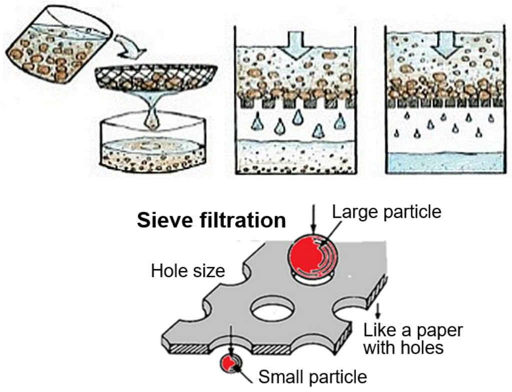
# ② Quest for Pure Water from SSF to EPS.

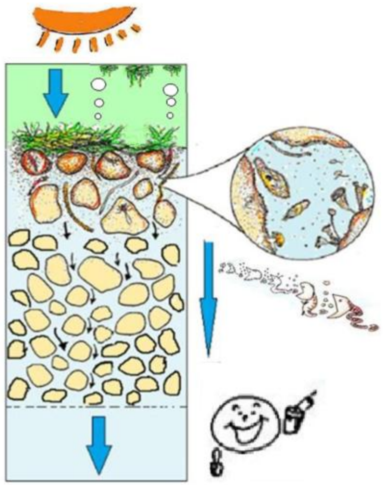
## Chemical free against SS: Up-flow Roughing Filter (URF)

Purification mechanism of **SSF** was **misunderstood under the name**.

Image of **S**low **S**and **F**ilter



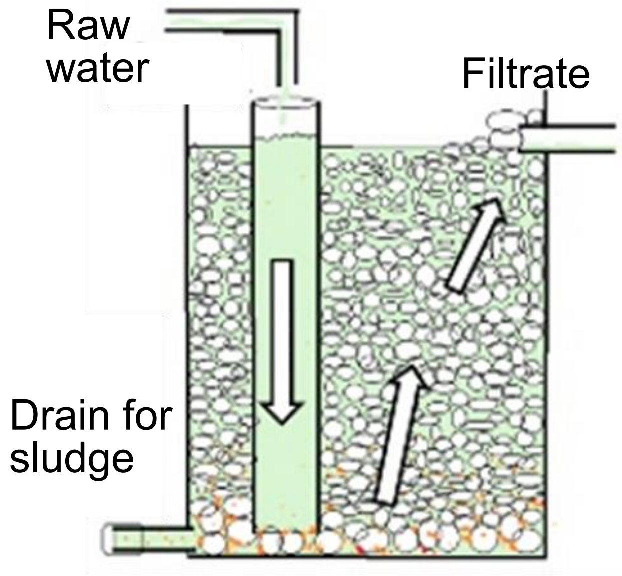

**200 years** have passed, since SSF was developed to supply clean water to **urban** areas in **London, UK**.



SSF is to make artificial spring water by biological community.

I, Nakamoto proposed **new name** of **EPS** instead of **SSF.**

Up-flow Roughing Filter

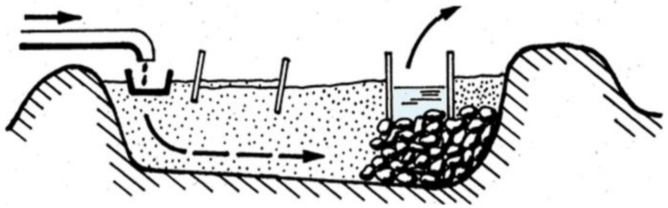



Artificial spring water, ss free water without chemicals.

# Quest for Pure Water, Origin of Public Water Supply

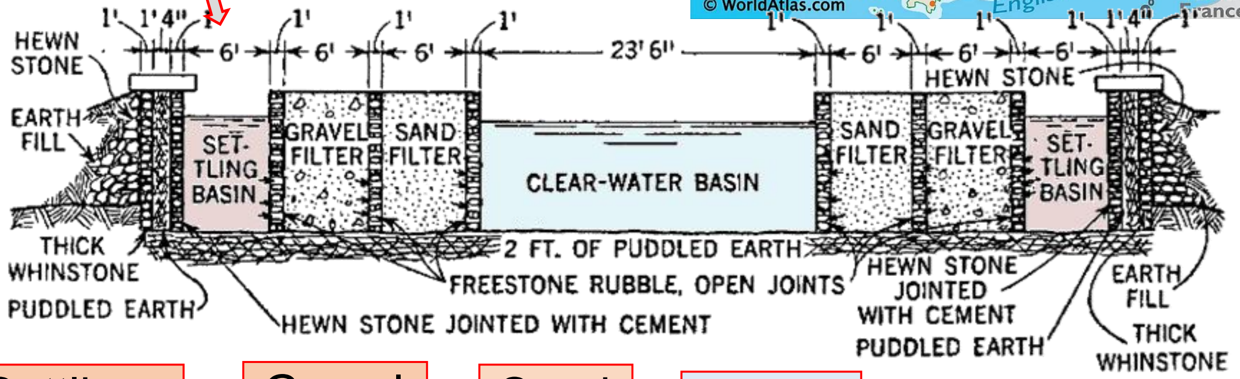

During the Age of Discovery, the textile industry developed.

In 1804, in Paisley, a suburb of Glasgow, Scotland, John Gibb created an artificial spring in a riverbed to wash away dye from dyed fabric.



He created an artificially clean spring water by horizontally through gravel and sand tanks.

Surface water from the Clyde river.




