

Sustainable Drinking Water

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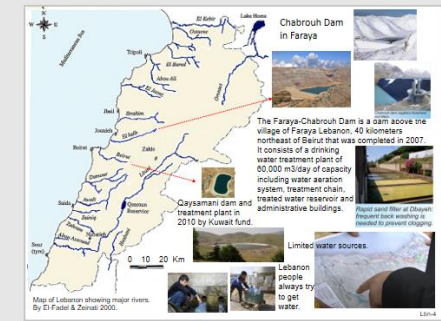
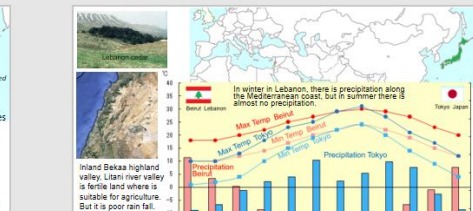
Tokyo Metropolitan Univ. Biology
⇒Phytoplankton: Ocean, Reservoir
Culture experiments, pond, reservoir, ocean and stream
→Shinshu Univ.: Applied Biology
⇒Ecological Purification System
⇒Wise Use of Biological Phenomena

Slow Sand Filter to make safe drinking water.

Plankton study in Pacific 1969
and Atlantic ocean 1970

Sustainable Drinking Water

I start to study Biology and Ecology.
I got a position of Applied Science, and I studied Applied Ecological point in aquatic environment.
I studied ecosystem ecology.
I studied growth of algae in nature, ocean, lake and river at university.
①Organisms in nature are waiting for opportunities to grow. This waiting period is so long.
②The hungry condition was long and normal.
③Organisms have generally been prosperous and declining repeatedly in nature.
I checked web survey on Lebanon related to water supply.
④Living things cannot live without water. Plants



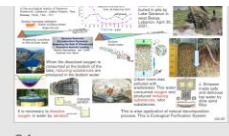
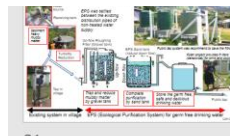
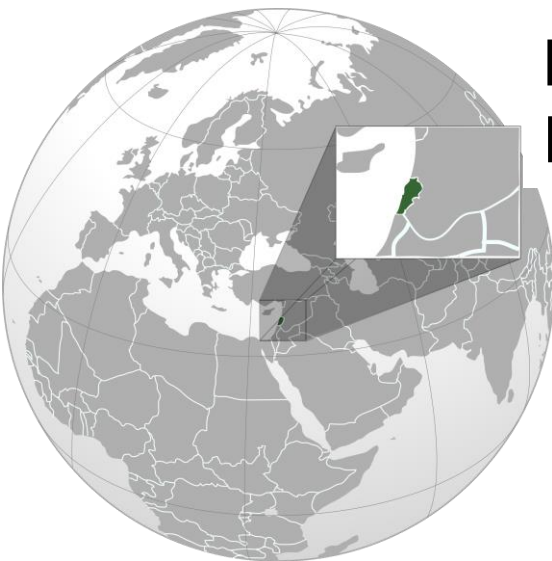
Sustainable Drinking Water

How to increase carrying capacity of drinking water by a sustainable way.
It's **Ecological Purification System**.

Quest for Safe and Delicious Water by Applied Ecologist

NAKAMOTO Nobutada, Dr. Science
Prof. Emeritus of Shinshu University, Japan

Web Lecture to Lebanon from Japan
March 2. 2022



Sustainable Drinking Water

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Japan

Lebanon

I was born in May,
1942 in Tokyo.

Tokyo Metropolitan Univ.: **Biology**

⇒ Phytoplankton : Ocean, Reservoir

Culture experiment, pond, reservoir, ocean and stream.

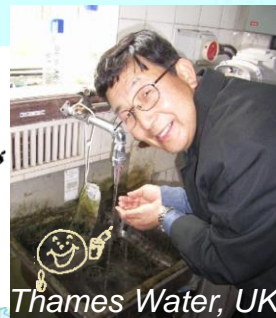
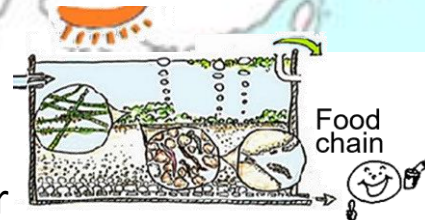
→ Shinshu Univ.: **Applied Biology**

Slow Sand filter to make safe drinking water.

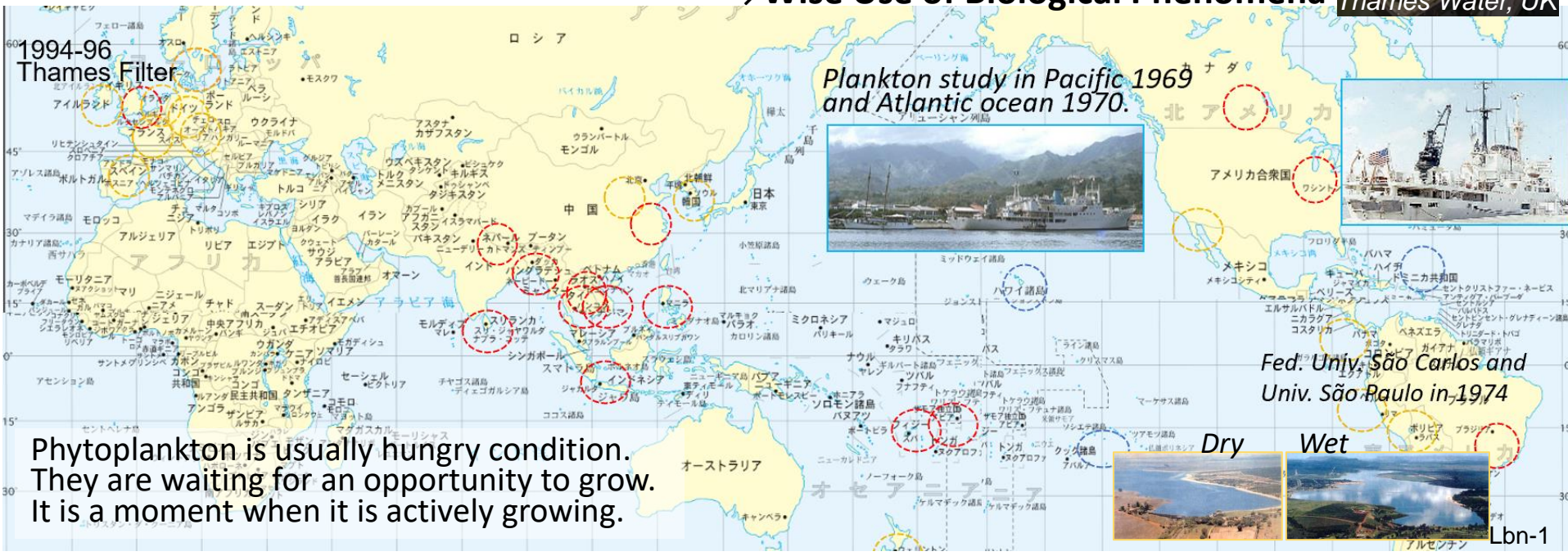
→ Slow Sand Filter

⇒ Ecological Purification System

→ Wise Use of Biological Phenomena



Thames Water, UK



Phytoplankton is usually hungry condition.
They are waiting for an opportunity to grow.
It is a moment when it is actively growing.

Sustainable Drinking Water

*I start to study
Biology and Ecology.*

*I got a position of Applied Science,
and I studied Applied Ecological
point in aquatic environment.*

① I studied ecosystem ecology.
I studied growth of algae in
nature, ocean, lake and river at
university.

② Organisms in nature are waiting for opportunities
to grow. This waiting period is so long.

③ The hungry condition was long and normal.

④ Organisms have generally been prosperous
and declining repeatedly in nature.

*I checked water condition and water supply in
Lebanon by web survey.*

⑤ Living things cannot live without water. Plants
and animals live where there is water.

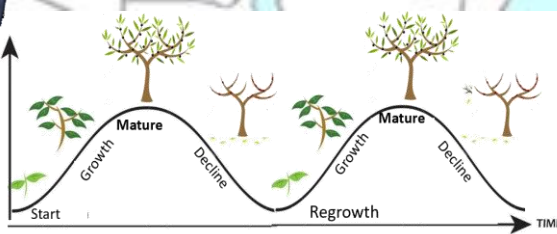
⑥ Humans also live in the natural world. It needs
to coexist with nature.

⑦ I think it is necessary to think of carrying
capacity. **How to increase carrying capacity of
drinking water by a sustainable way.**

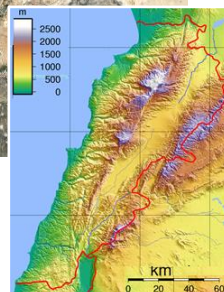
⑧ For a **sustainable society**, it is necessary to
adopt **suitable technology** for the region.

*Japan
surrounded
by sea.*

*Lebanon has a rainy winter
and a non-rainy summer.*



Ouadi Qadisha (the Holy Valley)
and the Forest of the Cedars of
God (Horsh Arz el-Rab)



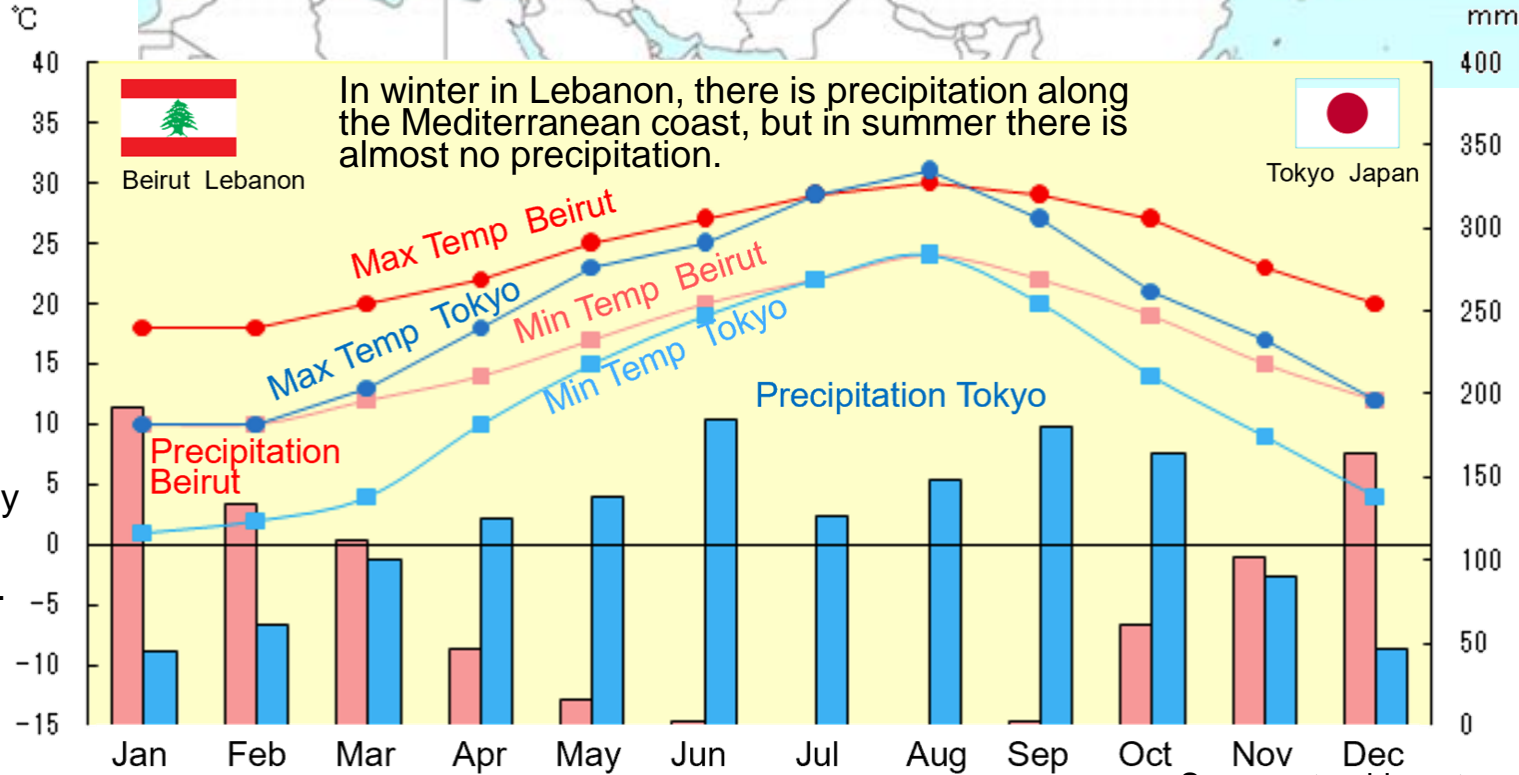
Urbanized Beirut



Lebanon cedar



Inland Bekaa highland valley, Litani river valley is fertile land where is suitable for agriculture. But it is poor rain fall.



