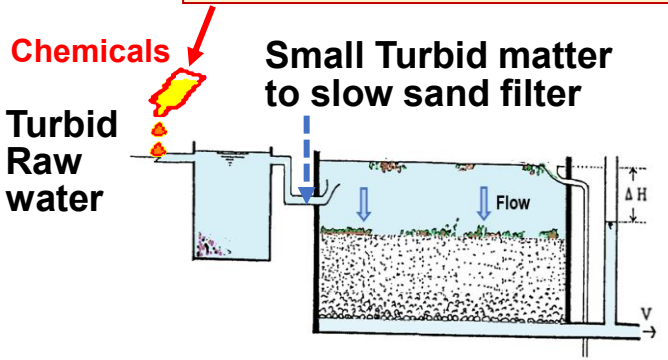
New intake of surface water for Someya WTP from 1953.

Altitude 600 m

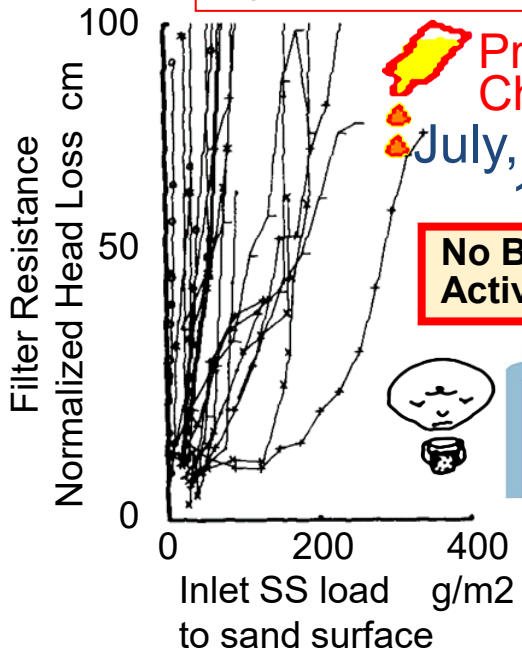
Algicides(chemicals) and filter resistance

In rapid sand filter, it was common knowledge to add chemicals that biological communities dislike. Chemicals were also added during slow filtration in biological treatment.

At Someya Water Purification Plant, pre-chlorination and copper sulfate were added as algaecides to suppress algal growth.
Then, the filters clogged easily.
There was also a problem with the smelly tap water.



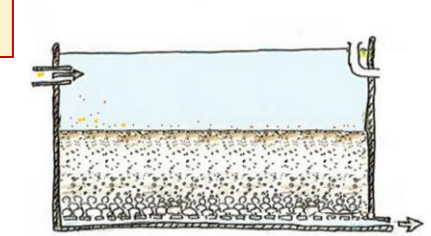
High solar radiation and high temperature period

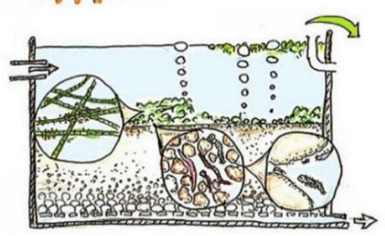


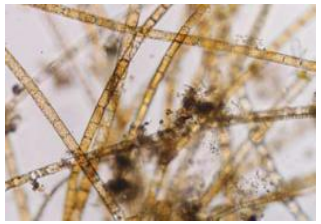
Quickly blocked with small turbid matter.

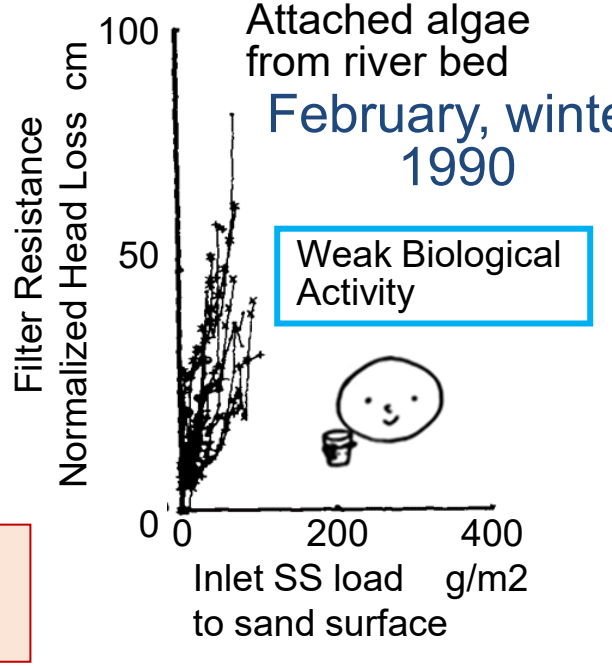
Weak radiation, Low temperature In cold period.

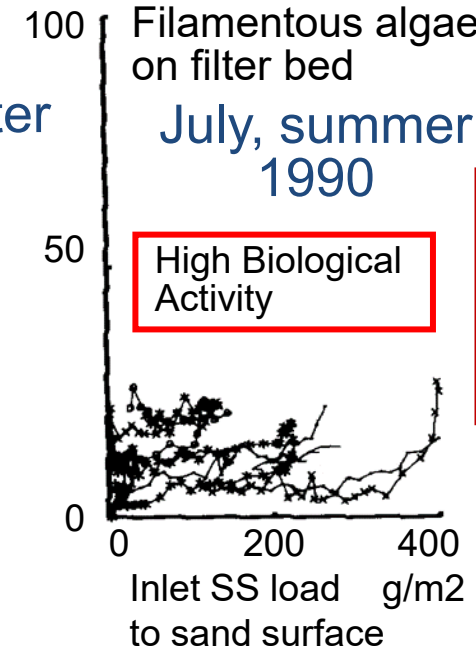
High radiation, High temperature In warm period.



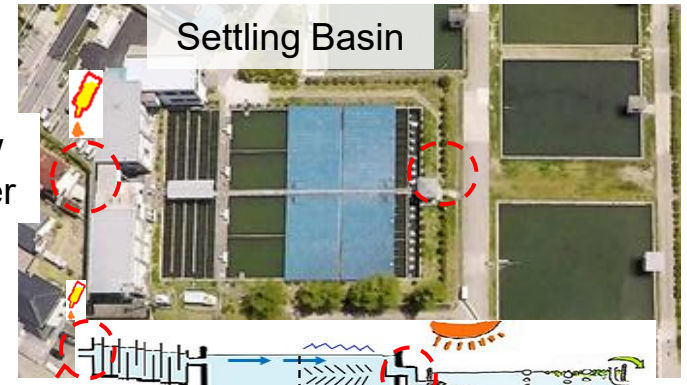






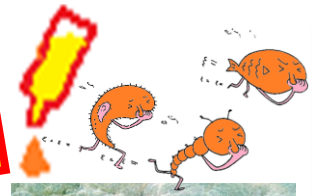


Filter did not blocked with turbid matter.