Settling Basin → Gravel Filter → Sand Filter → Clear-Water Basin

Horizontal flow

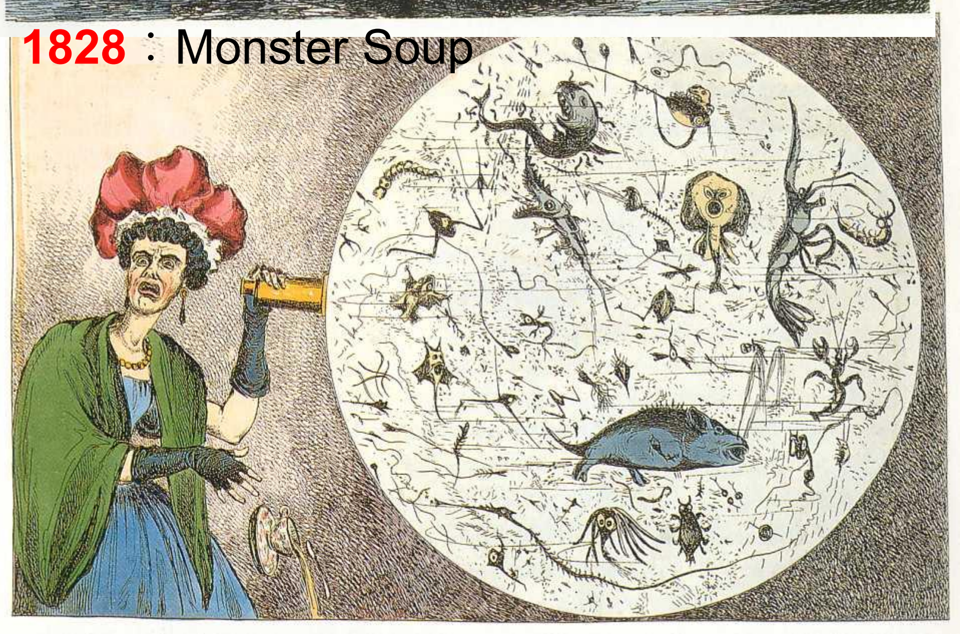
This is said to be the beginning of public water supply systems.

Gibb had water left over from his factory work, so he put it in barrels and sold it around the city by horse-drawn cart.

# During the Industrial Revolution, many people concentrated in cities, and urban rivers became polluted.

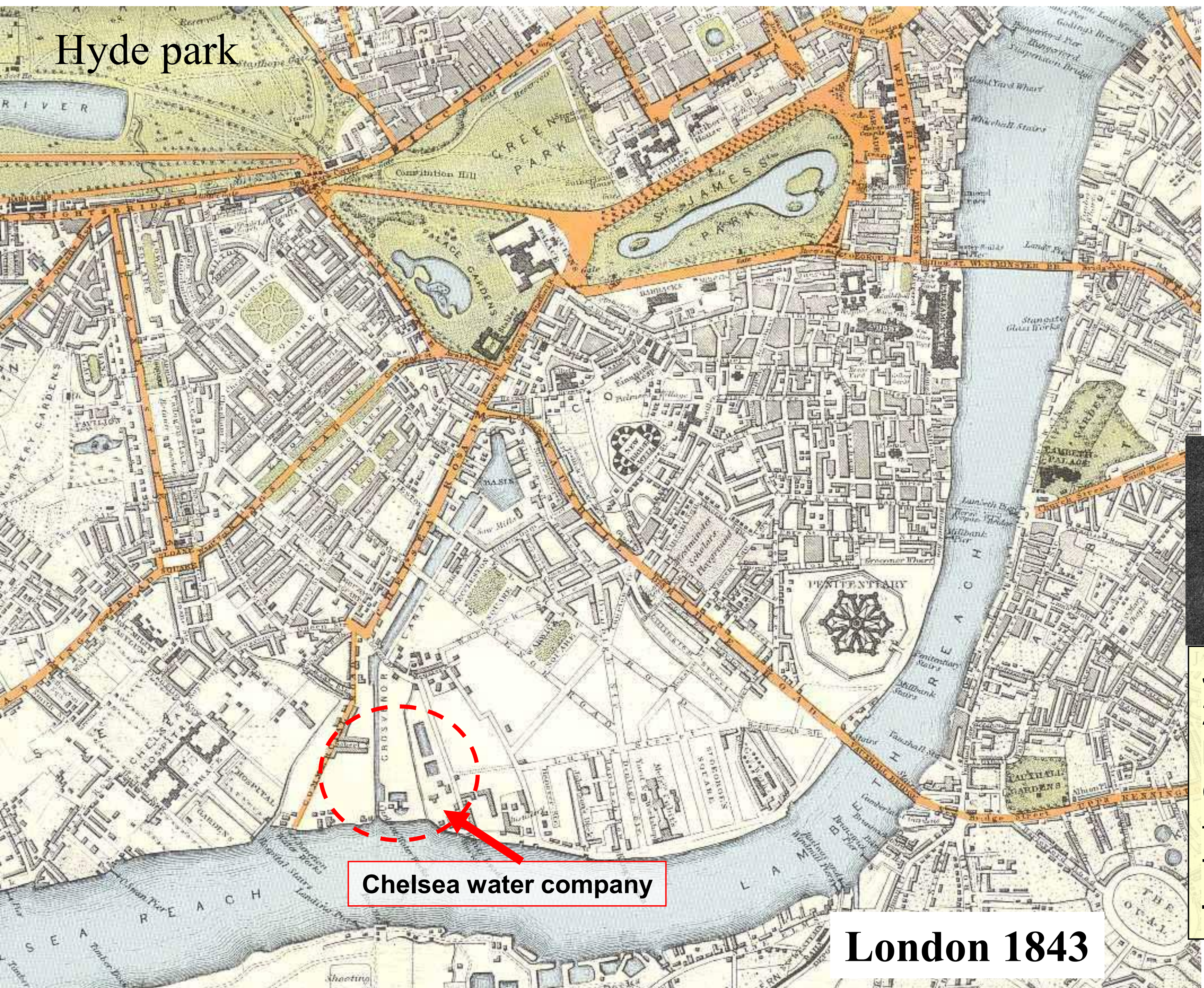
The River Thames in London during the Industrial Revolution

1832: Sewage was spilling into the Thames.