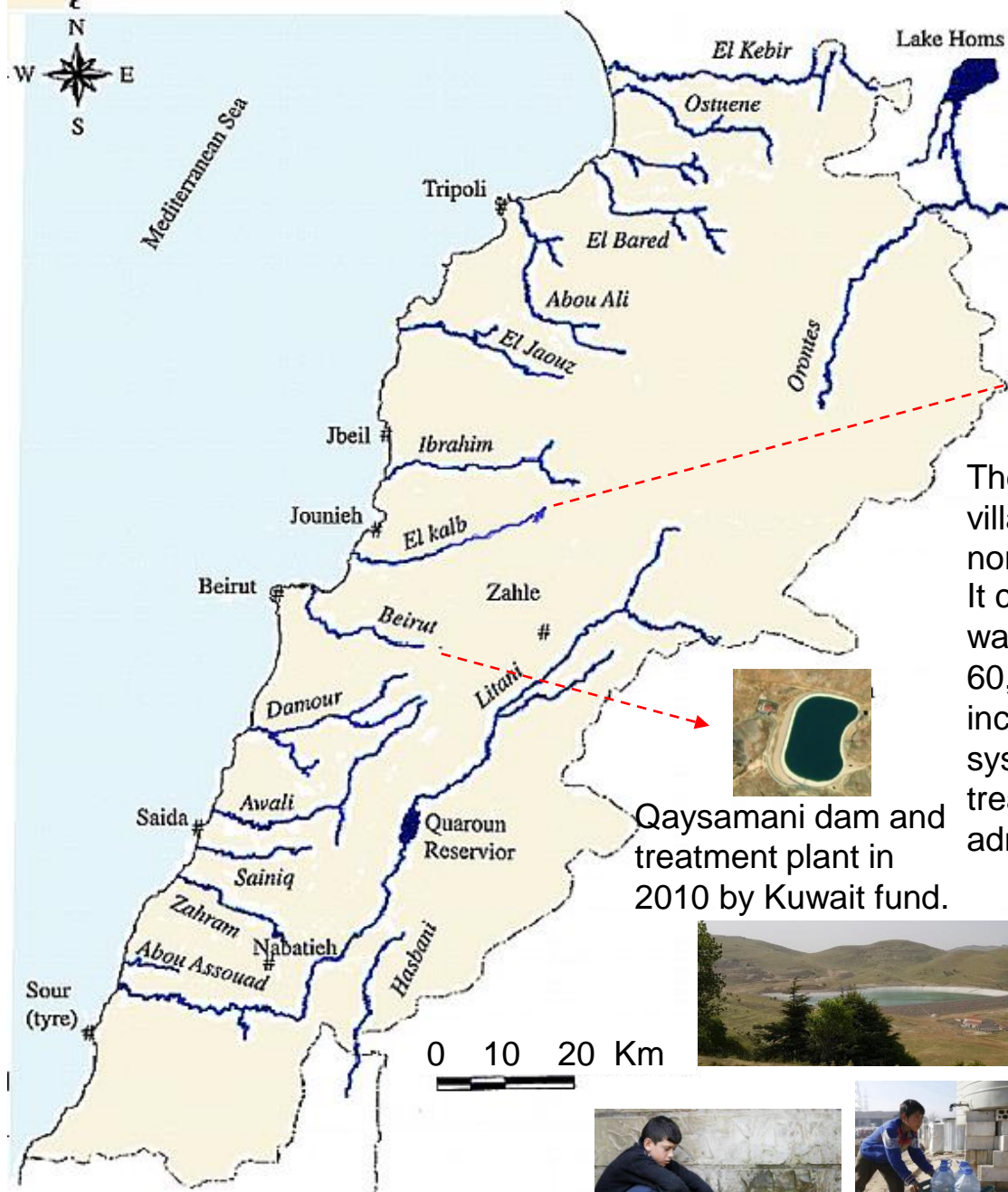
The Qaraoun dam, which created the artificial reservoir in 1959, is the largest dam built in Lebanon for multipurpose uses of hydropower generation (190 MW), irrigation of 28,500 ha (70,425 acres), and drinking-water supply.



Super-eutrophic water.



People clear dead fish from Lake Qaraoun in west Bekaa, April 30, 2021. Source: Xinhua Lbn-3



Map of Lebanon showing major rivers.
By El-Fadel & Zeinati 2000.

Chabrouh Dam in Faraya



Chabrouh dam supplies Keserwan and Metn.

The Faraya-Chabrouh Dam is a dam above the village of Faraya Lebanon, 40 kilometers northeast of Beirut that was completed in 2007. It consists of a drinking water treatment plant of 60,000 m3/day of capacity including water aeration system, treatment chain, treated water reservoir and administrative buildings.

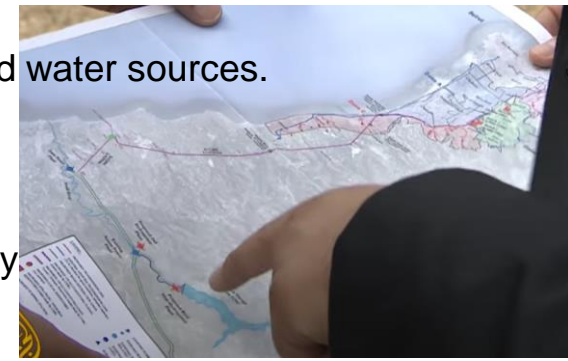


Rapid sand filter at Dbayeh: frequent back washing is needed to prevent clogging.

Qaysamani dam and treatment plant in 2010 by Kuwait fund.



Limited water sources.

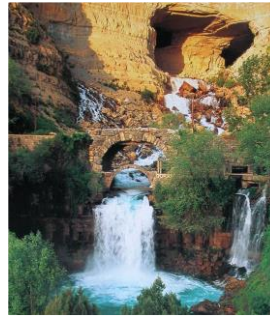


Lebanon people always try to get water.





The Mediterranean side has steep cliffs and high mountains. The winter season is the rainy season, when rain and snow precipitation **infiltrate underground**, reach the **aquifer** (or impermeable layer), and the groundwater flows laterally.



It flows out as **spring water from cliffs**. People in this country have used **spring water for their daily lives** since ancient times. However, there was almost **no precipitation in the summer**, and this spring was precious water.



The **city has developed**, the population has increased, the water demand in the city has increased, and there is a **shortage of water**.



This water shortage is serious in the summer when there is no rainfall. There, the terrain is steep and the length of the river is short. There **are few suitable places to build a reservoir dam**.

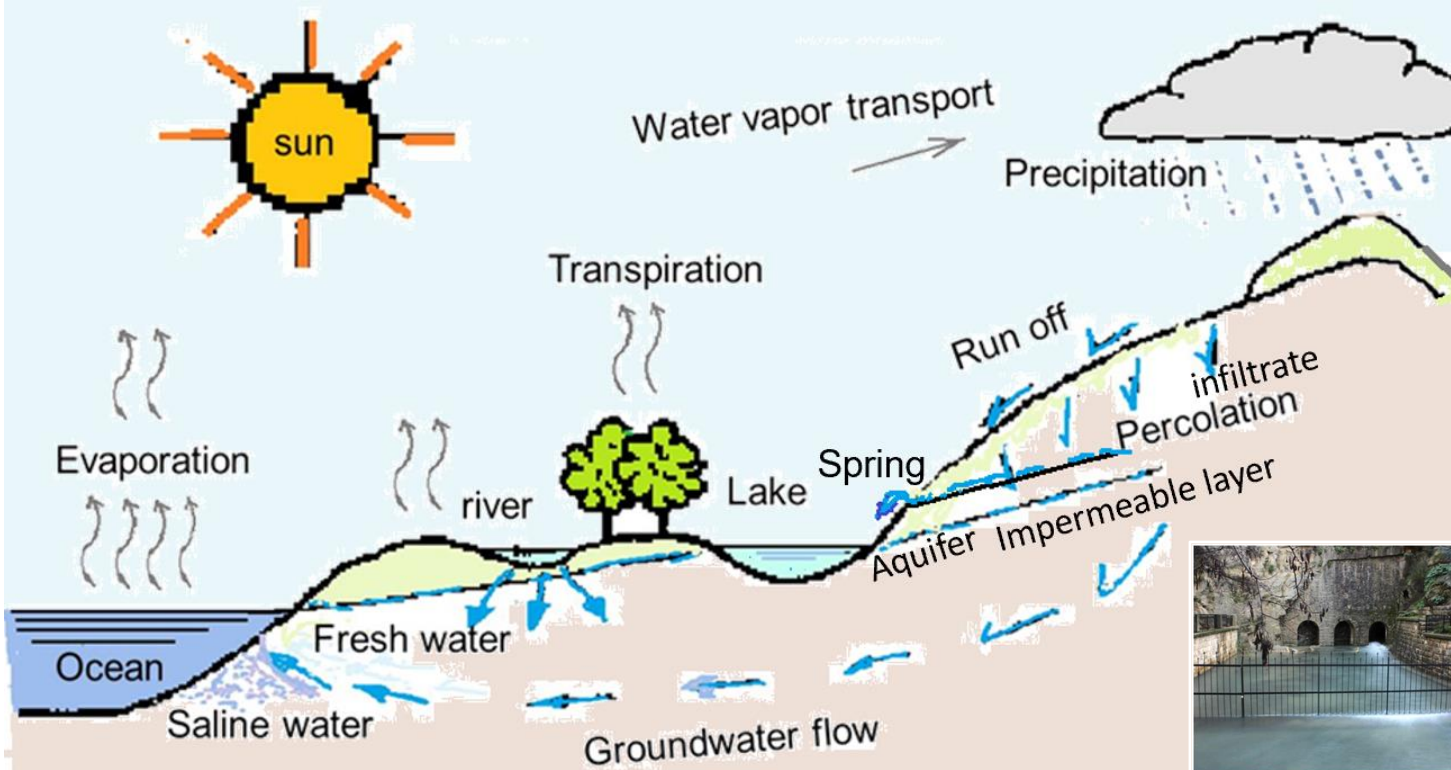
Let's go to my study on Quest for Drinking Water :

Water cycle. Origin of slow Sand Filter. Spread of SSF in the world.

Purification mechanism of Slow Sand Filter as Ecological Purification System.

Water cycle
in Nature:

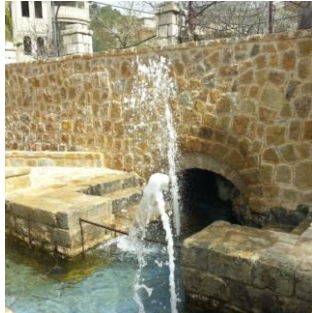
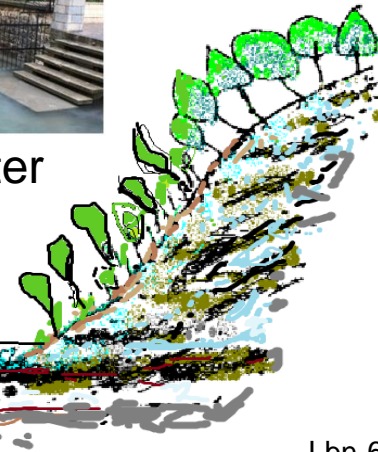
Human beings intercept the natural water cycle in order to take water for their purposes, and after using the water, they return it to the cycle.