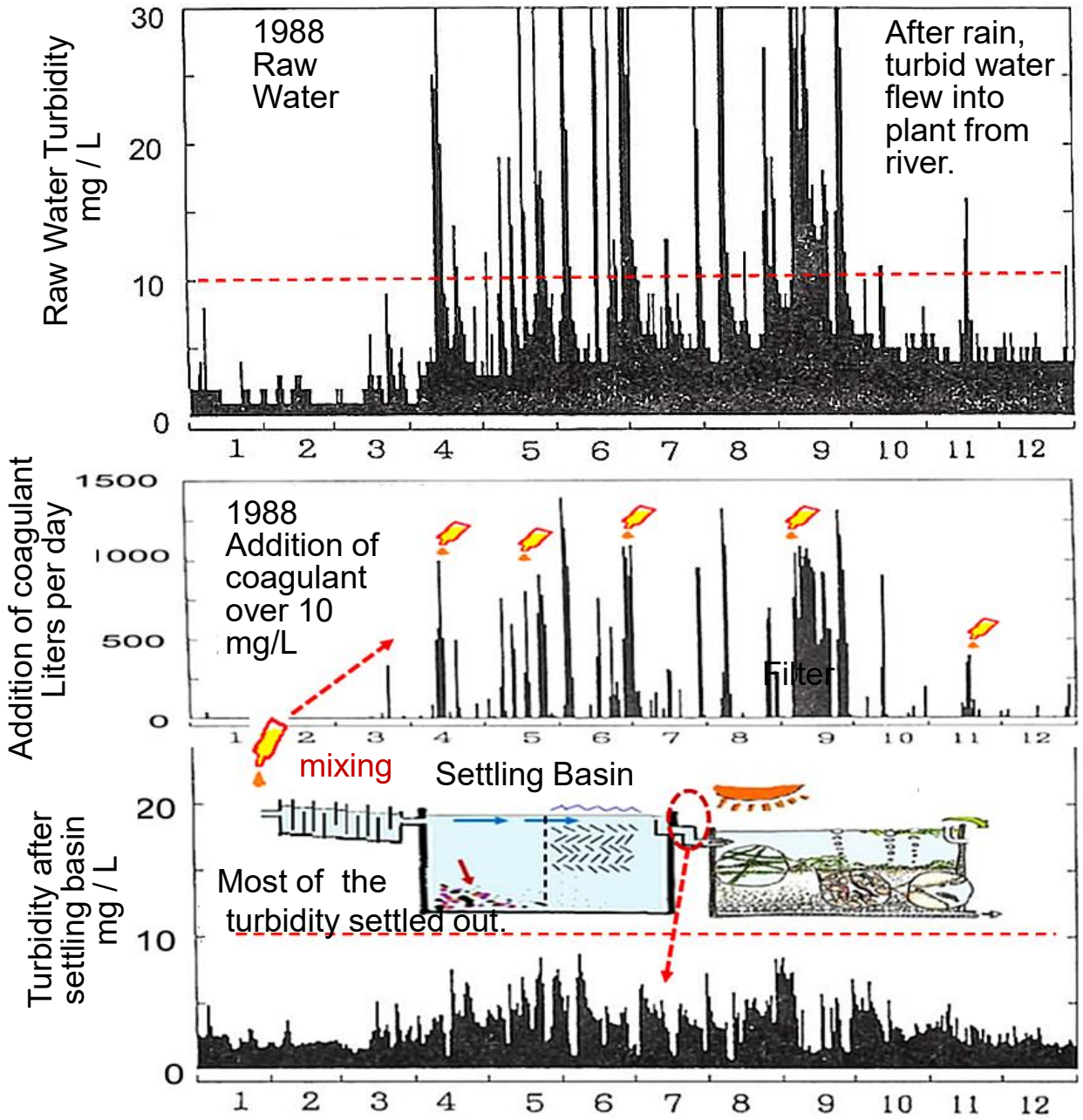
Addition of coagulant over 10 mg/L

Algae grow even small turbid water



Water became **clear** but algal mat **was covered with white powder.**

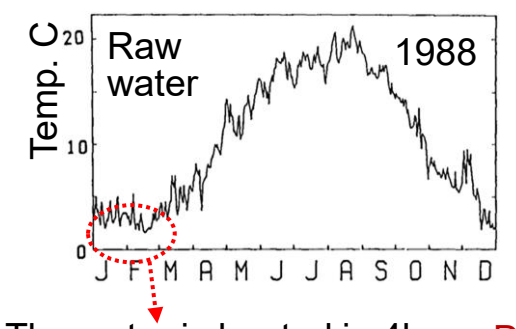
Stop algicide



At the Someya Water Purification Plant, even when turbid water came, the turbidity of the inflow water to the filter was reduced to below 10 degrees due to the sedimentation basin alone.

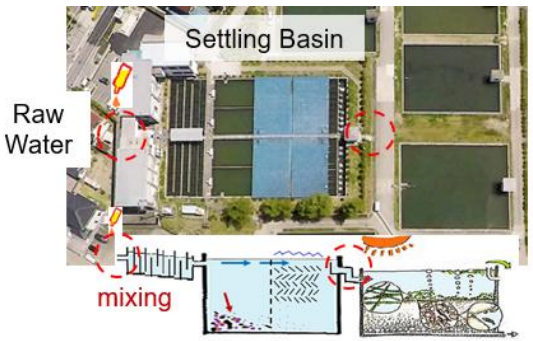
In Japan, a mountainous country, only settling tanks are sufficient. Flocculants are not necessary.

Filtration resistance is related to water temperature, water viscosity and biological activity.



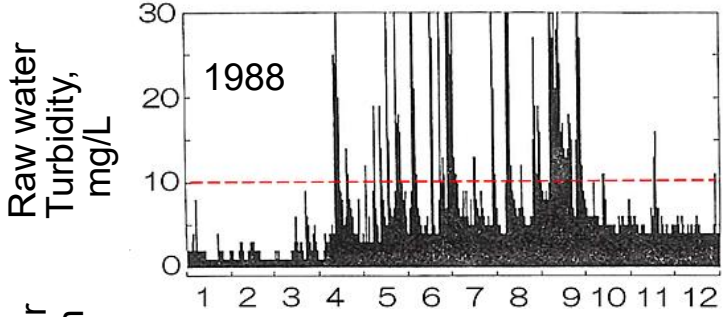
The water is heated in 4km of underground water pipes.

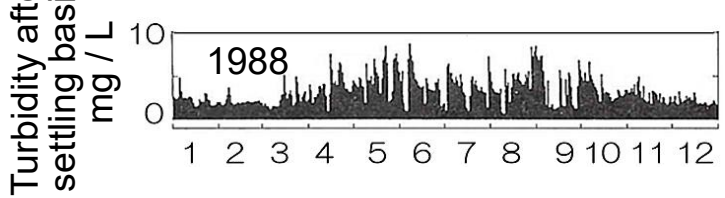
During the coldest months, the water surface of the filtration pond freezes.

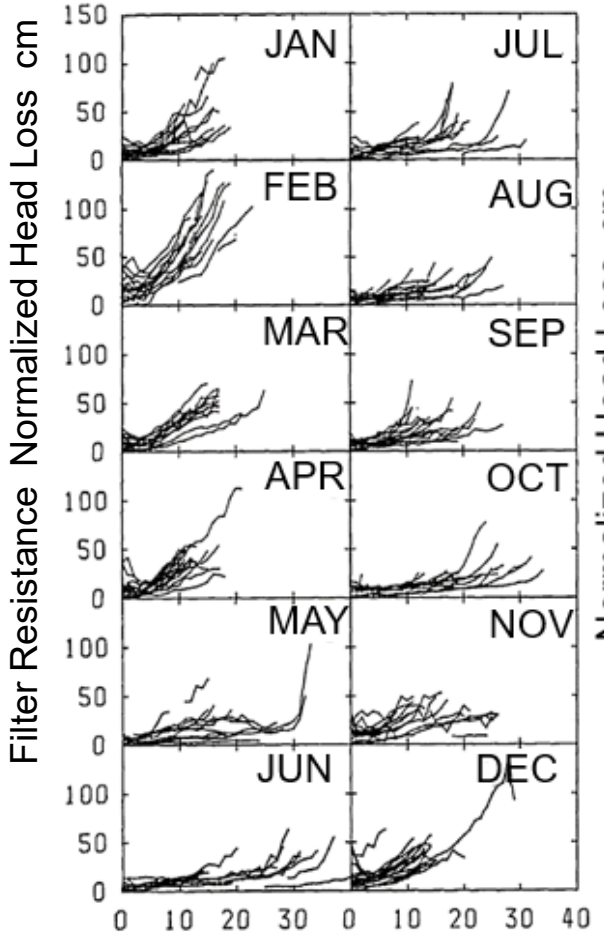


The viscosity of water is high, so resistance increases.

Biological activity is weak during the coldest months.

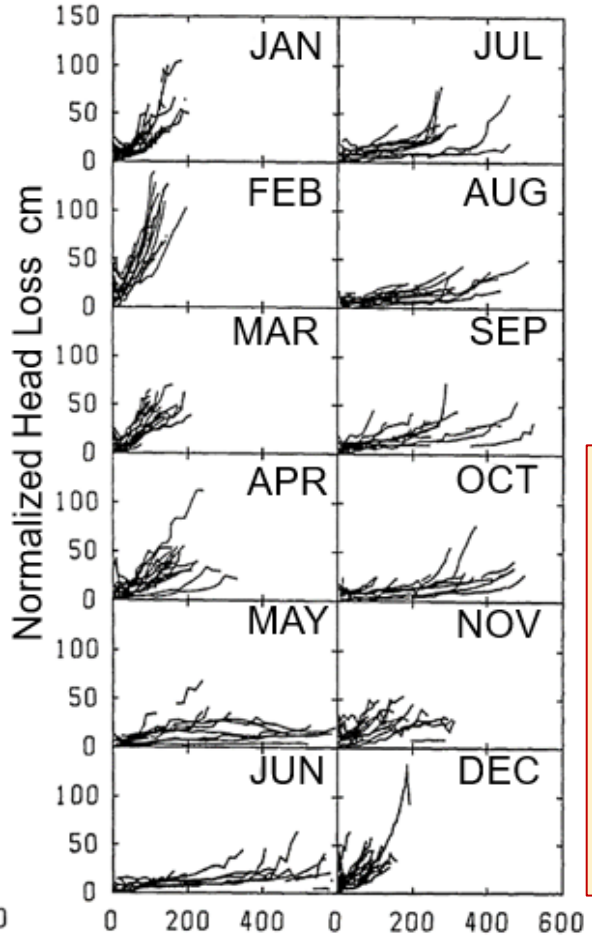






Filter run, days
In 1988

From May to November, when algae begins to grow in the filtration pond, the resistance does not increase.



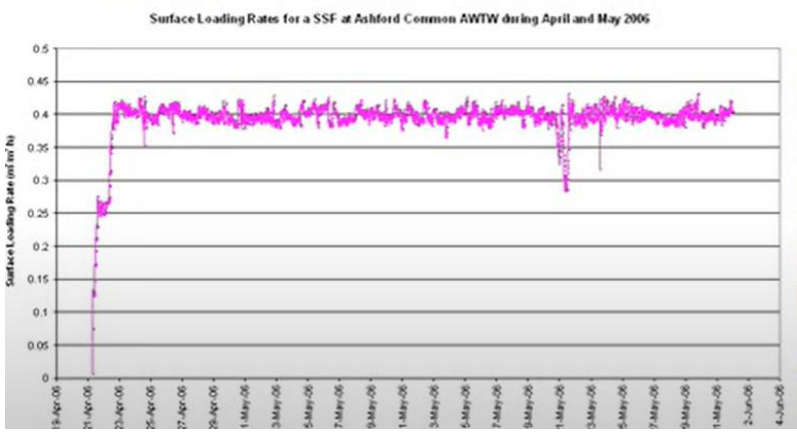
Inlet SS load (g / m2)
to sand surface

When algae began to grow, resistance did not increase even when turbidity entered the filtration pond.

If biological activity is good, filter resistance will not increase even if mountain river water becomes cloudy.

Water depth is the key.

Sand size is not so important.



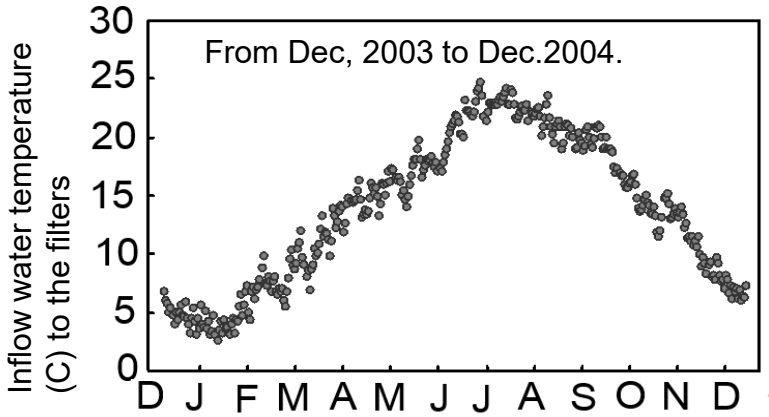
Shallow depth accelerates biological activity.