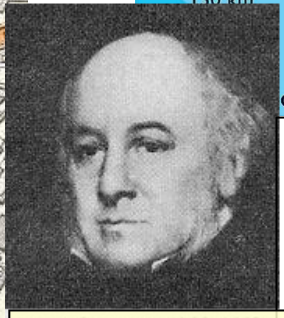



1828 : Monster Soup


In search of clean water, citizens relied on springs and water vendors.







James Simpson surveyed various parts of the UK for clean water.

James Simpson (1799-1869) was 24 years old (1823) when he joined his father's Chelsea Water Company and made a "2,000 miles tour of inspection" around England. This became known as the **Quest for Pure Water.**

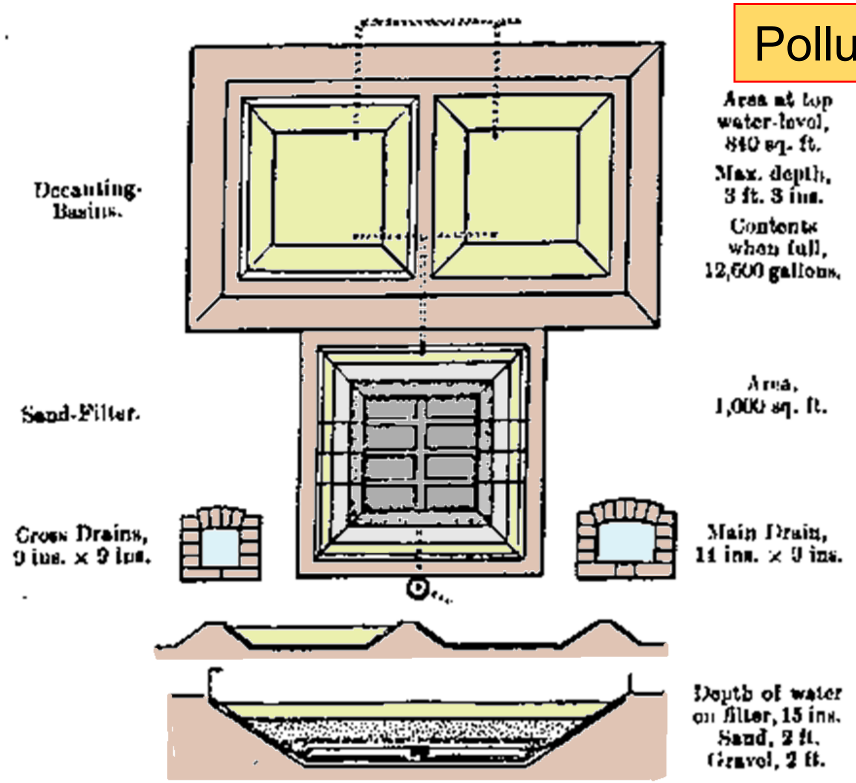



FIG. 28. JAMES SIMPSON'S EXPERIMENTAL FILTER OF 1827–1828

Polluted Thames water

Decanting Basin

Sand Filter : downward

Downward

Clear filtrate

1827:28 years old

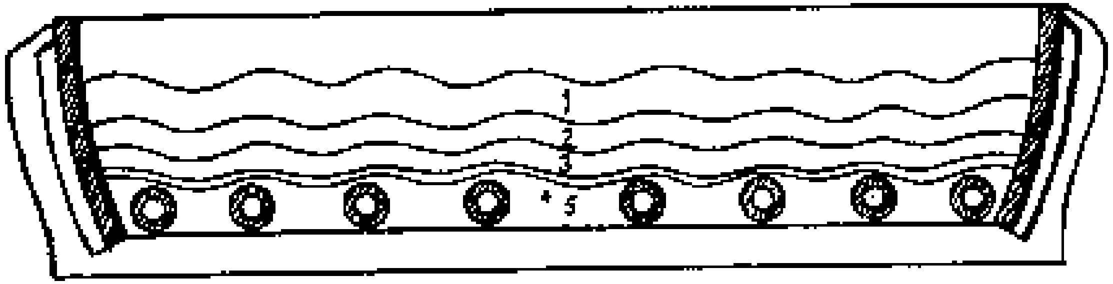
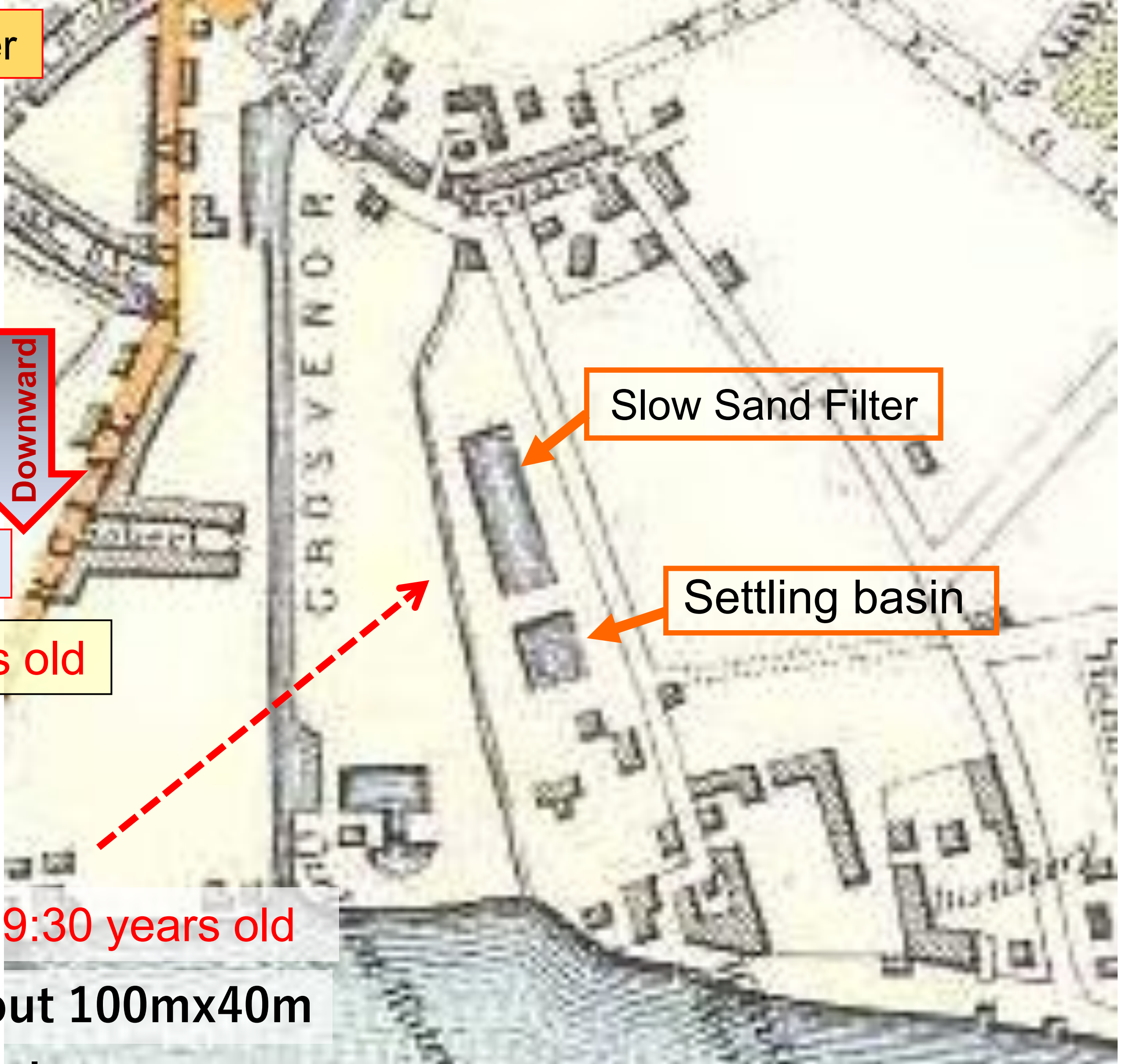