It flows out as **spring water from cliffs**. People have used **spring water for their daily lives** since ancient times.

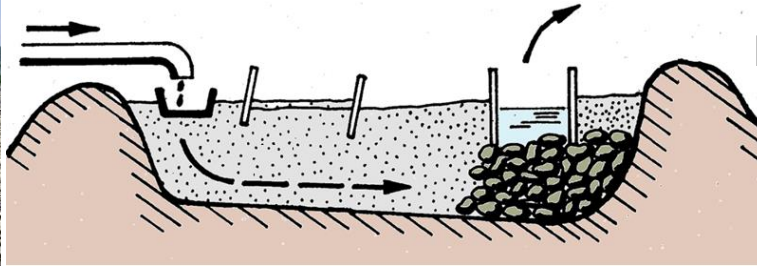


Stores spring water and supplies it.

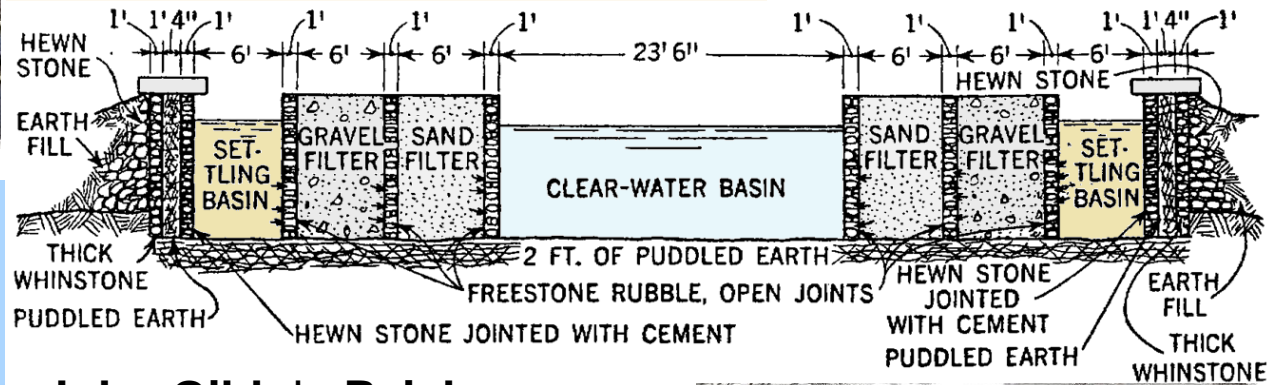


Origin of Public Water Supply by treated water.

Artificial system of natural clear water was developed from clear seepage water in the flood plain of a river.



Industrial Revolution period

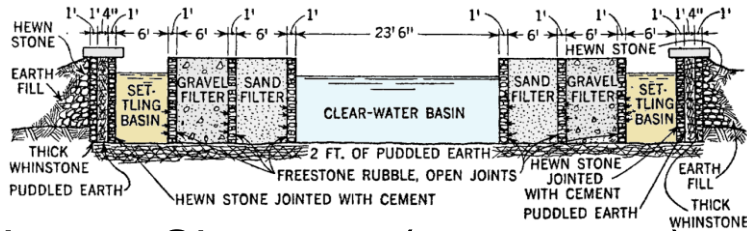


John Gibb in Paisley near Glasgow, Scotland. Bleacher of textile made an **artificial clear seepage water** of the flood plain of River Clyde for his factory in 1804, industrial revolution period.

He **delivered the clear water to Paisley town.** This is the origin of Public Water Supply of treated water.



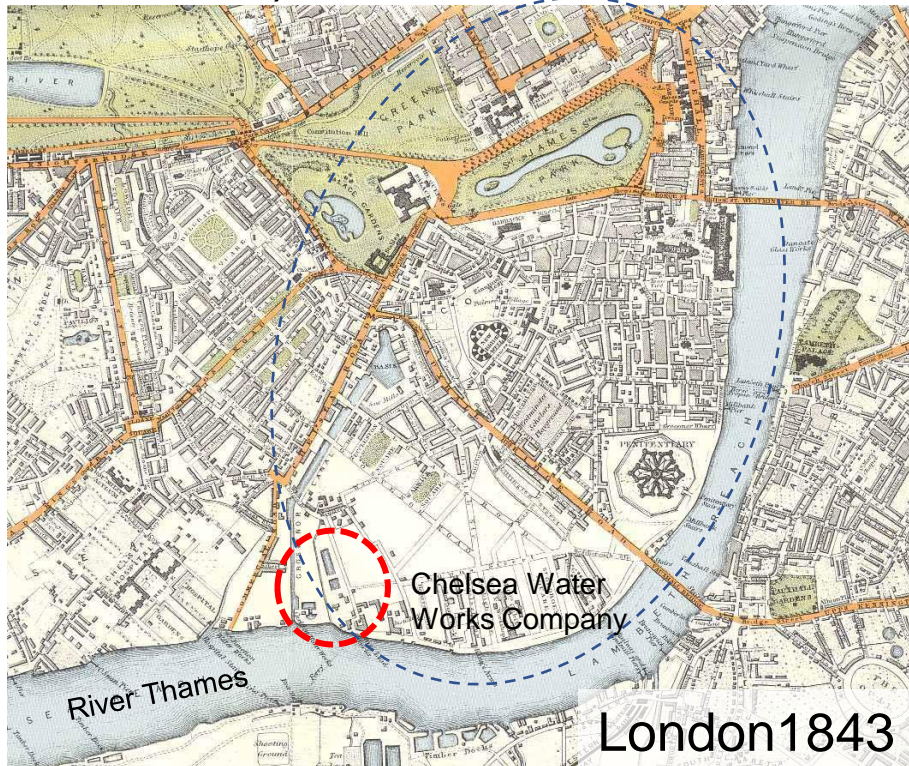
Completion of Slow Sand Filter(English Filter)



Horizontal

Vertical

James Simpson (1799-1869) worked at Chelsea Water Works Company in his age of 24 (1823) which was his father's company. At his age of 28, he started "2,000-mile inspection trip (Quest for Pure Water)" all over the Britain.



London 1843

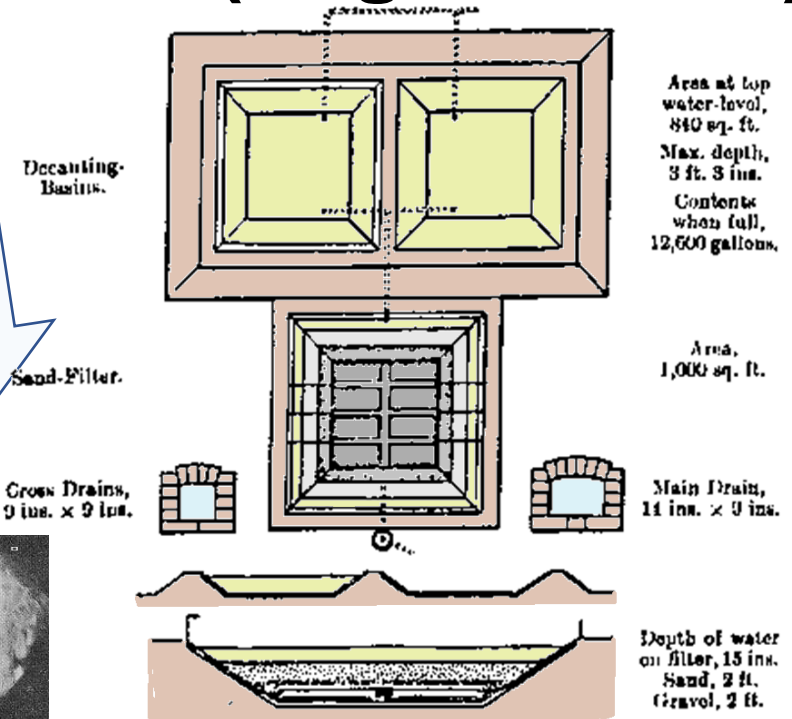


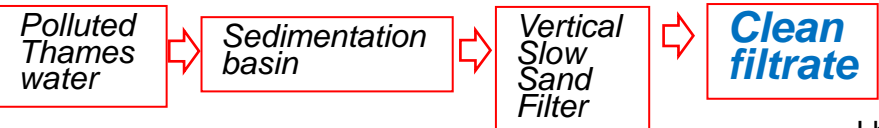
FIG. 28. JAMES SIMPSON'S EXPERIMENTAL FILTER OF 1827-1828

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

Depth of **water**: 15 inches(**38cm**)

Sand 2ft(**61cm**), **Gravel** 2ft(**61cm**)

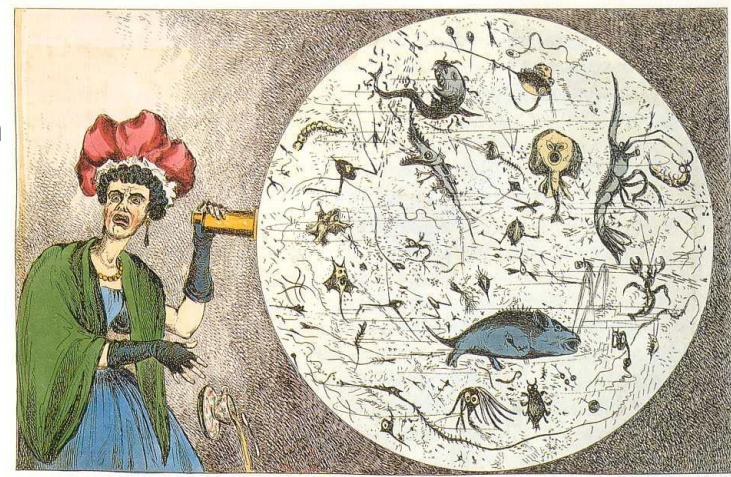
He examined vertical type of slow sand filter from 1827-1829 and made one acre filter (4,047m²=ca64mx64m) for **practical use in 1829.**



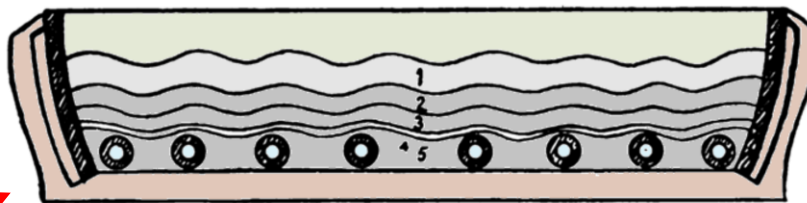
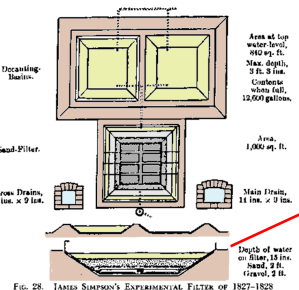


1832 : The great common sewers discharged into the Thames river. This was the Source of the Southwark Water Works.

Monster Soup commonly called Thames Water on the Metropolitan Water supply in 1828.



River Thames in London was highly polluted. Bad smell. They could see many floating dead animals in this river.