6 min

https://www.youtube.com/watch?v=4toIA05VYF8&t=1s

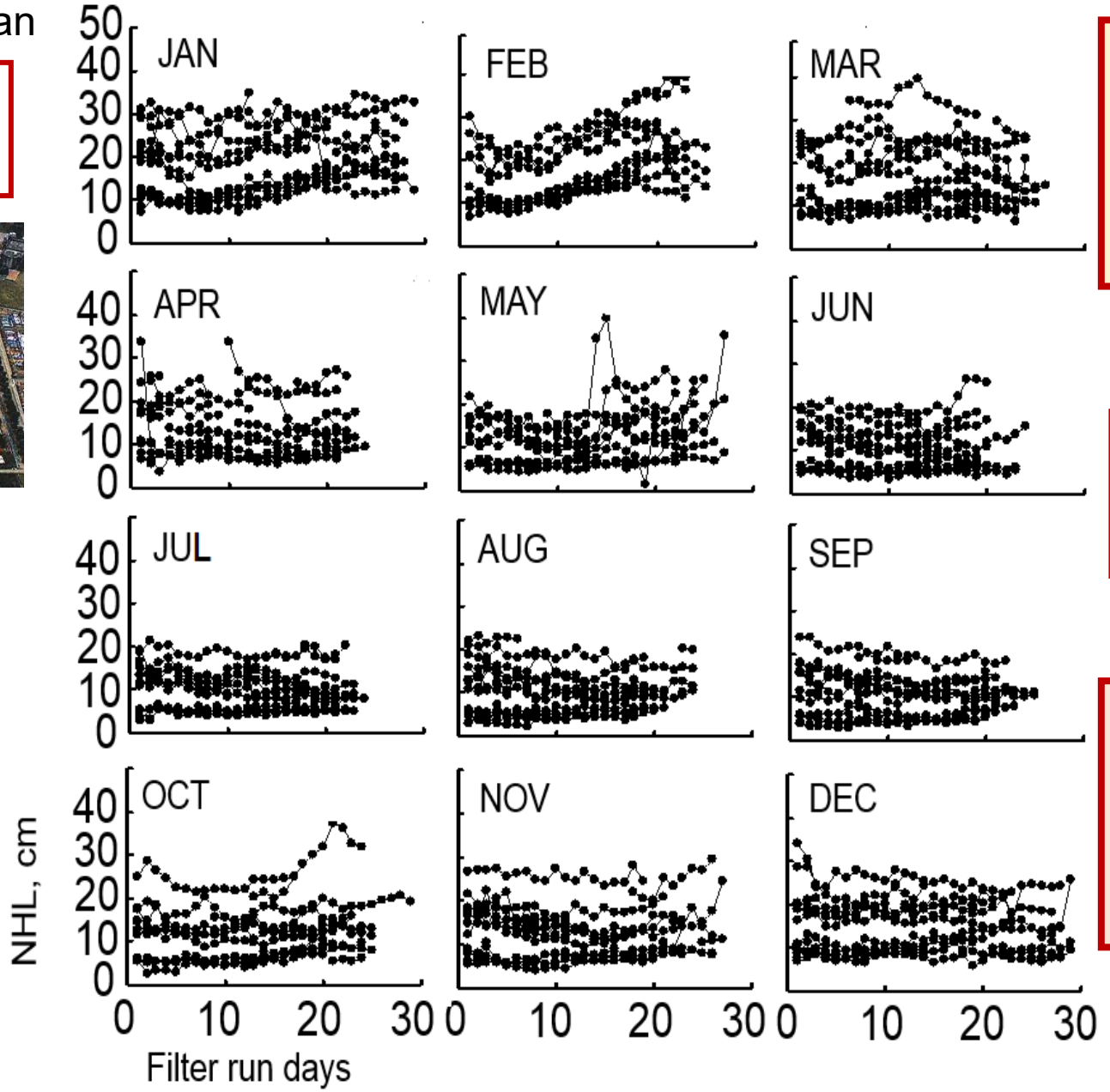
Wakata plant, Takasaki city, Gunma, Japan

Surface water of river → Sedimentation basin → Slow Sand Filter



The water surface of the filtration pond does not freeze.

Altitude above sea level : 150 m



Resistance did not increase even in cold water period.

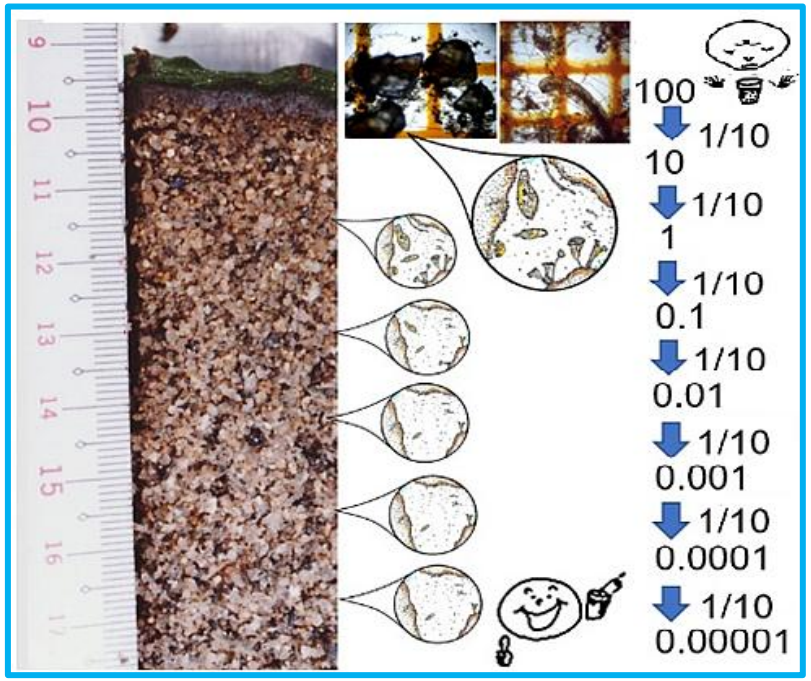
Filter does not clog in all the year.

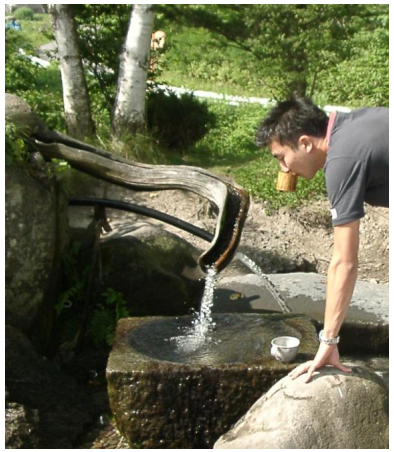
This means filter clog related to biological activity.

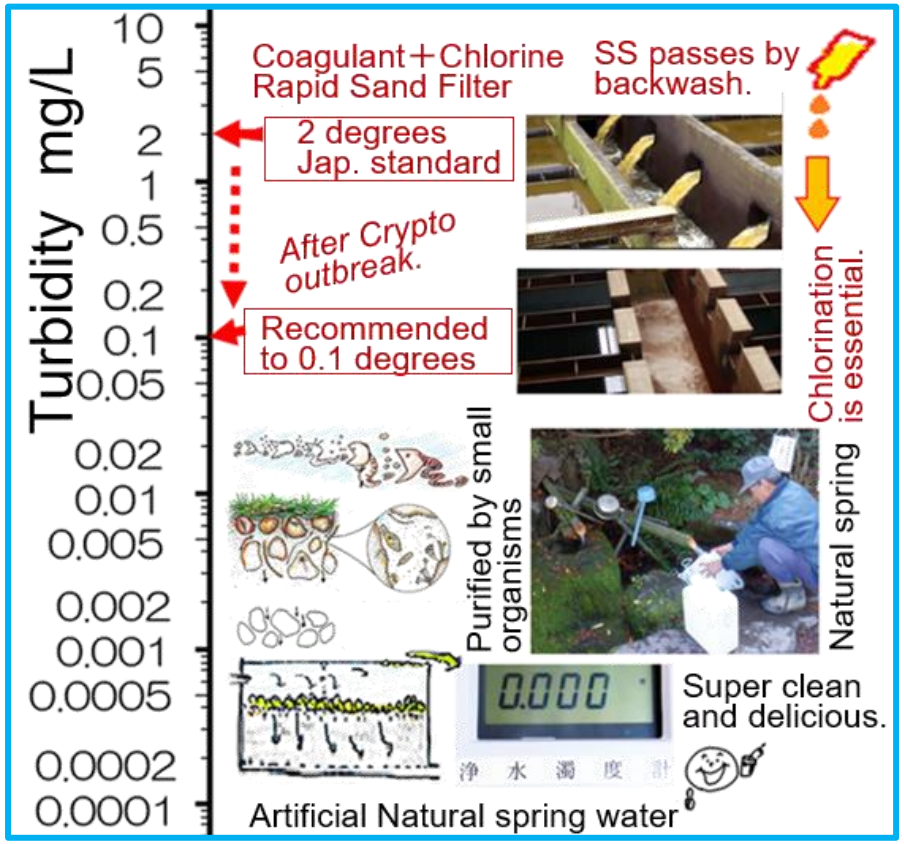
EPS makes Safe and Super Clean and Delicious Water. Acceptable Risk of Bacteria.