FIG. 29. CROSS SECTION OF SIMPSON'S ONE-ACRE FILTER FOR CHELSEA WATER WORKS CO., 1829




1829:30 years old

**About 100mx40m**

**No detailed drawings of practical filtration ponds remain.**

We (Thames Water) will be reporting our findings over the next 3 years and hope to have **an event in 2029 to celebrate 200 years since James Simpson's English Filter was established at Chelsea Water Works.**

The Chelsea Waterworks' working filters were in use from **1829 to 1856**. When the railway was built the water company moved and began filtering water upstream at Surbiton.

FARADAY GIVING HIS CARD TO FATHER THAMES;

And we hope the Dirty Fellow will consult the learned Professor.

It was said that even the polluted water of the River Thames could be made free of pathogens by using slow sand filtration. After that, slow sand filtration spread around the world as **English filter**.

Polluted Thames water

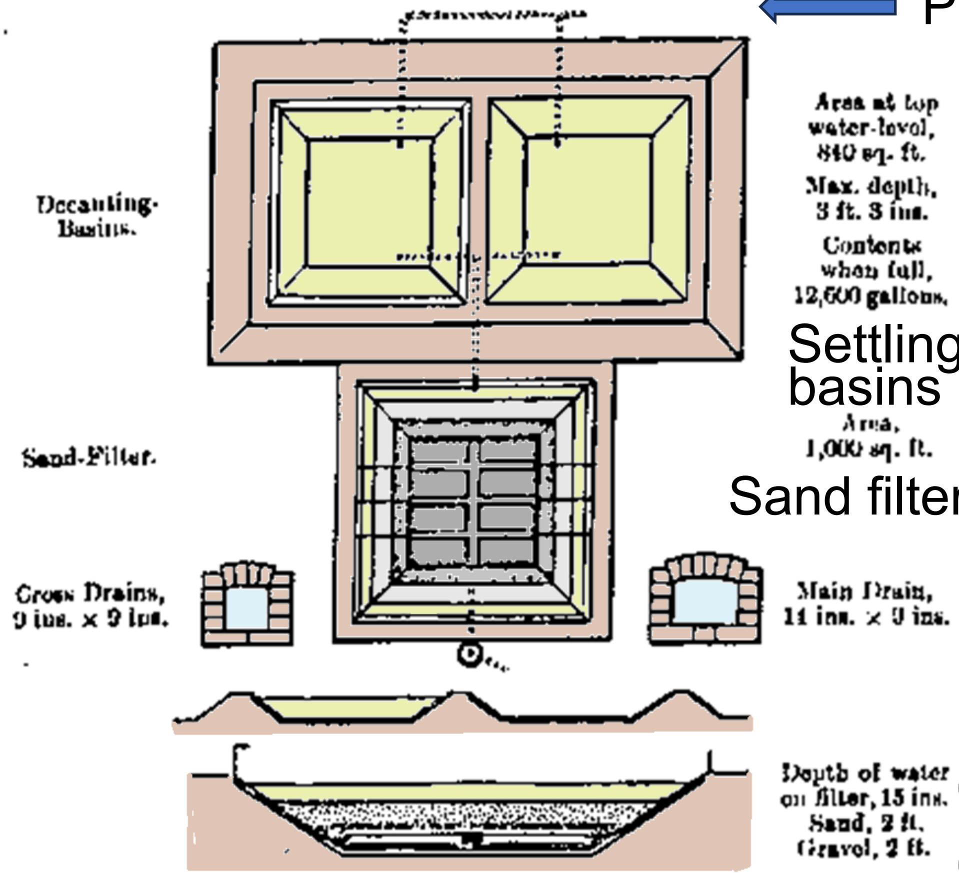