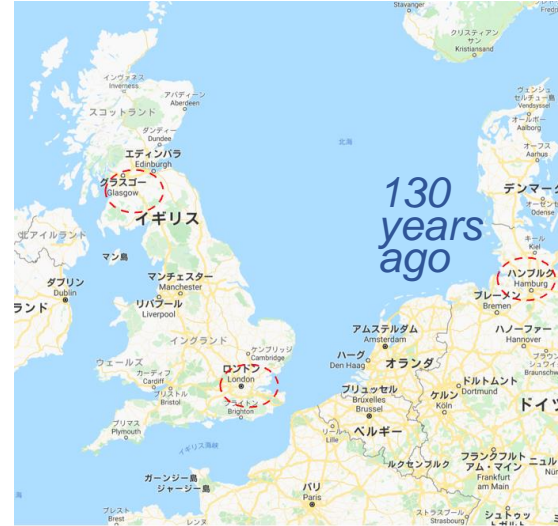
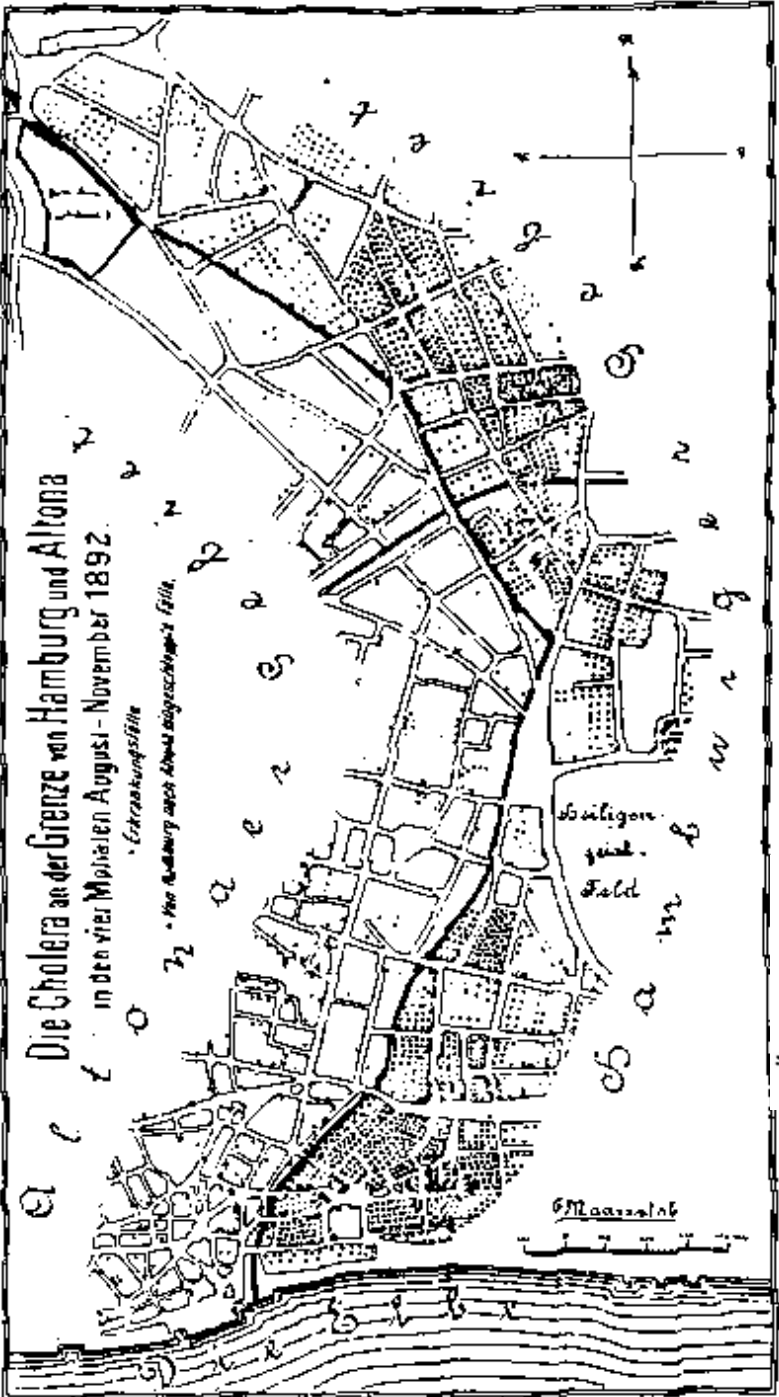
Cross Section's of Simpson's One-Acre Filter for Practical Use, 1929

- 1: fine sand,
- 2: loose sand,
- 3: pebbles and shells,
- 4: fine gravel,
- 5: large gravel containing underdrains.

Polluted Thames water

Vertical Slow Sand Filter

Clean filtrate

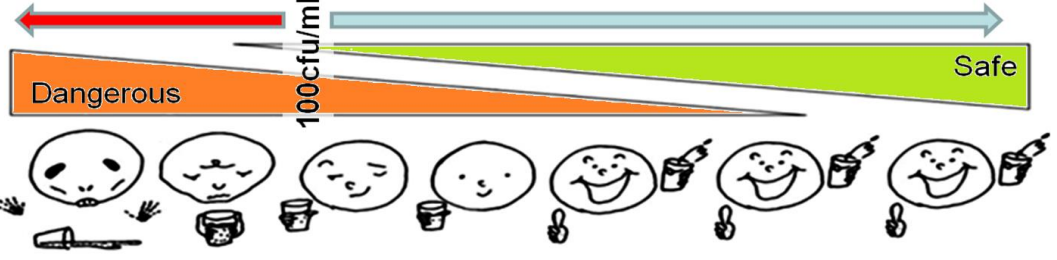


The clear proof of the slow sand filtration was provided in 1892.

Hamburg suffered from a cholera epidemic that infected and caused more than 7,500 deaths, while Altona was almost non of serious patient.

Dr. Robert Koch tested the bacteria in the water with slow sand filtration. 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".

Finger bowl



Wash our hands!
Reduce the risk of contamination.

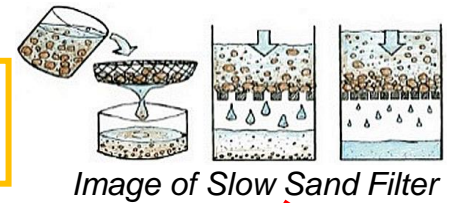


→ Slow Sand Filter (SSF)
→ Wise Use of Biological Phenomena
→ **Ecological Purification System (EPS)**

Principle of Purification mechanism to make artificial safe drinking water had been misunderstood as mechanical filter by the name of Slow Sand Filter.

1975: Shinshu univ.
Sugadaira Reservoir study

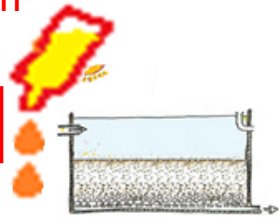
1984, April:
Slow sand filter



Eutrophication
⇒ algal bloom

Bad algae

Algaecide



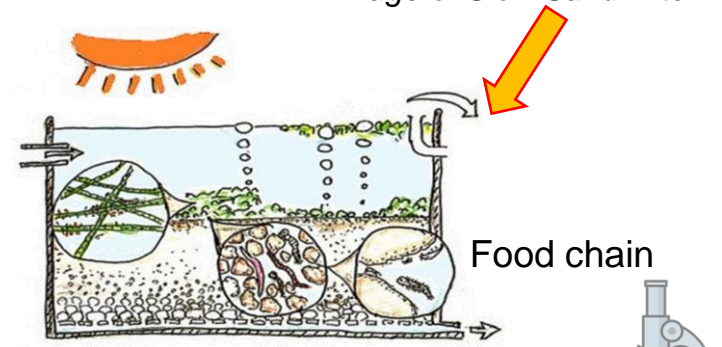
Odor problem of tap



Stop algaecide

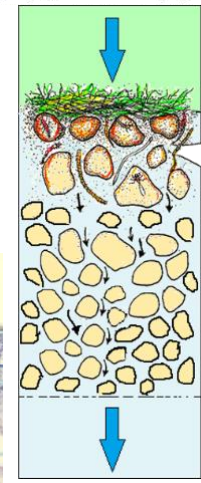


⇒ heavy algal bloom



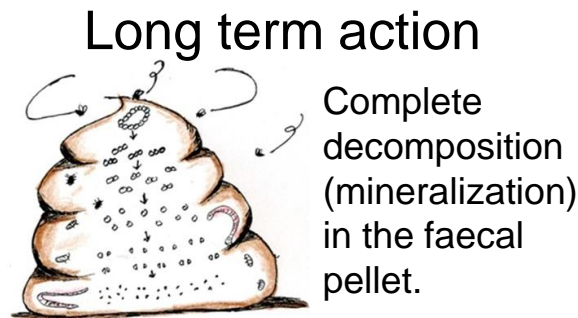
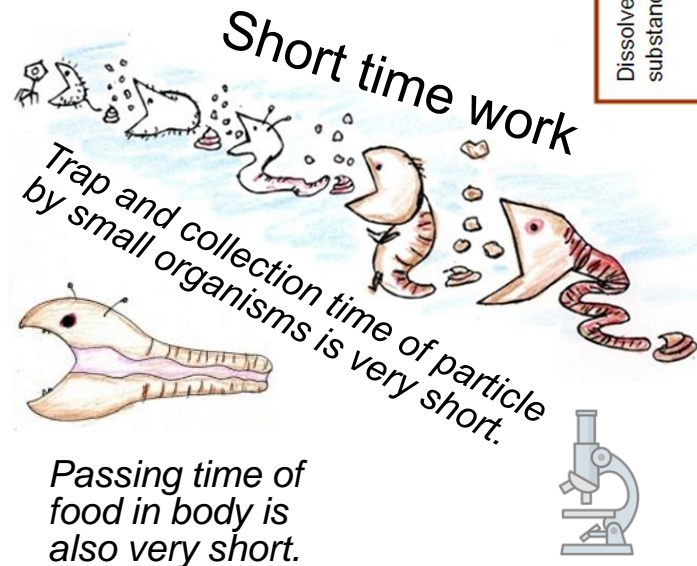
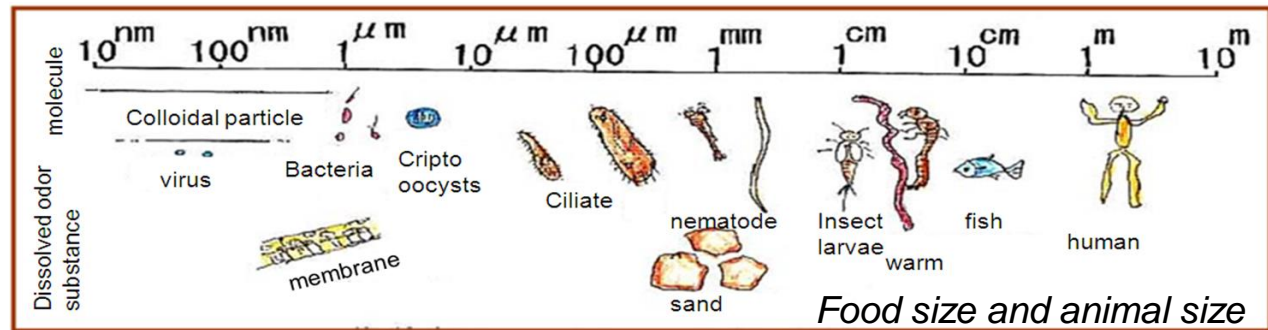
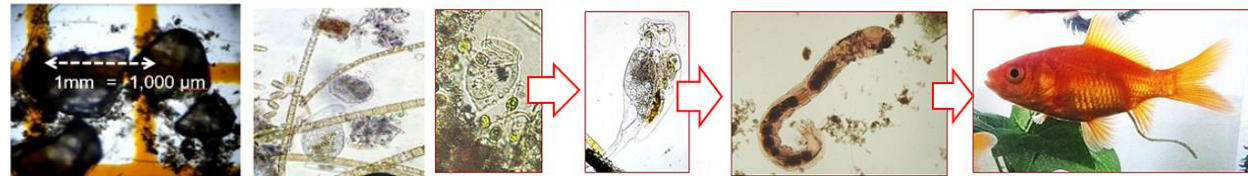
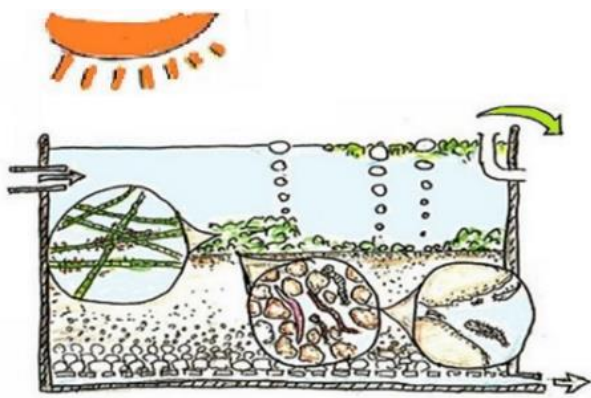
Food chain

Slow sand filter plant,
Someya WTP



Real purification is
done by the activity
of small biological
community near the
surface.