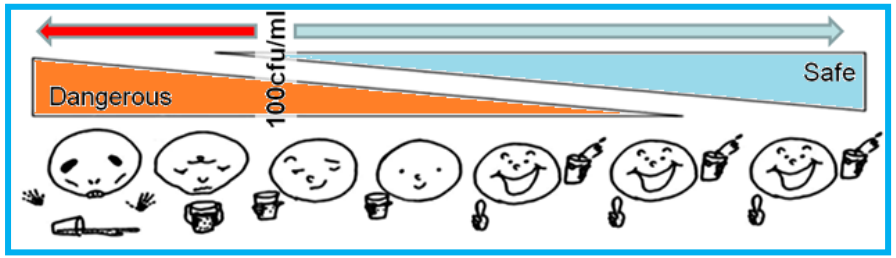
Part 8.

EPS 2025-OBW
Nov. Part 8:66-71
6 slides

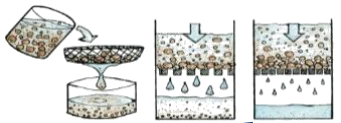




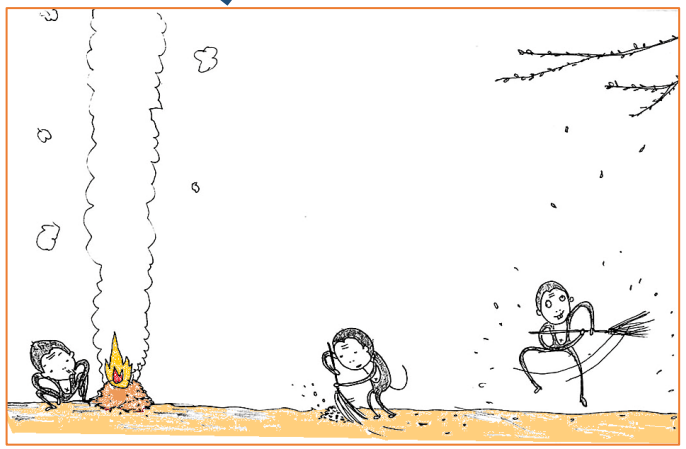




Acceptable risk



Original Image of Slow Sand Filter.

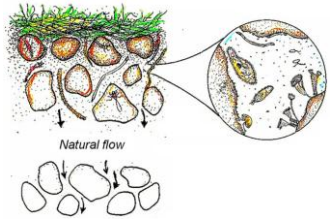


Burn out: change

Collection

Dilute

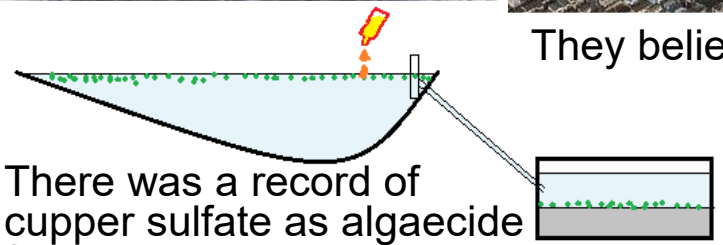
Real purification?



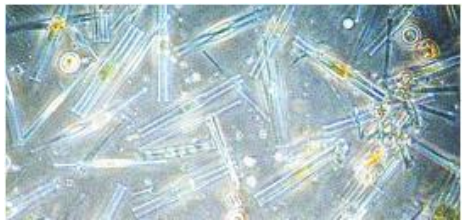
Ecological Purification System

Japanese leaders of water works misunderstood slow sand filtration, thinking it was simply mechanical sieve filtration. The use of algaecides caused the filters to become clogged, and the quality of the filtered water was poor. The turbid matter penetrated deep into the sand layer.

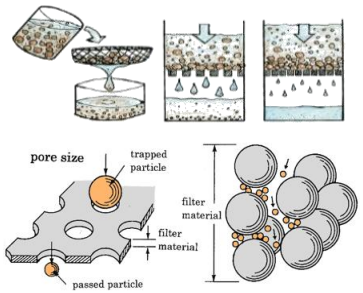
They believed that SSF was mechanical filter by the name of SSF.

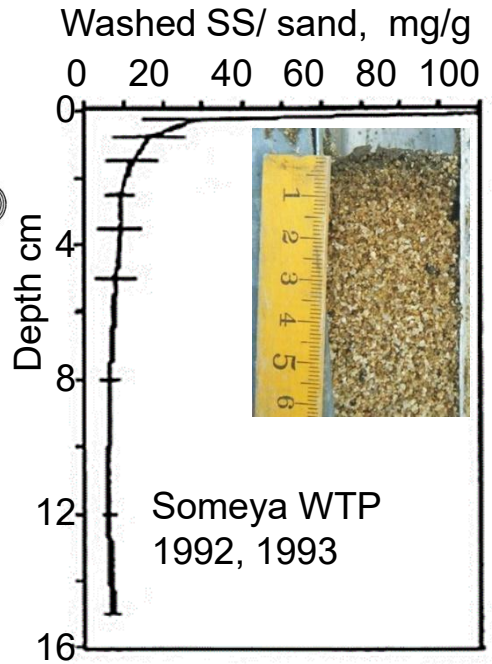


There was a record of cupper sulfate as algaecide from 1928.



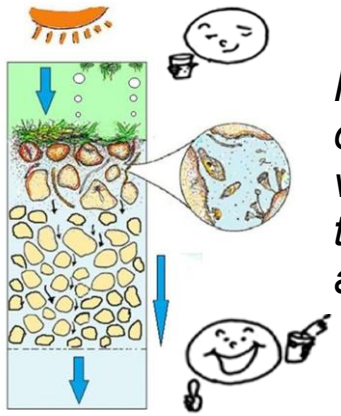
Phytoplankton from the reservoir is just accumulated on the filter bed. There is no growth of algae in this filter due to the influence of algaecide in the reservoir.



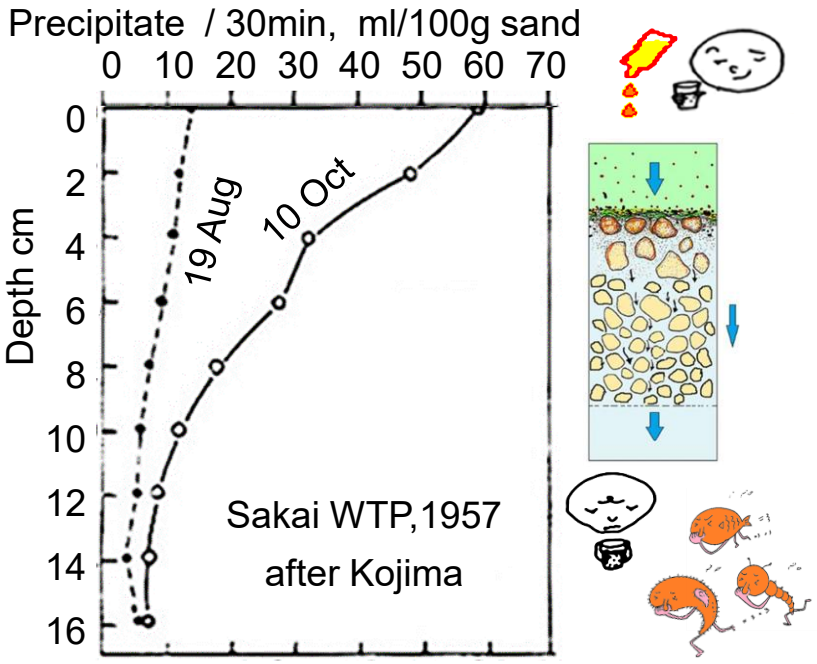


This is EPS.

Google map in Oct. 2025



Microscopic organisms is very sensitive to small amount of toxin.



If living organisms cannot play an active role, the sand layer becomes contaminated in deep.