Fig. 28. James Simpson's Experimental Filter of 1827–1828

James Simpson

Experiment filter 1827-1829

**28 years old**

**Filter rate**

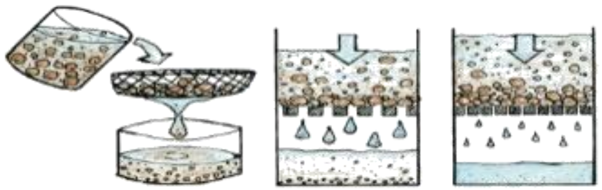
2-3 m/d (10cm/h)

38 cm **Water depth**

61 cm **Sand depth**

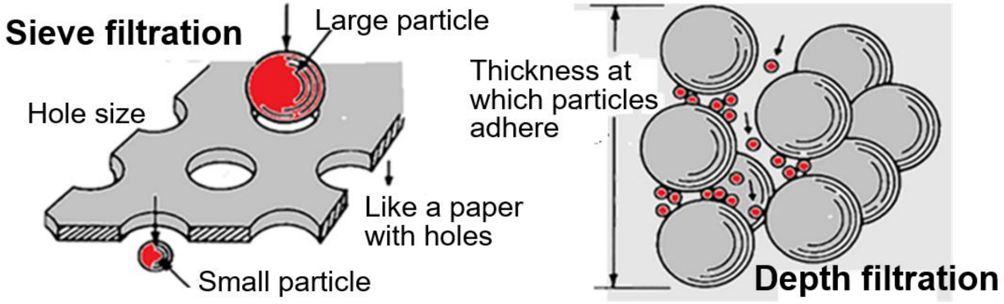
61 cm **Gravel depth**

Downward



The image of Slow Sand Filter

Slow Sand Filtration through fine sand




The mechanism of slow sand filtration that was able to remove fine particles at that time

**The world's most widely used English filtration rate**

4.8 m/d (20cm/h).

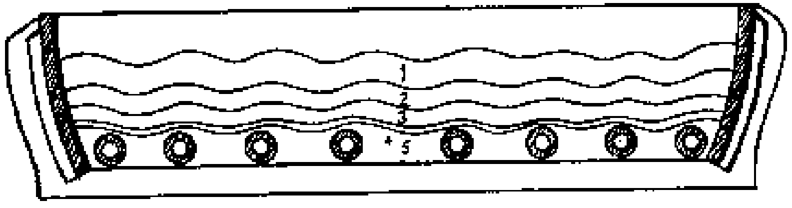


Fig. 29. Cross Section of Simpson's One-Acre Filter for Chelsea Water Works Co., 1829

The practical filter was completed in 1829.

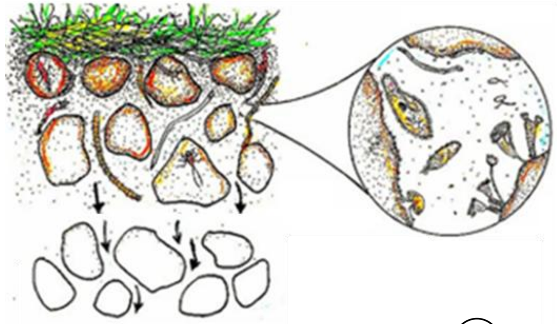
**30 years old**

**The sand doesn't move.**

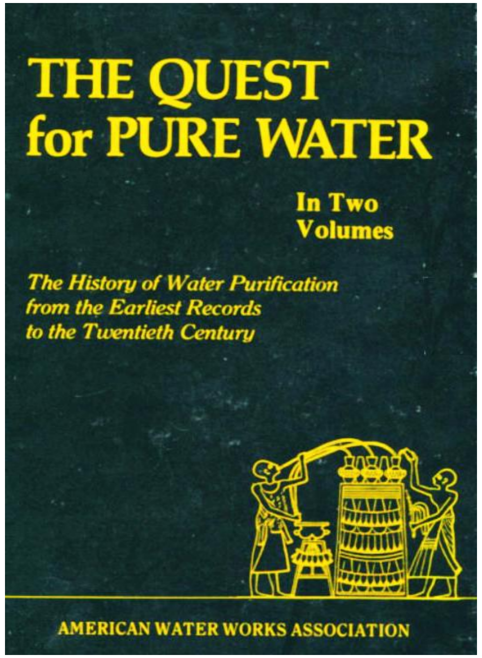
In 1838, James Simpson pointed out that slow sand filtration had greater removal capacity than mechanical filtration.