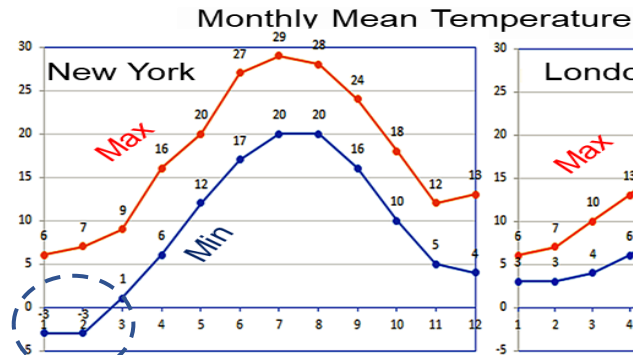




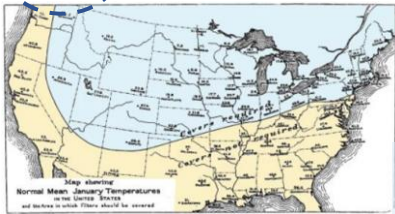
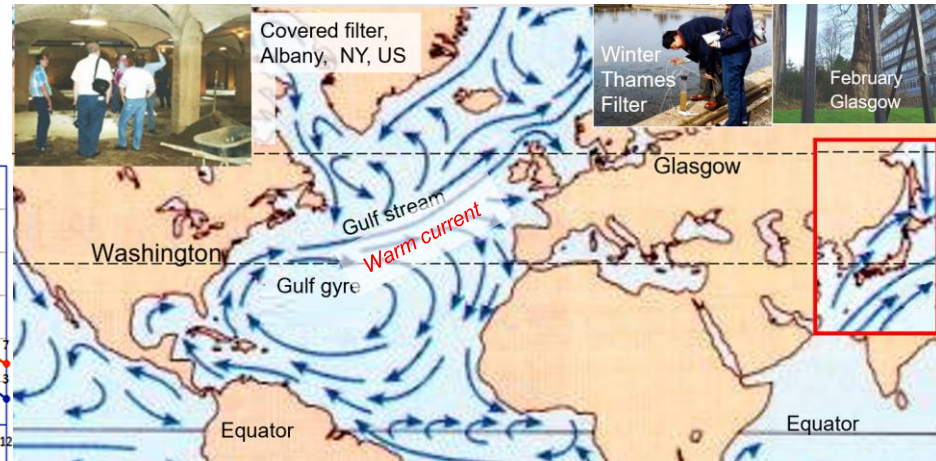
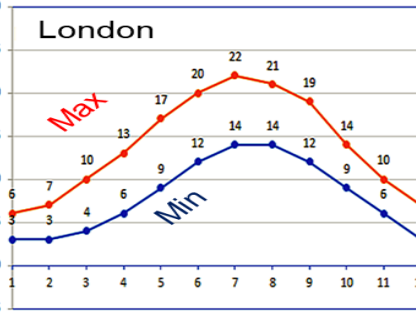
Anaerobic condition inside of fecal pellet.

When an organism reacts with dissolved substances, it means that the substance has adhered to the cell surface of the organism. Dissolved substances that organisms react to can also be decomposed in the fecal pellet during the fermentation process.

SSF spread to the world. SSF function depends on the biological activity. SSF is suitable to the **warm** regions.



Beirut is warmer than London.

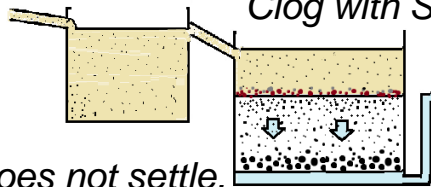


Covered required due to severe cold winter.

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**

Cold \Rightarrow Weak Biological Activity

Fine suspended solid Clog with SS



Does not settle.

Biological activity is weak in winter.

RSF is Commercial Filter

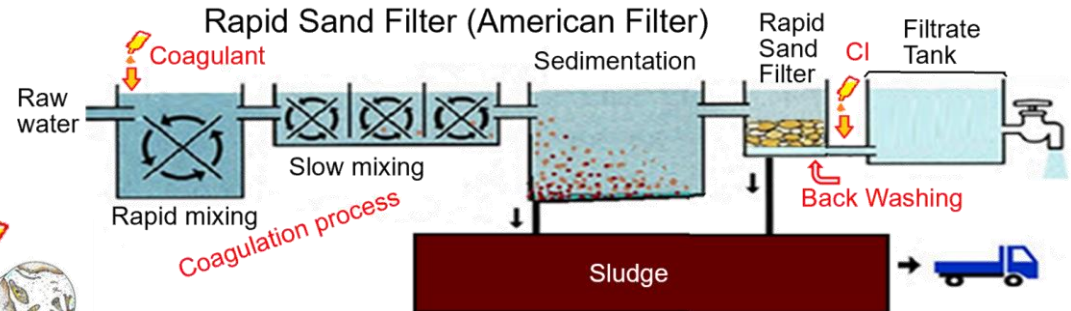
Present for you!
This is new technology.

RSF is American Commercial Filter

People loves new technology.



Organisms cannot play an active role in rapid filtration.

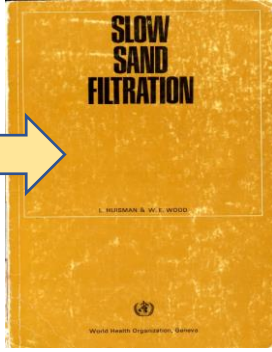
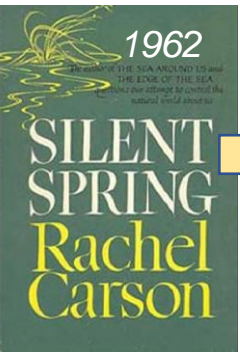


Algae were disliked by rapid sand filtration.



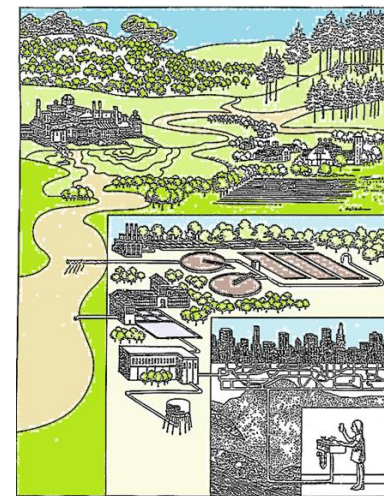
Rapid sand filter at Dbayeh: frequent back washing is needed to prevent clogging.

Bacteria pass through by backwashing, so sterilization with chlorine is essential.



Huisman & Wood 1974, WHO SSF manual of chemical free more safe treatment than chemical treatment.

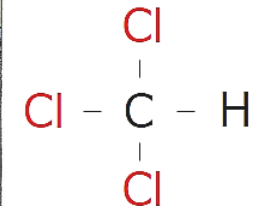
Everyone became interested in Chemical Free treatment of Slow Sand Filtration.



IS THE WATER SAFE TO DRINK?

Harris et.al. 1974 Consumer Report

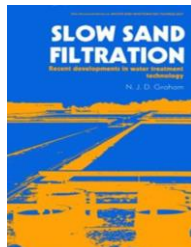
Cancer risk by Chlorin addition.



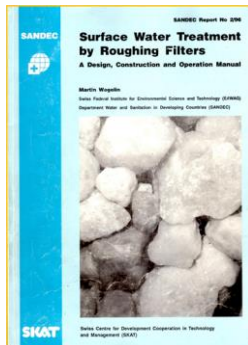
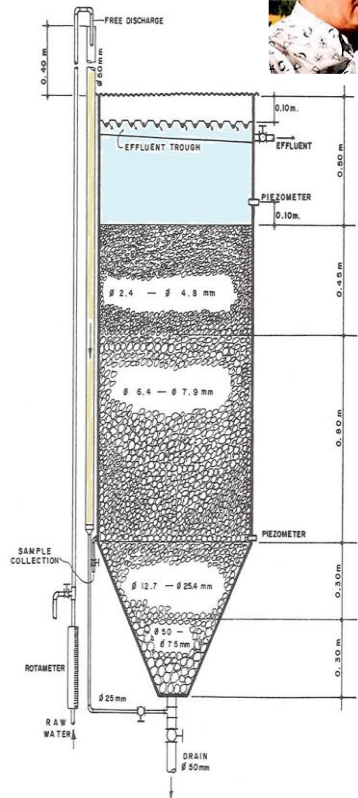
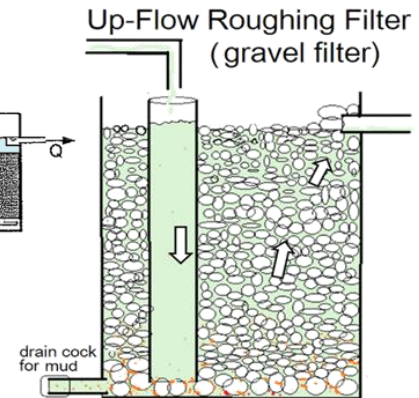
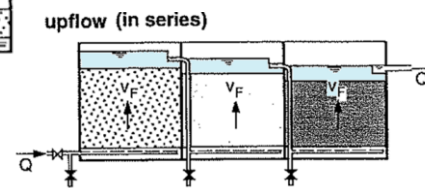
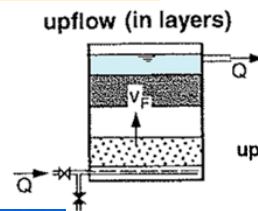
In the 1980s, the Up-flow Roughing Filter (URF) was developed to reduce turbidity **without chemicals**.



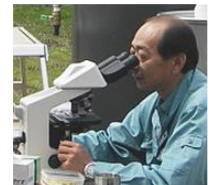
Luiz Di Bernardo 1980
Univ. Sao Paulo, Brazil



1988
London



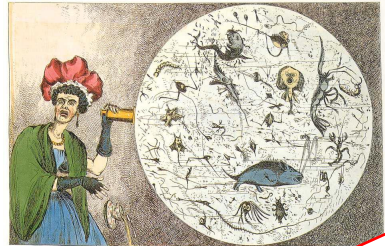
M. Wegelin
SANDEC,
Swiss,
October
1996



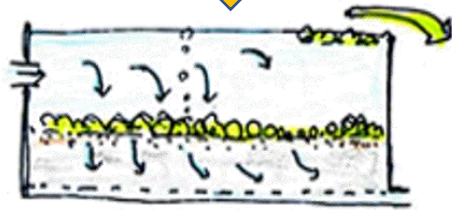
Food Chain
is Key.

URF is also EPS.

River Thames is super eutrophic and hard water. They make delicious tap water by SSF.



Nutrient highly rich water



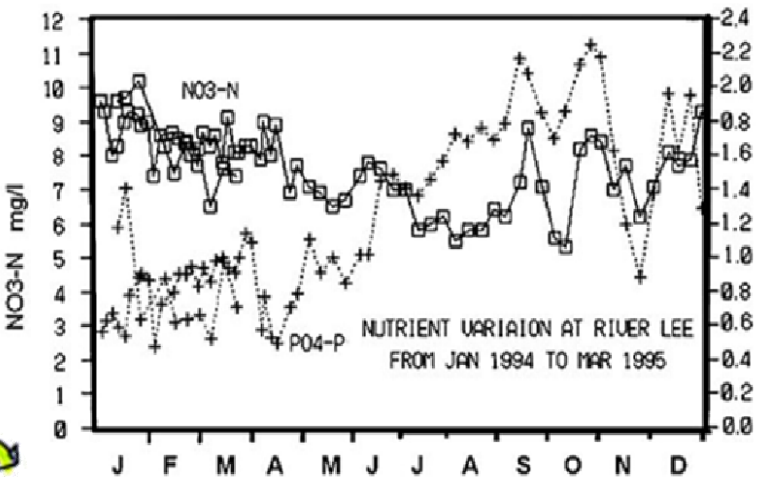
Algal bloom is always remarkable all year round.