Natural sweet spring water

감로수 Sweet drop water 甘露水

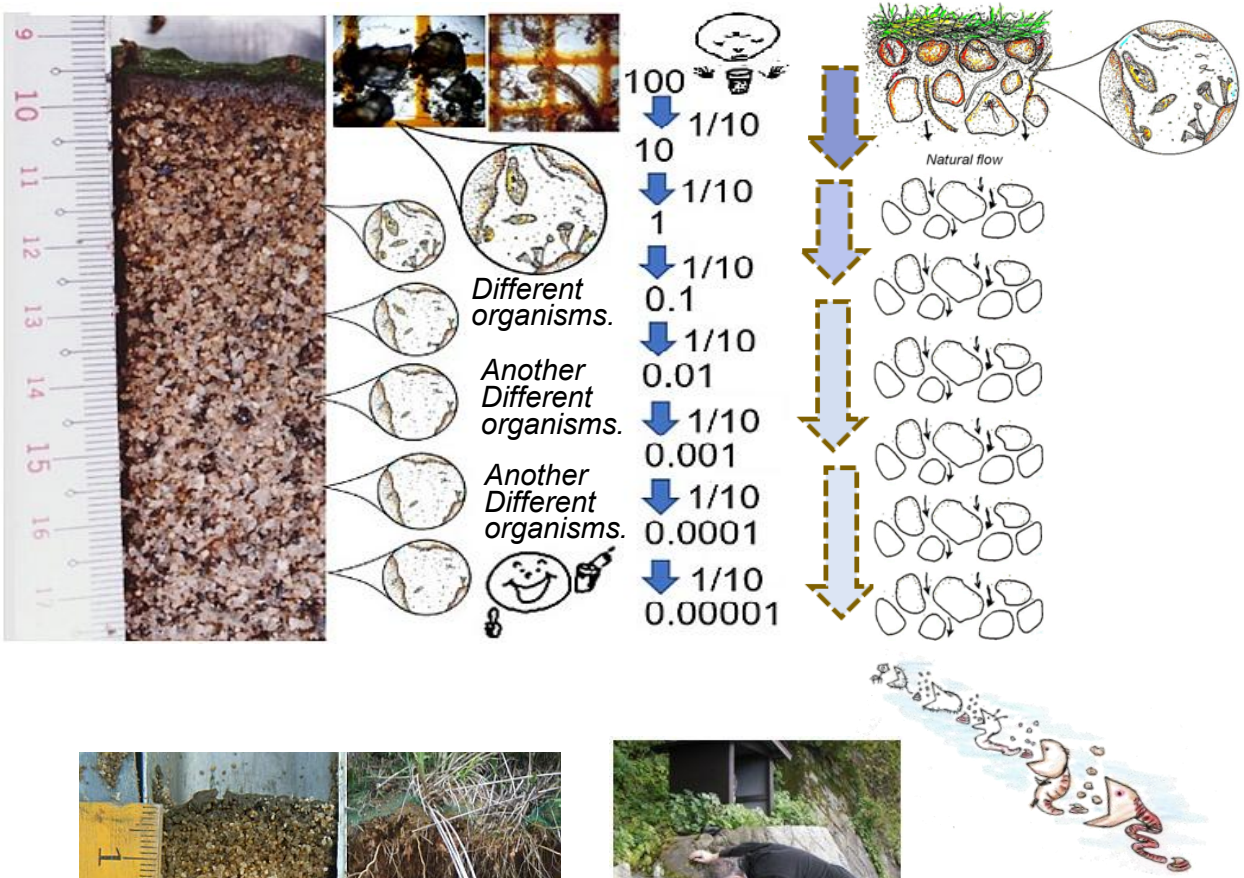
Rain harvest tank

Natural springs and rainwater are usually sweet and delicious.

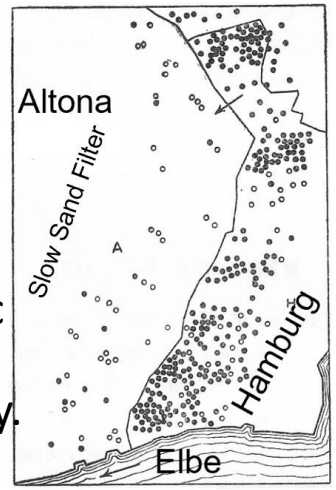
Tap water is for drinking water.
But people don't drink water directly from the tap.

Something wrong.

Organisms living on the surface and beneath it are not the same. Different creatures are active. There is different food for different creatures.

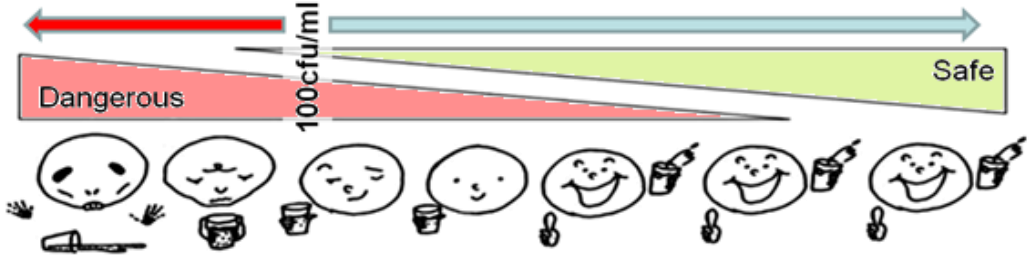


A cholera epidemic broke out in Hamburg, Germany.



Dr. **Robert Koch** found in **1892** that when bacterial counts were less than ***100 colony-forming units per mL*** (cfu/mL), epidemics of cholera and typhoid were reduced.

Present WHO safe standard for bacteria is referred to this 100 cfu/mL by Dr. R. Koch.



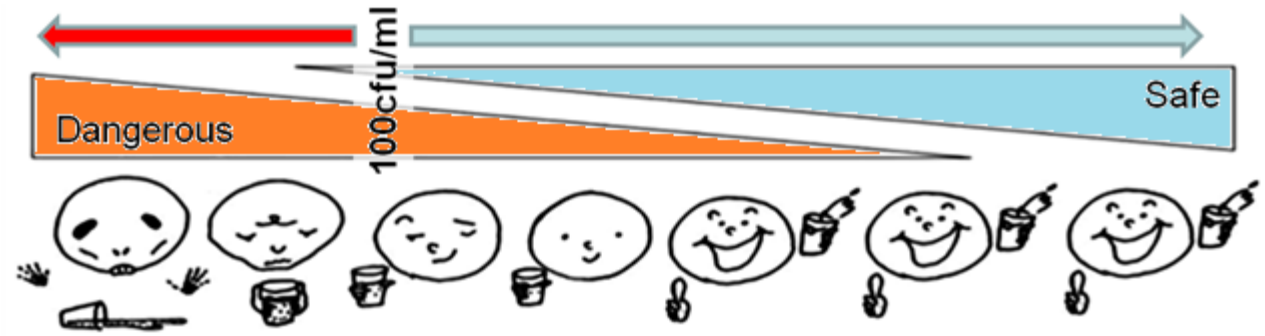
*This idea is so called **Acceptable Risk.***

How to reduce the risk.

One of the best ways.

Wash our hands!

We have to think about acceptable risk.



General bacteria: many in the natural environment

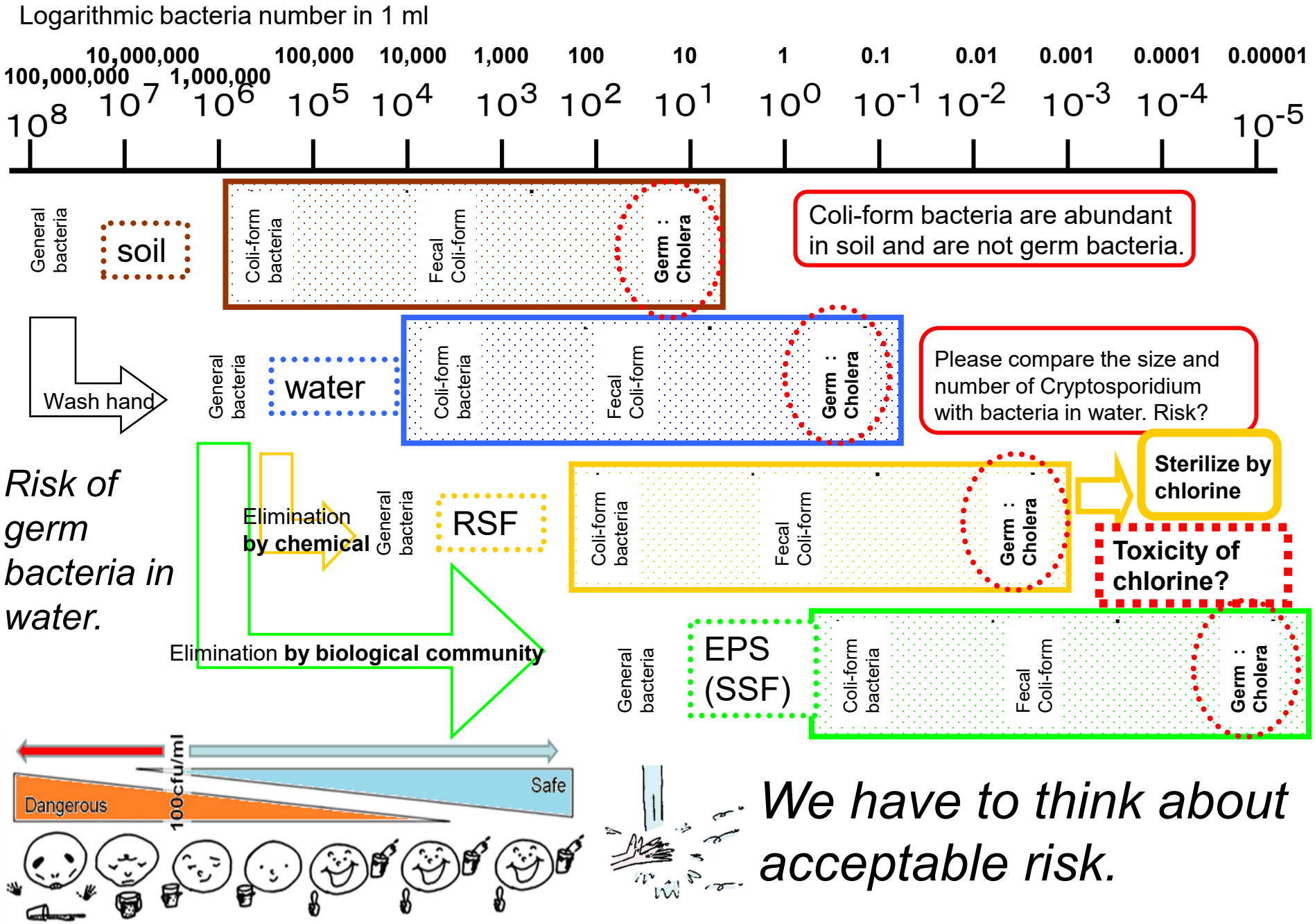
Group of coli-form bacteria : an indicator of pollution: many in the natural environment

Escherichia coli : indication of intestinal bacteria.

Fecal *Escherichia coli* : an indicator of fecal contamination of mammals.

Pathogenic bacteria

There are so many bacteria.
→Medical doctor touches with patients.
Doctor is safe.



EPS from Japan to the world as our technology that we can make it by ourselves.

Part 9.

EPS 2025-OBW
Nov. Part 9:72-79
8 slides

Yamaha motor company provided Safe Water to Villagers as Social Contribution in Indonesia in 2001.

Villager maintains over 10 years by themselves.