**39 years old**

**Did Simpson feel that biological activity was involved?**



M. N. Baker 1949.
*The Quest for Pure Water*




https://babel.hathitrust.org/cgi/pt?id=mdp.39015007372272&seq=10

## *James Simpson and the Chelsea Water Works Company*

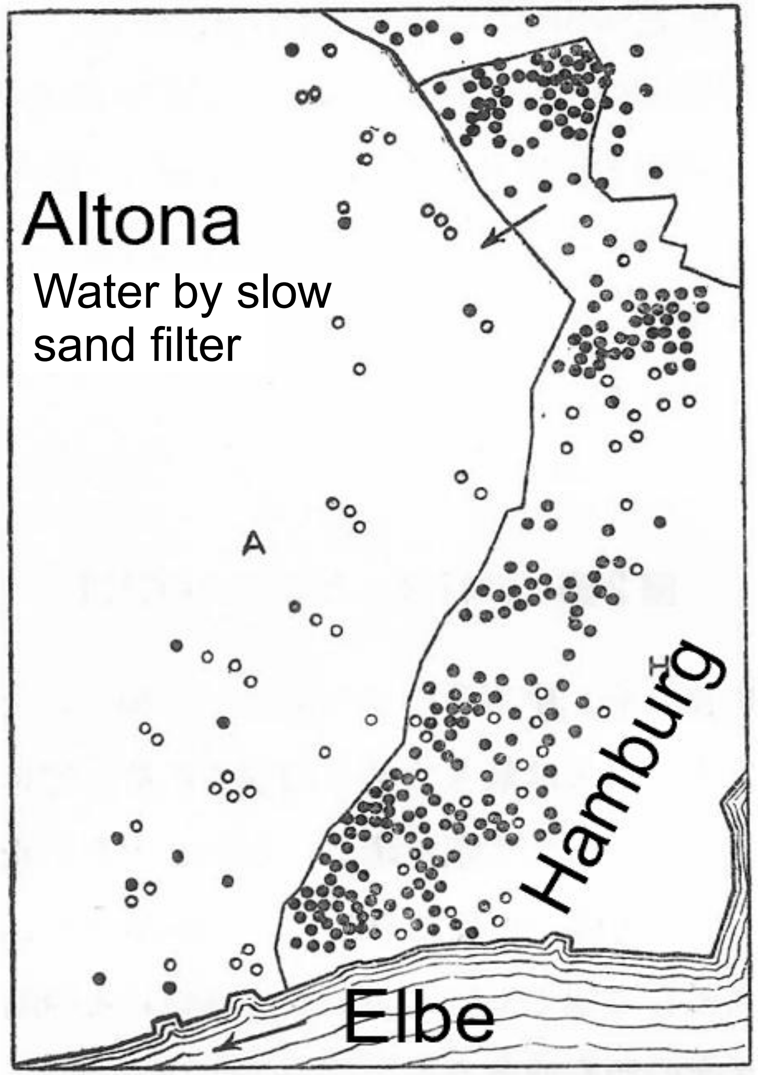
Best known of all the filtration pioneers is James Simpson. He was born July 25, 1799, at the official residence of his father, who was Inspector General (engineer) of the Chelsea Water Works Co. The house was on the north bank of the Thames, near the pumping station and near what was to become the site of the filter that was copied the world over. At the early age of 24, James Simpson was appointed Inspector (engineer) of the water company at a salary of £300 a year, after having acted in that capacity for a year and a half during the illness of his father. At 26, he was elected to the recently created Institution of Civil Engineers. At 28, he made his 2,000-mile inspection trip to Manchester, Glasgow and other towns in the North, after designing the model for a working-scale filter to be executed in his absence. On January 14, 1829, when Simpson was in his thirtieth year, the one-acre filter at Chelsea, commonly known as the first English slow sand filter, was put into operation.

Of the eight water companies supplying Metropolitan London in the 1820's, five, including the Chelsea until early in 1829, served raw water from the always polluted and sometimes turbid Thames, taken within the tidal reach of the stream into which numerous sewers discharged. The Chelsea Water Works Co., probably led by James Simpson, was the first to give official attention to this deplorable con-

Unfortunately, this drawing does not remain.

We (Thames Water) will be reporting our findings over the next 3 years and hope to have **an event in 2029 to celebrate 200 years since James Simpson's English Filter was established at Chelsea Water Works.** (2025/06/17)


Clear evidence of the effectiveness of slow sand filtration came in 1892: a cholera epidemic broke out in Hamburg, killing 7,500 people. However, in the neighbor city of Altona, which was supplied with water that had been filtered by slow sand, there were almost no deaths.



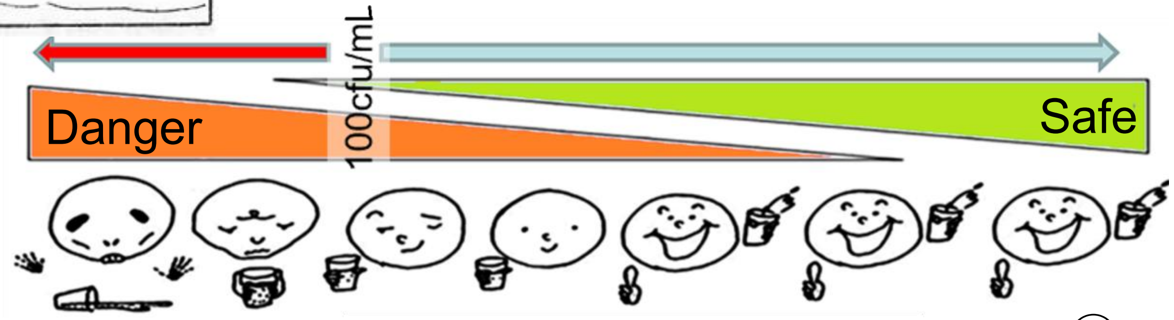

Robert Koch investigated bacteria in tap water and reported that **water is safe** for preventing cholera and typhoid **if the general bacterial count is less than 100 per mL.**

This idea and values are carried over to the current WHO drinking water standards.