Ashford Common WTP, London, UK.

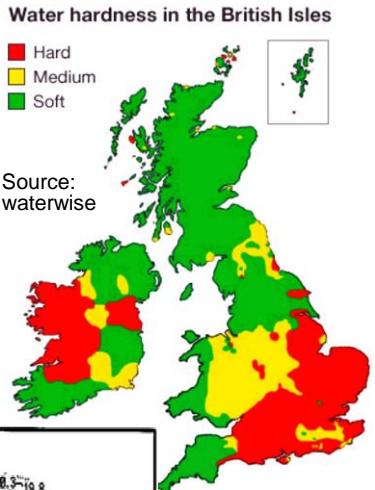
Heavy algal bloom

Queen Merry Reservoir



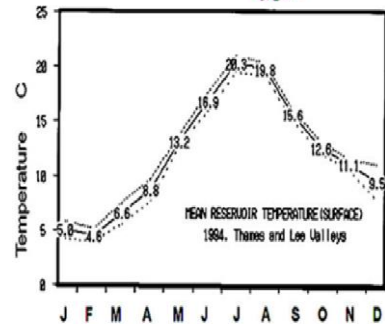
Filamentous green algal bloom in summer

Biological roughing filter without chemical. *Decomposition & mineralization by ecological function*



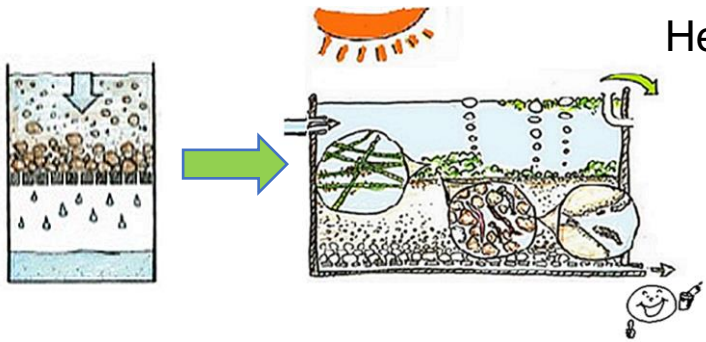
Water in England is hard water.

SSF 32 filters. 100mx35m

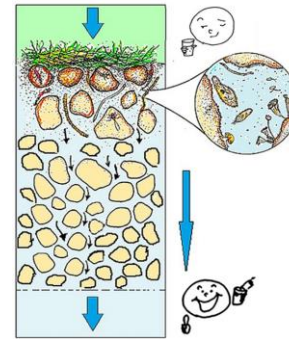


Filamentous diatom in winter

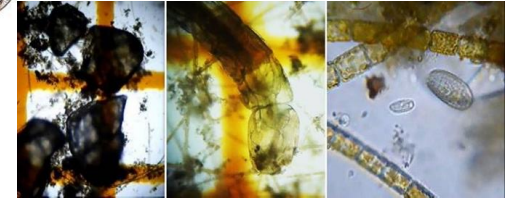
SSF is Ecological Purification System. Aerobic condition is essential.



Heavy algal bloom



Large oxygen Production
Large oxygen Consumption

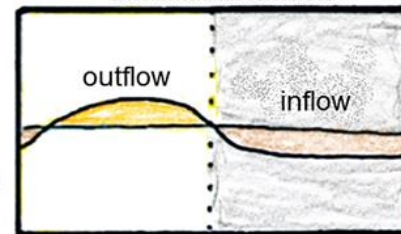
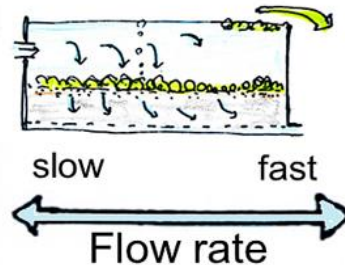
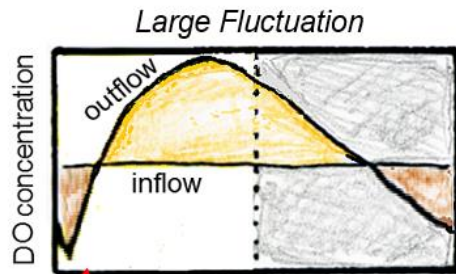


Faster flow rate is better for small organisms to keep aerobic condition.

4.8 m/d

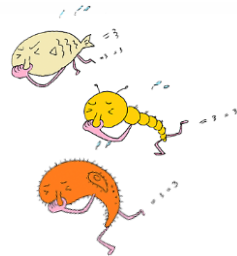


9.6 m/d



Day Night
Low DO
Dangerous for small animals

Small animals rush and escape from a risky water of low DO environment.



Day Night
Gentle and Reliable
: from microbe to animals.

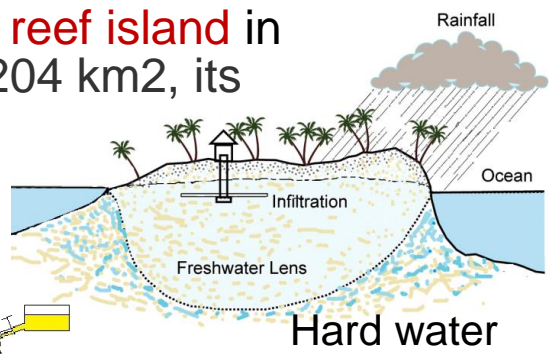
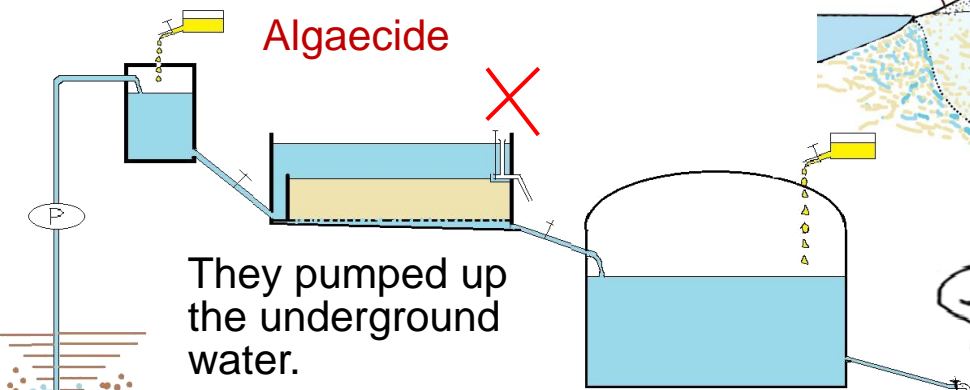
Present Thames Utility adopted higher flow rate of 9.6m/d in order to keep aerobic condition for biological community.



I checked the washed clean filter sand of the filter bed in London. Thames water utility does not care about sand size and uniformity. Large size of sand is better for faster flow rate.

Key is to keep aerobic condition for EPS.

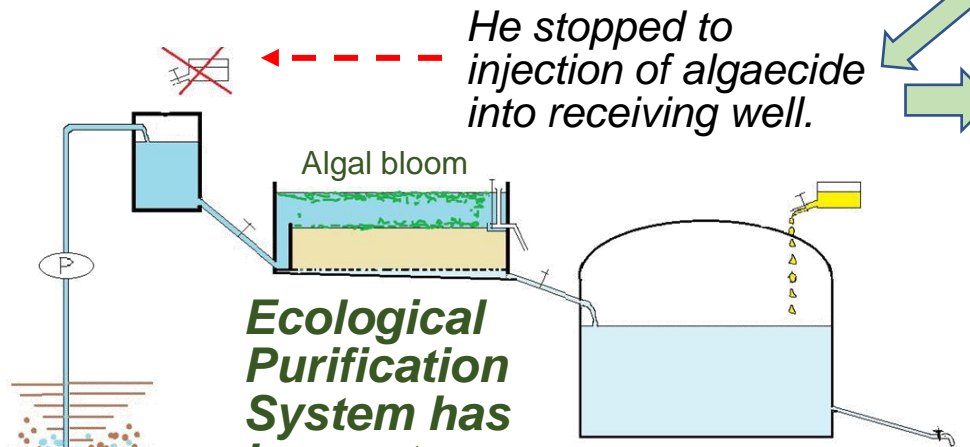
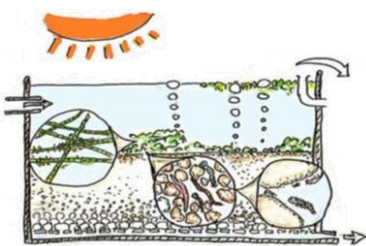
Miyako-jima island is an **uplifted coral reef island** in south of Japan. Area of this island is 204 km2, its population is 55,000 persons.



They pumped up the underground water.

They could not flow out from the scum out. The **pre-chlorination** as **algaecide** was introduced to kill the algae in filter pond.

Nakamoto explained about the **ecological purification system** of slow sand filter to the plant director on July 8, 1997.



He stopped to injection of algaecide into receiving well.

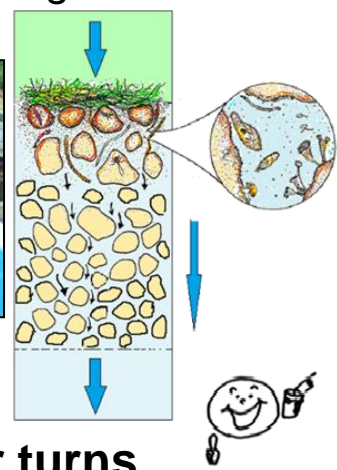
Ecological Purification System has begun to work.

The taste of tap water became **delicious**.

Just after the **Chlorine injection was stopped** in summer of 1997, the algae grew well in filter ponds.



New hard work raised to remove floating algae.



Even the hard water turns to delicious by EPS process.



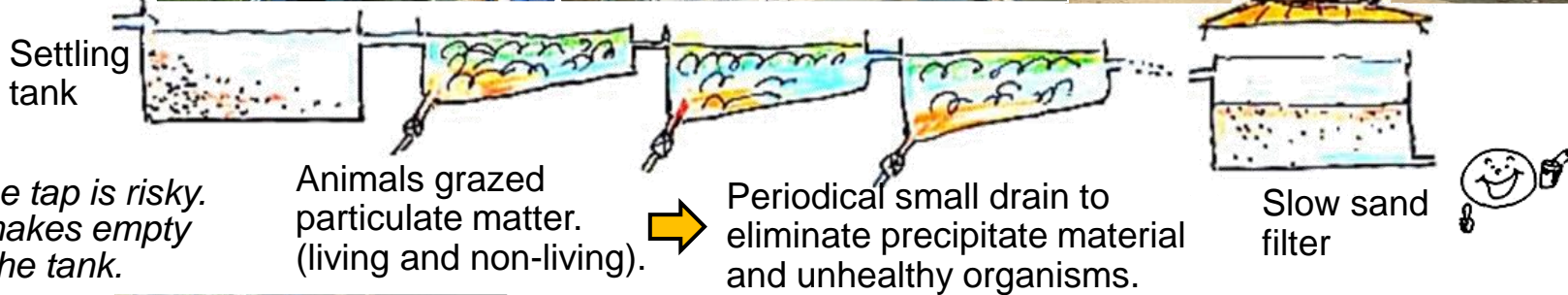
YAMAHA motor company in Indonesia made a purifier for clean and safe water in 1991. But this purifier is expensive. Villagers could not buy this.



YAMAHA motor company asked me to make safe drinking water by EPS for villagers. This project is an activity of **social contribution** of YAMAHA motor company.