Public tap system

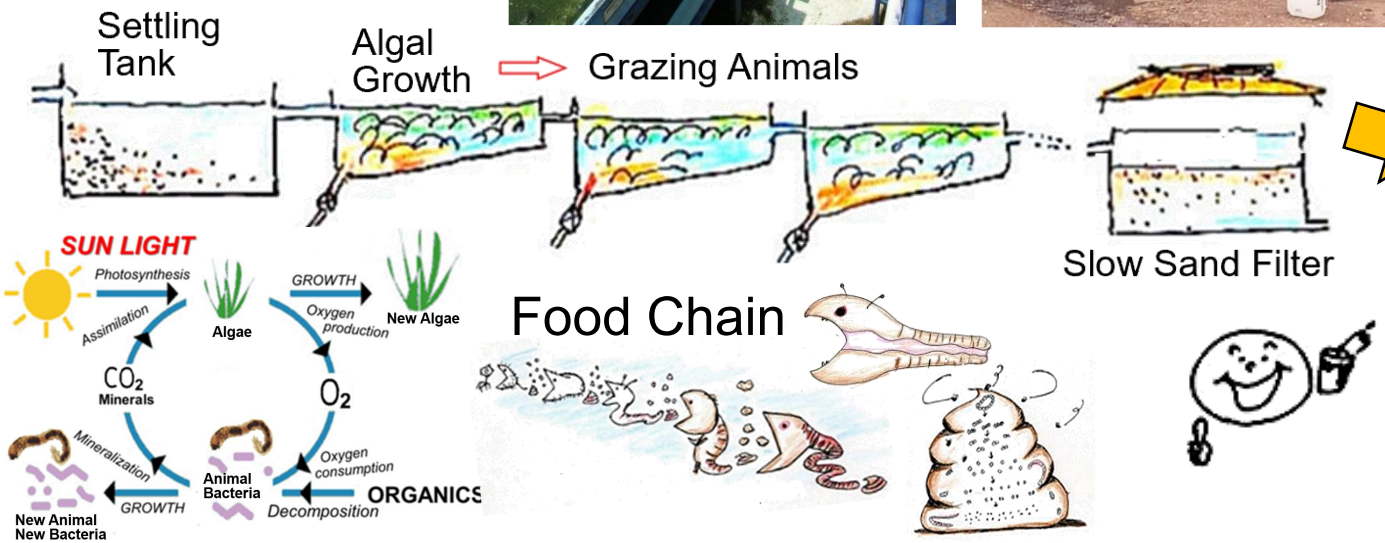
Tap keeper collects money of filling the bottle for the maintenance cost of the plant.

Two bottles of 20liters per 1 family. This water is used for drinking and cooking only. This water is not used for bath and washing hands. Diarrhea and eye sickness are disappeared.

Turn to Health village.

Sanitary sense and its level are distributed to the villagers.

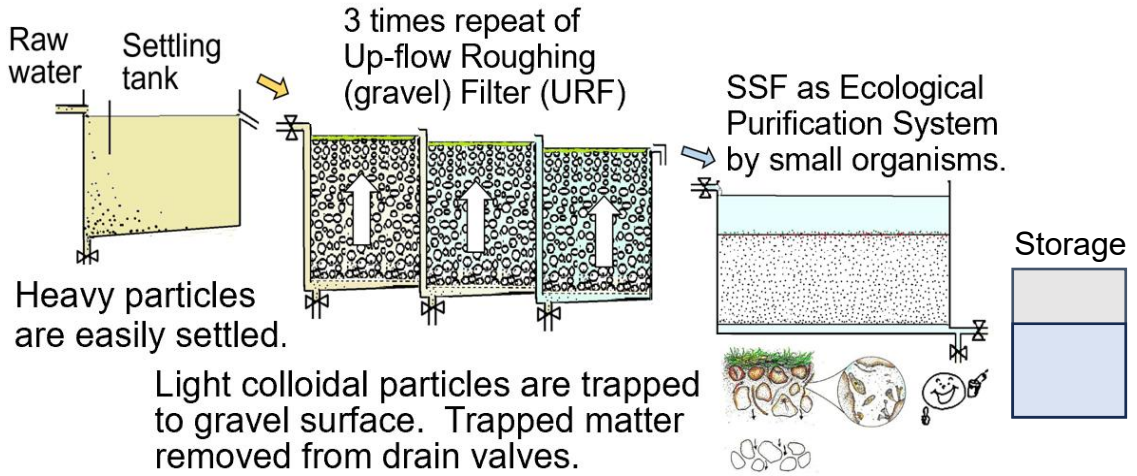
This acts to protect against sickness.



YAMAHA clean water system *to the world.*

Acceptable Risk

I advised to construct new Water Purification plant for a national hospital, Sri Lanka by EPS in 2001.



Turbid matter reduction by Settling tank and URF without chemicals.

Two Slow Sand Filters

Storages for Filtrate

To protect against fallen leaves and branches, we covered it with wire mesh.

Two lines of 3 steps of URF

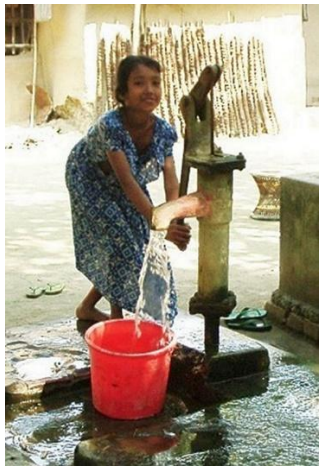
I explained EPS mechanism of chemical free system.

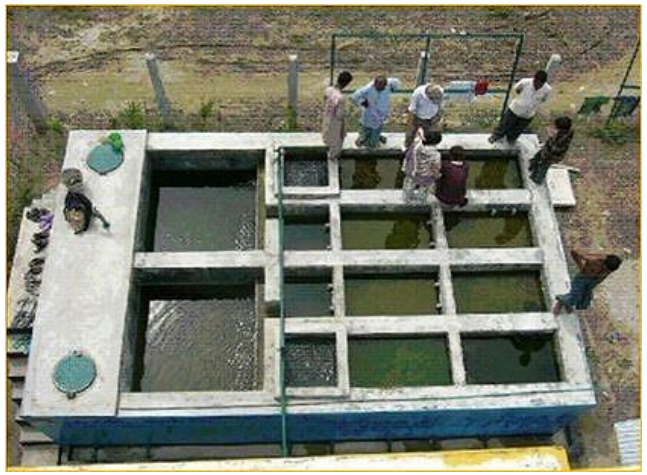
Manager said "**Conventional system is a commercial filter. This is a natural filter**".

I advised EPS for safe drinking water in arsenate contaminated Bangladesh in 2004.

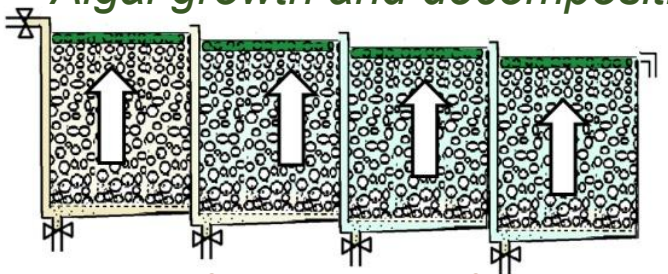
Surface water is polluted and ground water is contaminated with arsenate in Bangladesh.

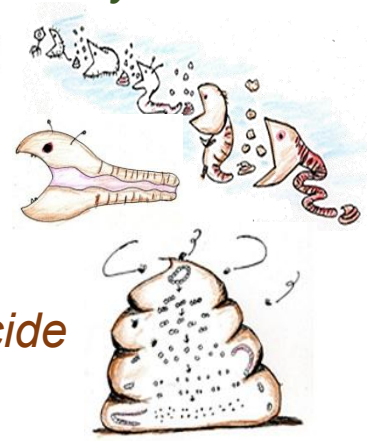
They asked me that reduction system for herbicide and pesticide without chemicals.



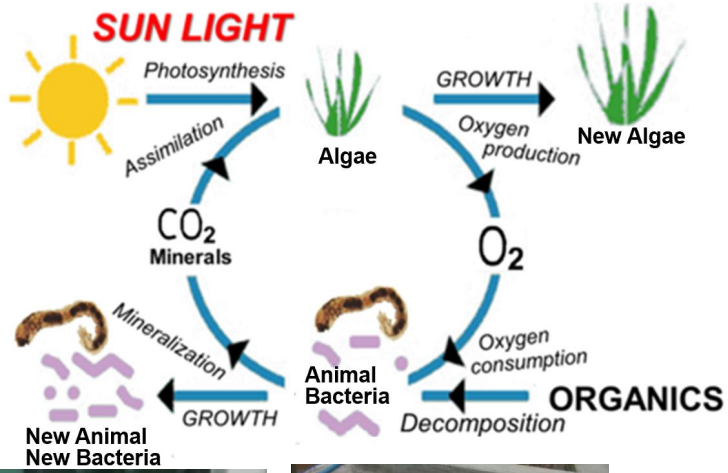


Algal growth and decomposition by animal.





Repeat for 4 times of URF to completely decompose herbicide and pesticide by repeated process of food chain.



Local staffs of Asia Arsenate Network (NGO) understood the EPS mechanism.

Complete decomposition (mineralization) in the faecal pellet.

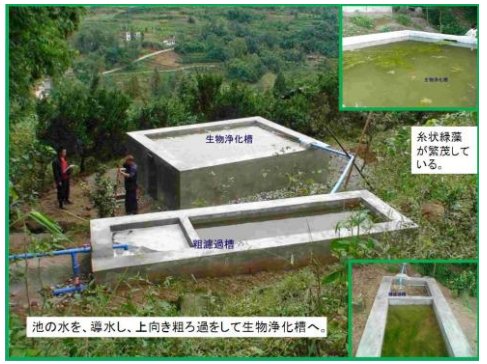
Anaerobic condition in fecal pellet.

Mr Mizan sent me photos. They made new EPS in Sylet, Bangladesh by themselves, by UNICEF fund.

Mr. Jin Shengzhe, translator of Chinese version of Japanese EPS manual, made three EPS plants in China in 2008 after the great earthquake.

Aug. 2005.