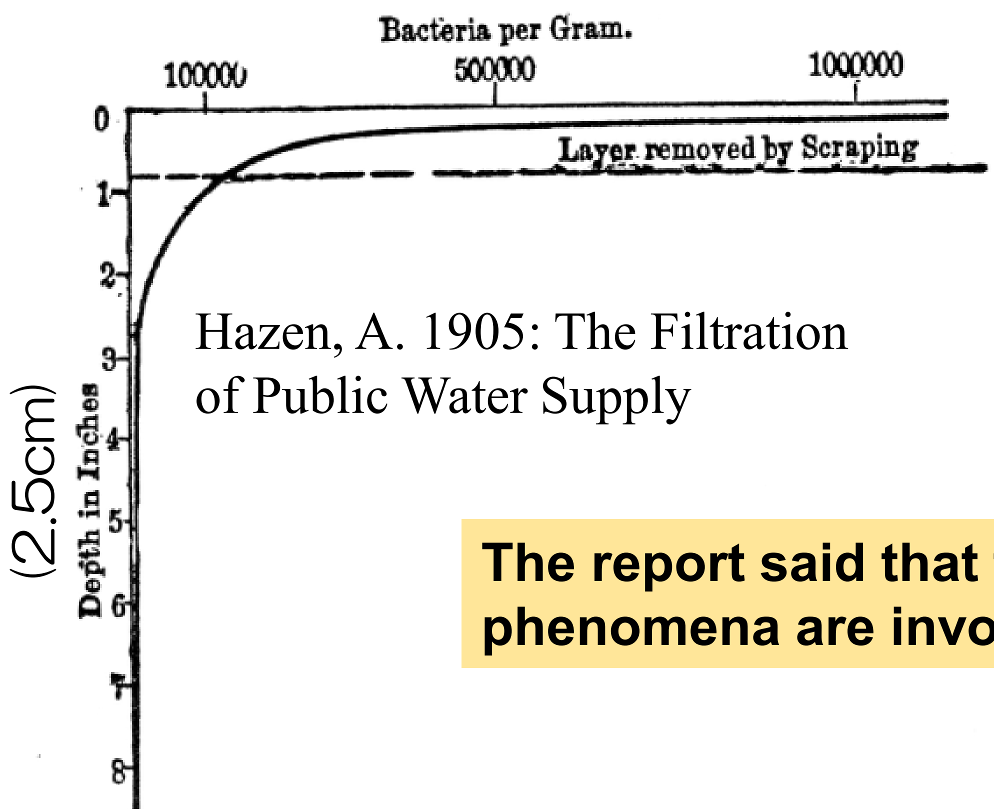
This idea does not require complete sterilization.

**This is an acceptable risk.**

Normally, even if we are exposed to small number of pathogens, humans have a strong immune system and are fine.
Reduce the risk of danger, dilute it, or make it an **acceptable level**.



**In 1838, James Simpson pointed out that slow sand filtration had greater removal capacity than mechanical filtration.**

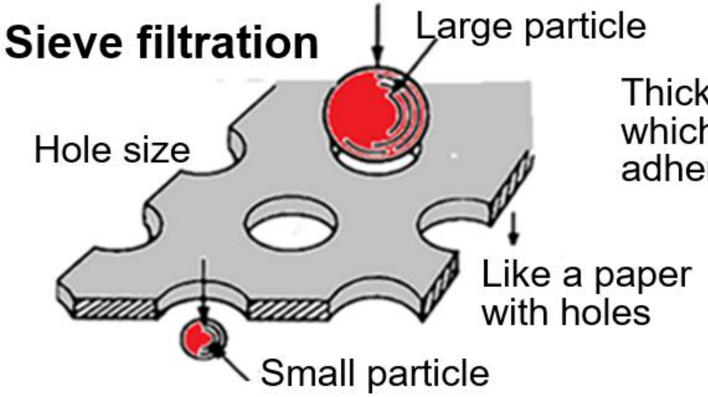


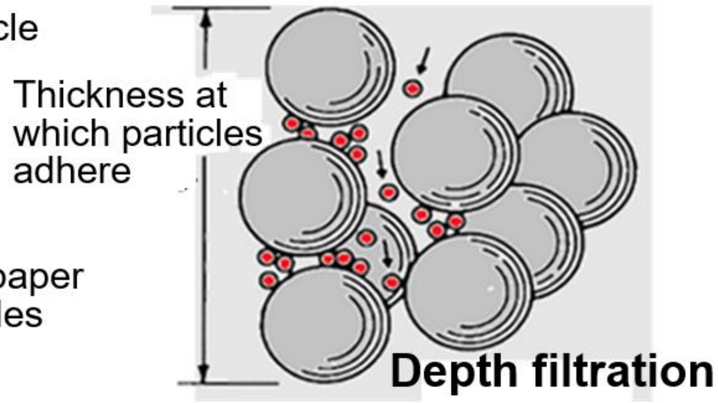

Hazen, A. 1905: The Filtration of Public Water Supply

55 years after Simpson's findings, in 1893, a report from a water purification plant in **Berlin** stated that only the upper part of the sand layer was polluted. **The erosion was deep in winter and shallow in summer. However, algae were in bloom in summer. When comparing open and covered filtration ponds and investigating bacterial removal for 20 years, the open filtration ponds had a better removal rate. The report said that this may have been something special.**

**The report said that temperature and solar radiation are related, that biological phenomena are involved, but that mechanical removal is the greater factor.**

**He was exactly as Simpson had described "slow sand filtration."**

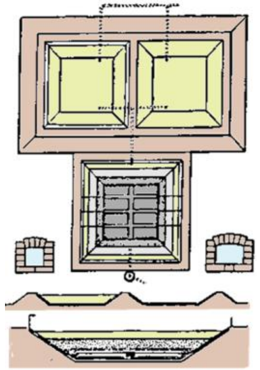



**Considering the size of the pathogens, their removal cannot be explained by the size or gaps in the sand, nor by mechanical sieving or filtering through the sand.**