I advised a New Ecological pre-treatment for SSF

This is new idea of ecological process to reduce silt and colloidal particle for sand filter instead of URF.



Two bottles of 20 liters per 1 family. This water is used for **drinking and cooking only**. This water is not used for bathing and washing hands.

Diarrhea and eye sickness are disappeared.
→ **Health village**

→ sanitary sense and its level are distributed among the villagers.

→ This acts to protect naturally against sickness.

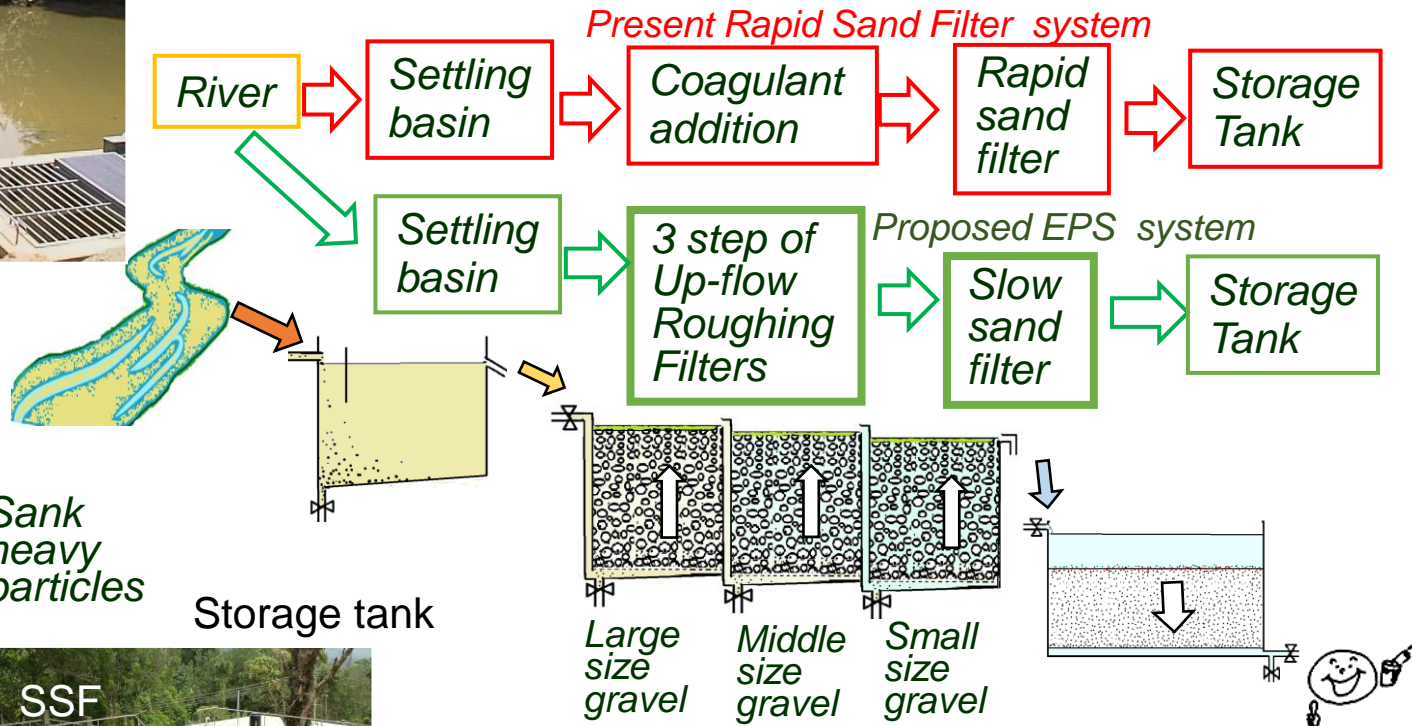
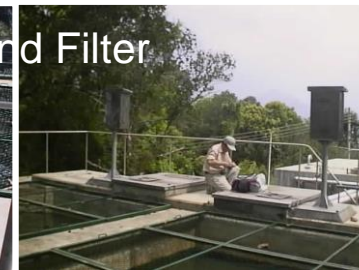
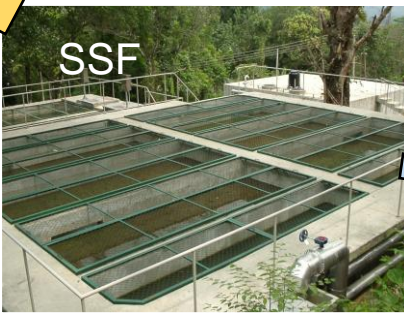


Public tap system and collect money for maintenance of this plant.

The villagers have maintained this plant by themselves for more than 10 years.

I helped to construct a renewal WTP of National Hospital in Sri Lanka, in 2000.

Mr. Okada, Japanese consultant visited to make a renewal plan of Rapid Sand Filter. This old plant did not work well. He asked me that a suitable treatment system for tropical turbid water. I advised to apply a new URF system for turbid water.



A fairly large size of 3 steps of URF

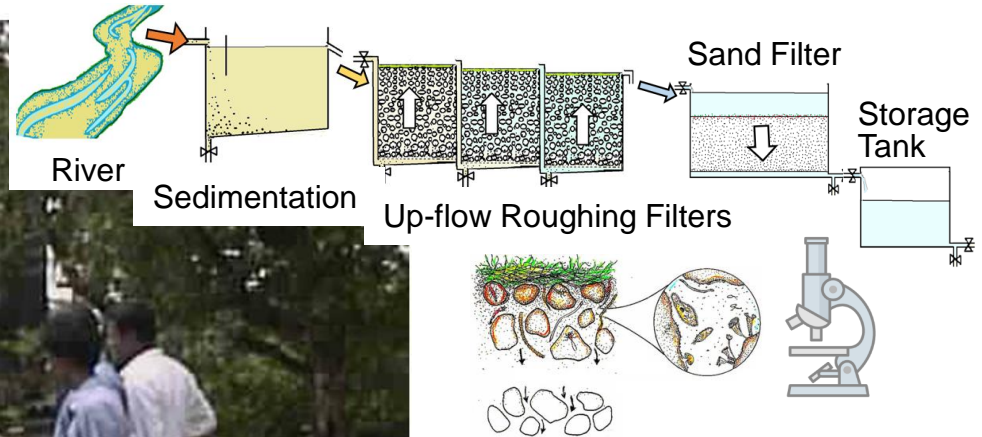
Two set of settling basins, URFs and sand filters were constructed.

These open system was covered with metal mesh screen to protect fallen leaves and plastic bags.

I explained the chemical free purification system of EPS to the engineers.



Commercial Filter : RSF



Natural Filter

We need simple low technology.

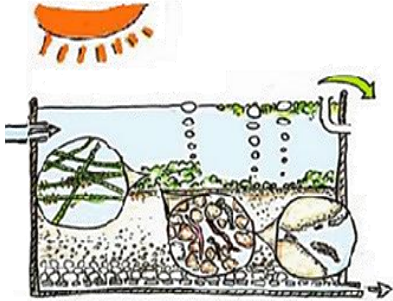


This is wise use of natural system.

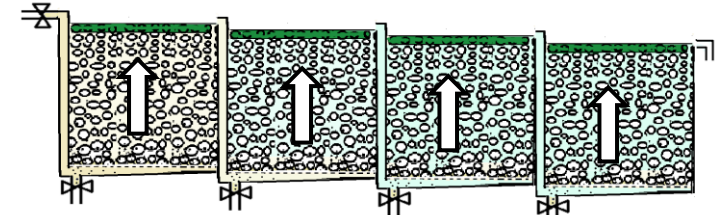
The manager understood that this old RSF was a commercial technology.

I visited again this site after construction in 10 years later. The hospital director said there was no problem.

Since 2002, I have cooperated with the Asian Arsenic Network (AAN, NGO) activity in Bangladesh. I was asked to consider a mechanism that can decompose herbicide and pesticide without using chemicals.



Repeated growth of algae and decomposition by grazing animals, and real decomposition of herbicide and pesticide under anaerobic condition in fecal pellets.



Repeated URF process of algal growth and decomposition by animals in 4 times. DO in water is necessary for animal activity in this system.



AAN made new constructions with UNICEF fund in 2019.

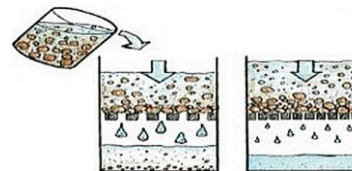
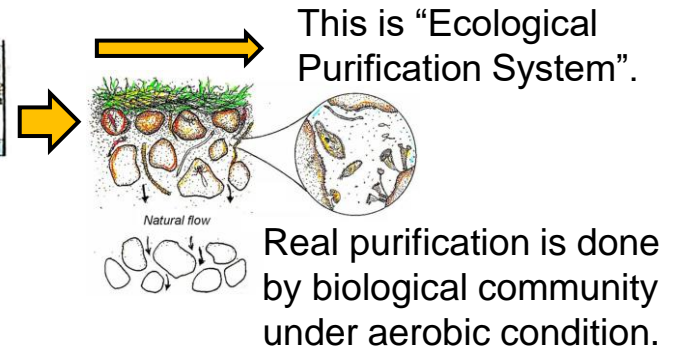


Image of Slow Sand Filter is "Slow filtration by fine sand".





2011.8.



2012.9.



National EPS project in Fiji started from Jan. 2013.

Fijian EPS project opened for rural people in Jan. 2013.

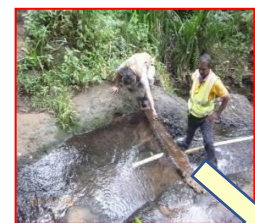
A public tap system of water supply for germ free safe water was proposed.

Mr. Jeet from Fiji learned EPS during JICA Training in Okinawa in Aug. 2011.

He confirmed the performance by his model in Fiji.

He explained EPS to PM at an event in Sep. 2012.

New plans for cleaner water



Water source

Receiving tank

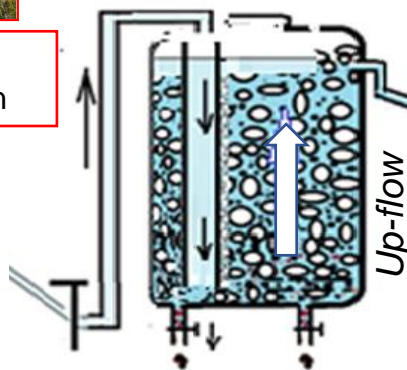
EPS was settled between the existing distribution pipes of non-treated water supply.

Sediment heavy muddy matter



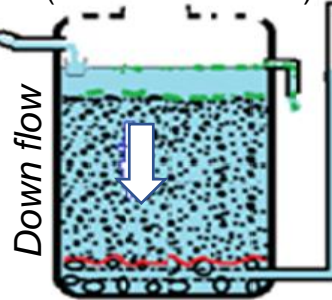
Turbidity Reduction

Up-flow Roughing Filter (Gravel tank)



Trap and reduce muddy matter by gravel tank

EPS Sand tank (natural down flow)



Complete purification by sand tank

Public tap system was recommend to save the filtrate.

Fijian project provides 6 liters /person/day for drink and cook.