May 2009.



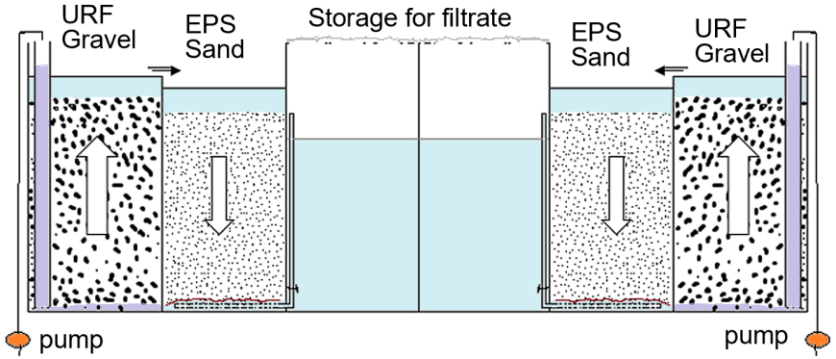
In 2008, Huo Dai Shan, Shenqiu county, Henan province, made safe drinking water from contaminated groundwater under the guidance of Jin Shengzhe.

Since then, water purification systems have been constructed in over 40 locations.

Raw water → Settling Tank → URF gravel → EPS Sand → Storage tank

Covered EPS was constructed at a school for students and villagers in August, 2014.

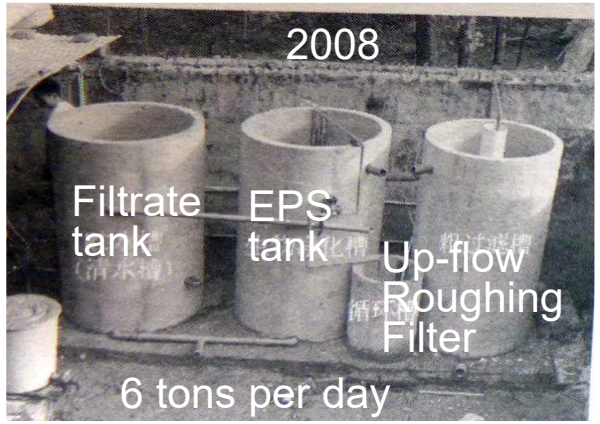
Covered EPS was necessary in cold winter.



Filter (2 m x 4 m) 2 set (URF+EPS)

70-80 m3/d, 16 liters/d/person

246 students and 4,600 villagers



Groundwater (tube well)

May 2016.

Jin Shengzhe

Huo Dai Shan

Mr. Jin said that there is a saying in China, “ 積善積徳 Accumulate good deeds and virtues"

Mr. Vishwa Jeet from Fiji learned EPS from JICA training in Okinawa in 2011.

Cava ceremony

I cannot say chlorinated water.

Reduce the risk

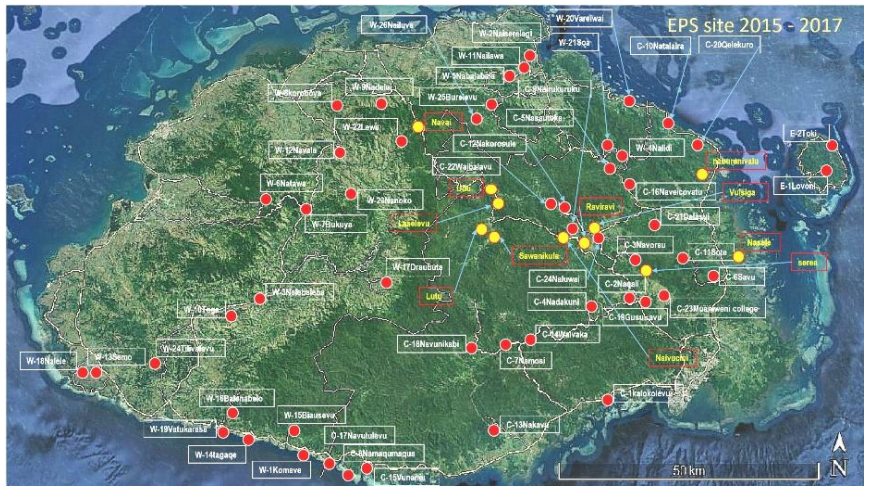
2011.8.MiyakoJima Island

Jan. 2013. Project opening seminar on Safe drinking water for all villagers by EPS in Fiji.

Vishwa confirmed EPS performance.

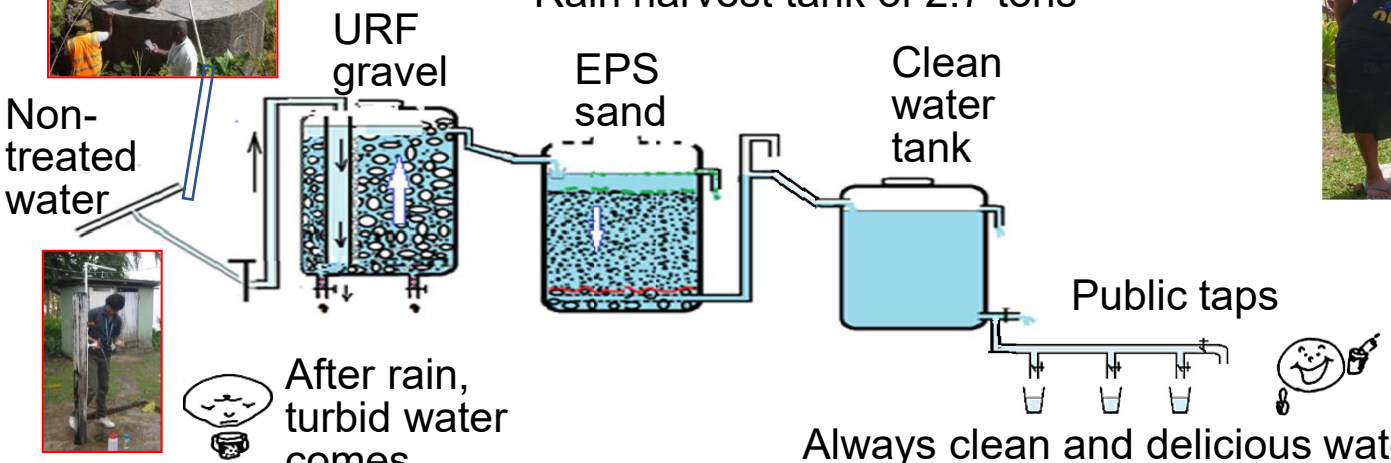
Present storage tank

Rain harvest tank of 2.7 tons



EPS plants were completed from 2014 to 2018 （4 years).

I contributed as a short-term expert (2 times of 1 month per year).



After rain, turbid water comes.

Always clean and delicious water.

From 2006 to Samoa
JICA Okinawa project

Increase biological activity and help improve maintenance and management.

1984-’87 SSF by Germany

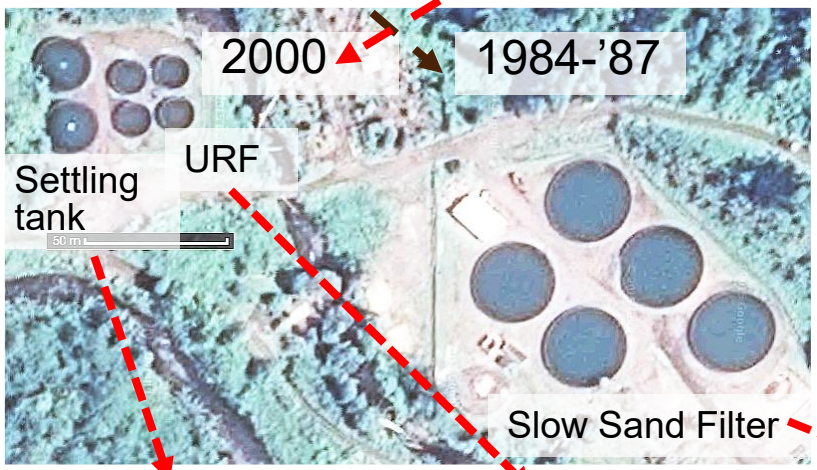
2000 Settling and URF by Germany

Trouble during rainy season.

2006～JICA Miyakojima

They learned about EPS function.

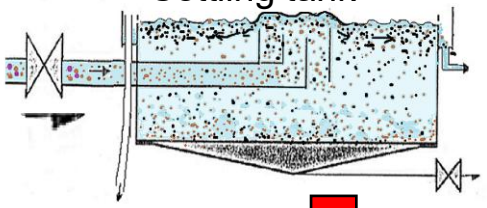
2010～JICA Miyakojima⇒All Okinawa
Advice EPS, Water system



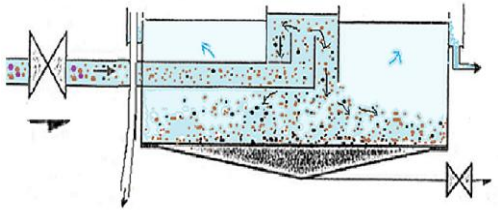
URF

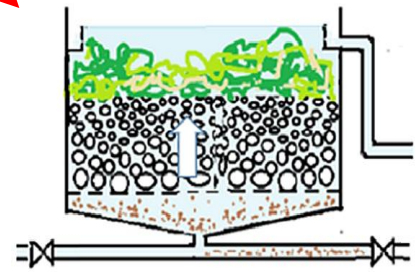
Settling tank

Settling tank

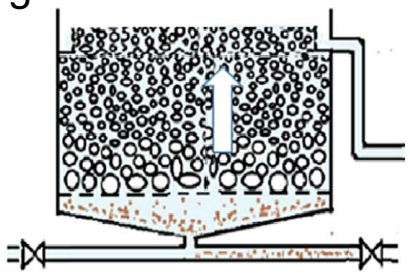


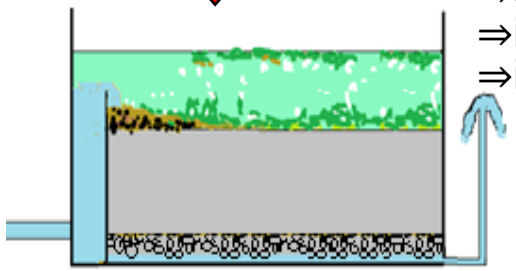
Reduce inflow
⇒Easy to settling





Put more gravel
⇒Increase area of gravel surface





Deep water depth
⇒put sand
⇒shallow depth
⇒increase algal growth
⇒increase EPS function

Samoa Water Authority began to make EPS plant for villager by themselves from Nov. 2019.