Store the germ free, safe and delicious drinking water



Public tap

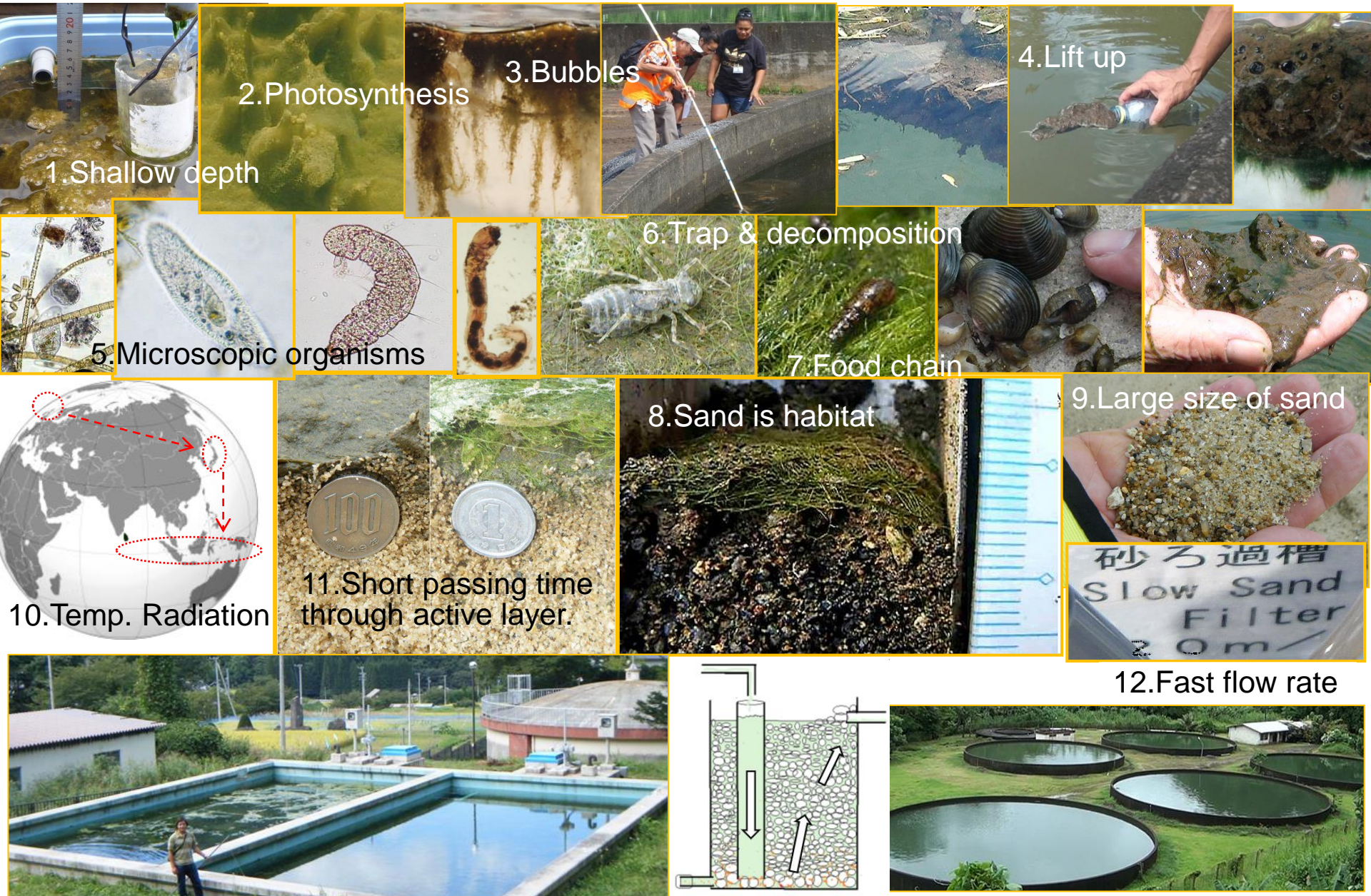
Tap in village



Existing system in village

EPS (Ecological Purification System) for germ free drinking water

EPS is wise use of natural system. You can make an EPS plant by yourselves.



Gentle: chemical free

URF for turbidity reduction

EPS is Eco-Friendly Smart Technology.



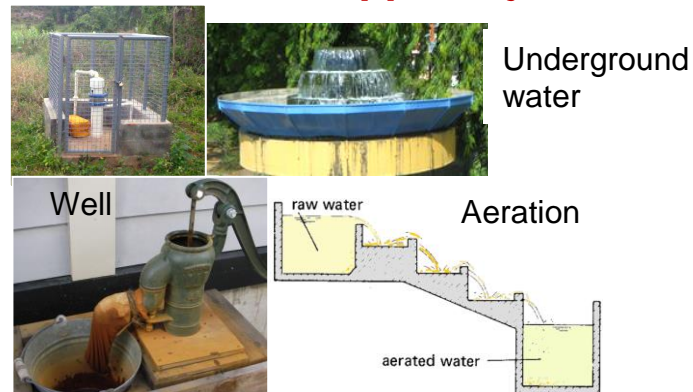
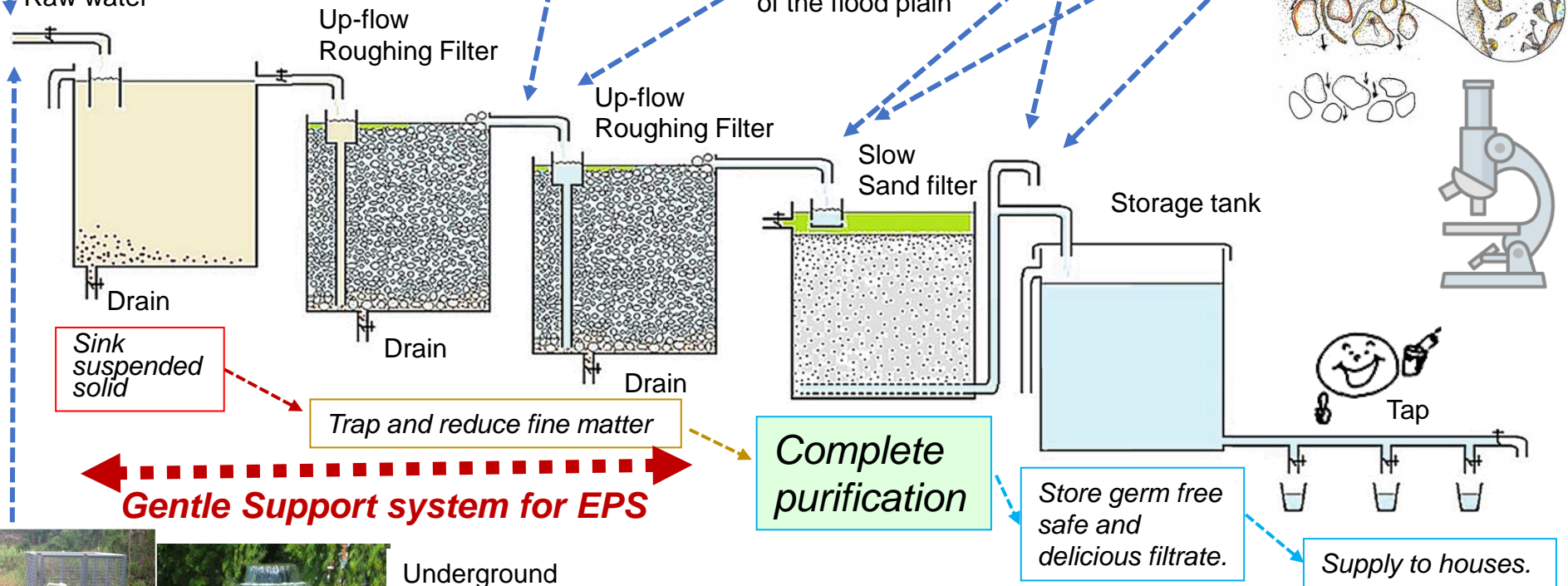
Surface water of river

Reservoir, lake

Subsurface water of the flood plain

Clear spring water

Raw water



Ecological Purification System (EPS):
This is Wise Use of Natural Phenomena.
This is Chemical Free System.
Slow means Gentle for any organisms.

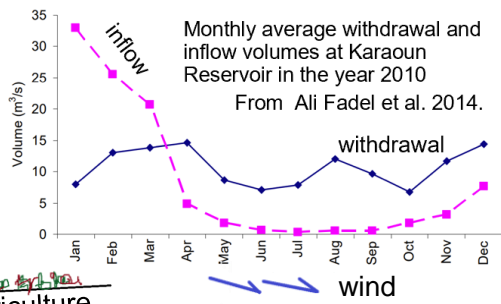


Nutrient rich water due to human activity.



People clear dead fish from Lake Qaraoun in west Bekaa, April 30, 2021.

Fadel A., et al. (2014). First assessment of the ecological status of Karaoun Reservoir, Lebanon. Lakes Reserv. Res. Manag. 19(2), 142 - 157.



Dead fish are buried in pits by Lake Qaraoun in west Bekaa, Lebanon, April 30, 2021.



Spring: increase radiation
Warm surface water.
Algal Bloom

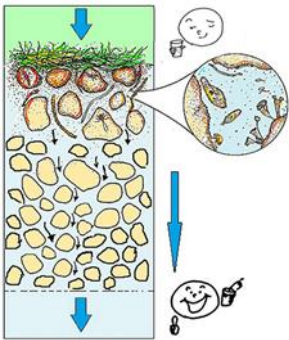


Anaerobic condition in the bottom layer.

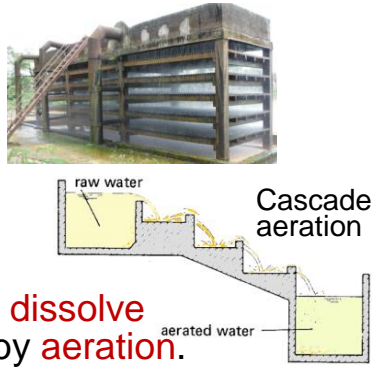
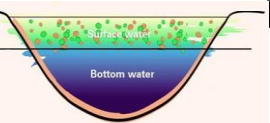
Qaraoun Reservoir Eutrophication Dynamics: Assessing the Role of Climate and Excessive Nutrient Loading
Ibrahim Alameddine Jan 7 2020
American Univ. Beirut



Bottom water rises.



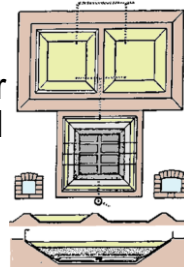
When the dissolved oxygen is consumed at the bottom of the lake, **reducing substances** are produced in the bottom water.



It is necessary to **dissolve oxygen** in water by **aeration**.



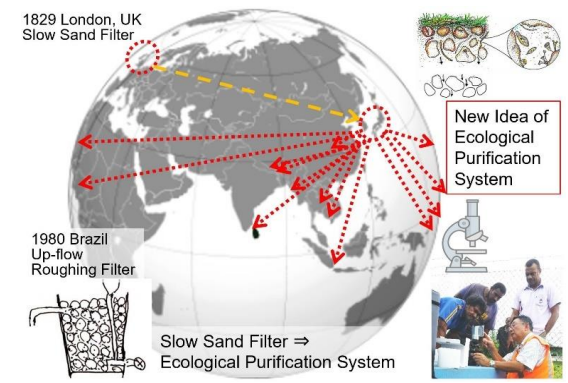
Urban rivers was polluted with wastewater. This water consumed **oxygen** and produced **reducing substances**, odor substances.



J. Simpson made safe and delicious tap water by slow sand filter.

This is wise application of natural decomposition process. This is Ecological Purification System.

SSF has been misleading by name.
This is Ecological Purification System.



How to make an EPS model.

<https://www.youtube.com/watch?v=Ye-POV6qBU0>

You can find more detail explanation from my English Manual in 2018.



<http://www.cwsc.or.jp/files/pdf/EPStext-NC-2019.pdf>

https://www.youtube.com/watch?v=V6_uDZE_l8E



<https://jica-net-library.jica.go.jp/lib2/08PRDM007/pdf/reference01-eng.pdf>



Ecological Purification System for Safe Drinking Water

- Application of Natural Process -
Eco-friendly technique to make artificial spring water

NAKAMOTO Nobutada, Dr. Science
Prof. Emeritus of Shinshu University, Japan



Fig.0. Fijian EPS using rain harvest tanks in a village.

August 2018

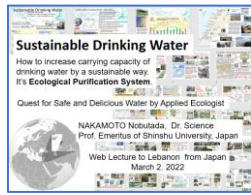


<https://www.youtube.com/watch?v=Wv1FxTkDfsM>



Hard water island: Japanese, English super.

<https://www.youtube.com/watch?v=r1LIPuQliu0>



This web lecture by 9 minutes.

<https://youtu.be/SnECwMq1J68>