I contributed to JICA training on EPS in Okinawa from 2006.





Ms. Marista from the Solomon Islands, gave a speech of thanks on behalf of the trainees at the end of the six-week JICA training in Okinawa on September 1, 2010.

It is also worth appreciating the Ecological Purification System as taught by you, Dr. Nakamoto; a simple, natural and yet an effective water purification technology, we can all agree to as the most relevant technology for the Islands.
It is cheap to construct, operate and maintain which makes it even more attractive. We are grateful to your pioneering research on this technology and for generously impart this to us, so that the people of the pacific may in the very near future will have access to the high quality and delicious taste that this technology provides.

International Course on Slow Sand Filter in Okinawa, in 2010 by JICA – YouTube / 6:08

https://www.youtube.com/watch?v=c3mVIbmFPqA&t=27s

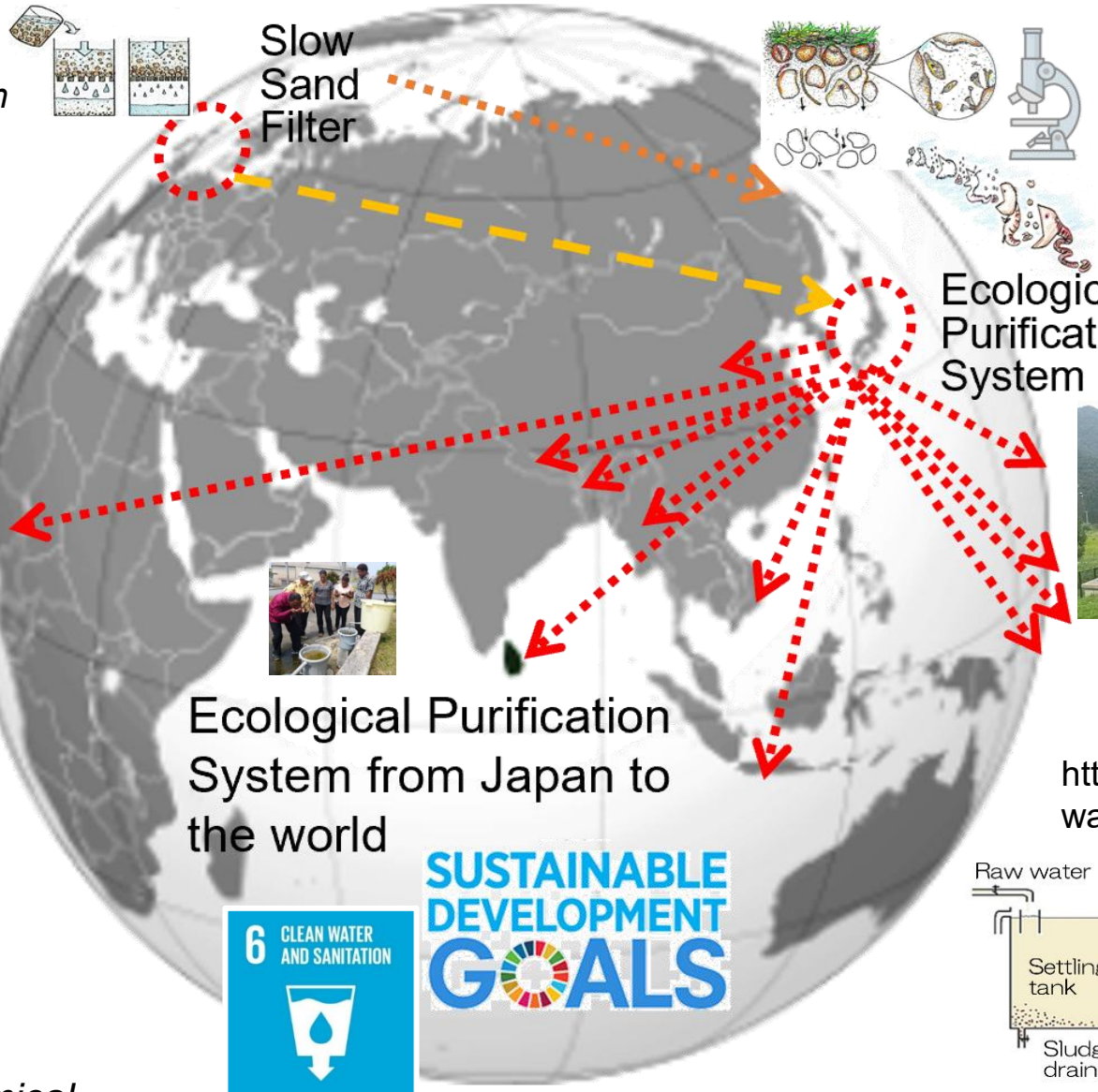
Slow Sand Filter is Ecological Purification Systems.

This new purification technique from Japan has spread all over the world.

They believe SSF is Mechanical Filter to make clean spring water in a flood plain.

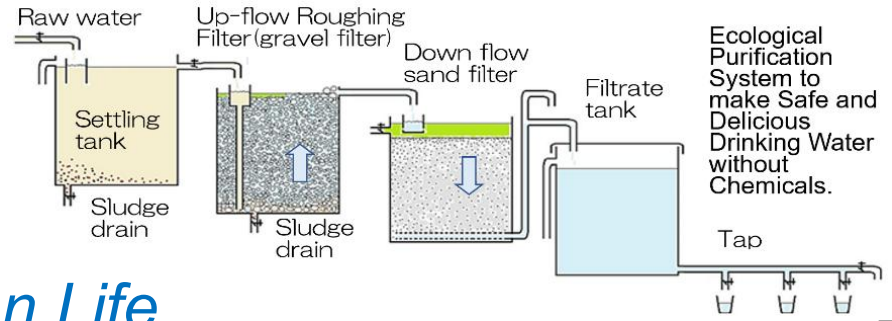
Nigeria

Chemical free

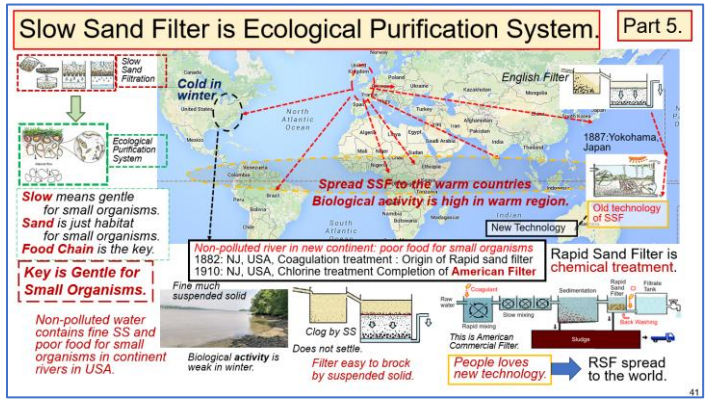


Mechanism of EPS
7 minutes

https://www.youtube.com/watch?v=ArWM3PVY3GM



Applied Ecology is for Human Life.



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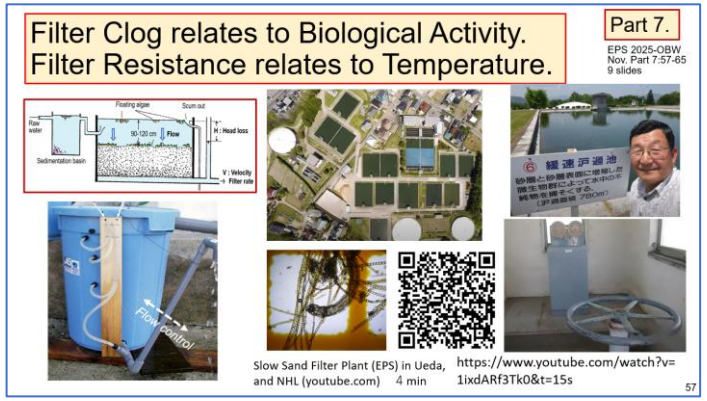

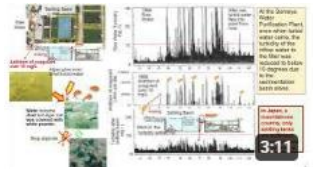

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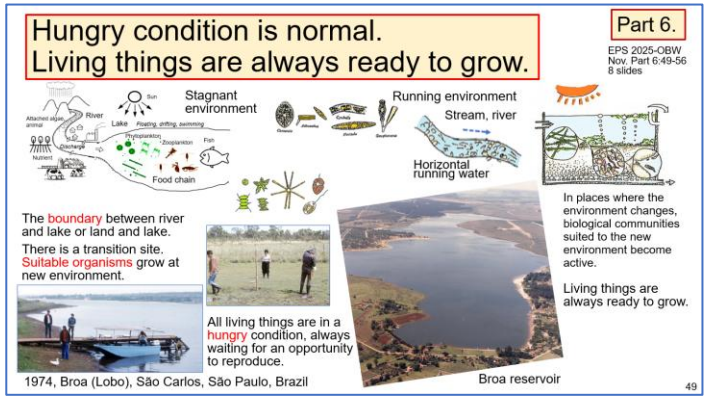
https://youtu.be/i6gYGt5bRAM



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