# Open Filtrate Basin

Experiment filter 1827-1829



Practical Filter 1829

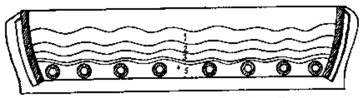


FIG. 29. CROSS SECTION OF SIMPSON'S ONE-ACRE FILTER FOR CHELSEA WATER WORKS CO., 1829

**Germ free filtrate**

1832: Richmond, Virginia, USA

From 1872: Poughkeepsie Filter plant, NY

Sand filter

Filtrate basin

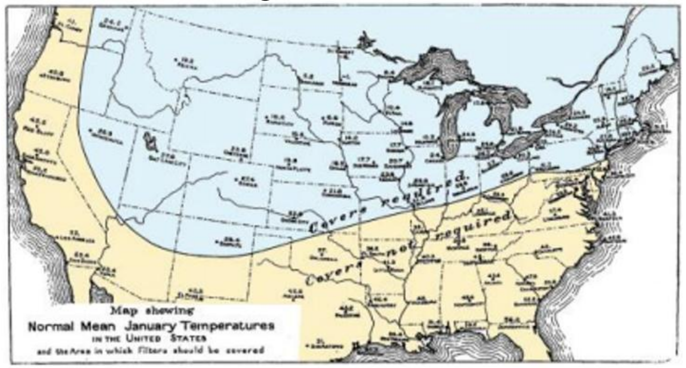

1891: Ilion, NY.



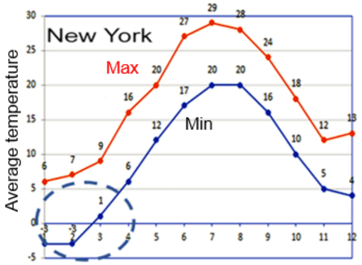
Slow sand filtration removed pathogens from the polluted water of the Thames, making it safe to drink.

The filtered basin was open because the pathogens had already been removed.

The average temperature in January is below 0 degrees.

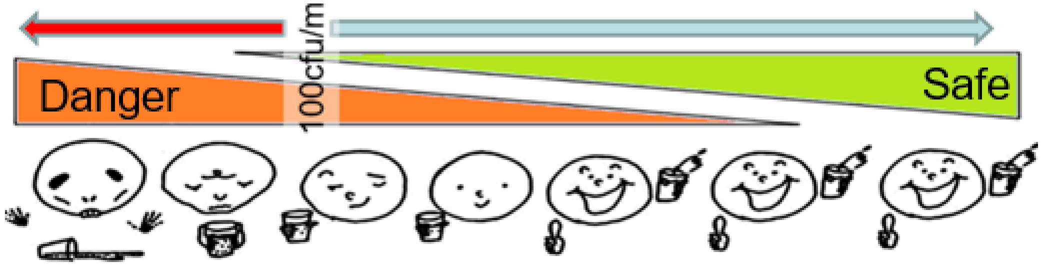



In the United States, it is recommended to cover filter ponds and filtrate basins to prevent freezing.



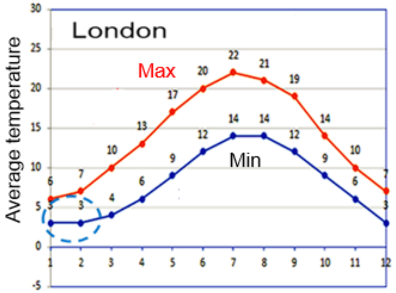

New York gets very cold in the winter and hot in the summer.

Normally, even if we are exposed to small number of pathogens, humans have a strong immune system and are fine.



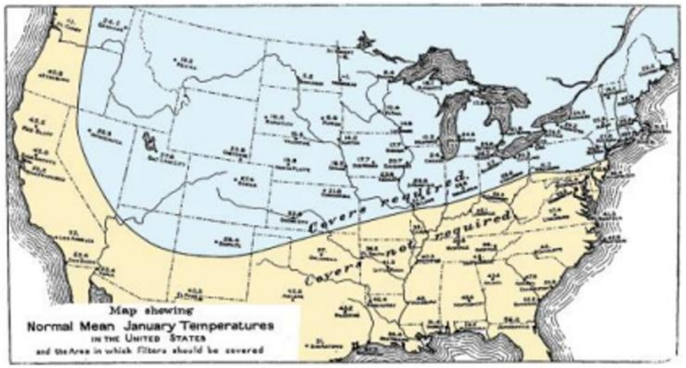

Vartry Water works, Dublin, Irlanda, from 1860s.

**Clear water basin is open in 1998.**

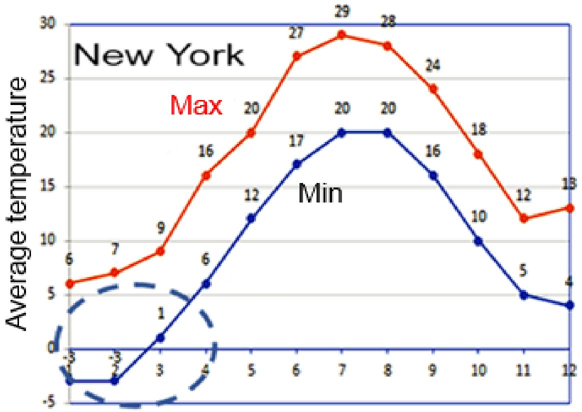




London doesn't get very cold even in winter.

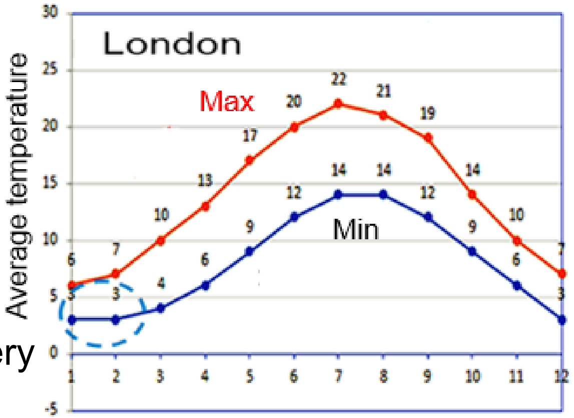



The inland of North America is extremely cold in winter.




New York gets very cold in the winter and hot in the summer.

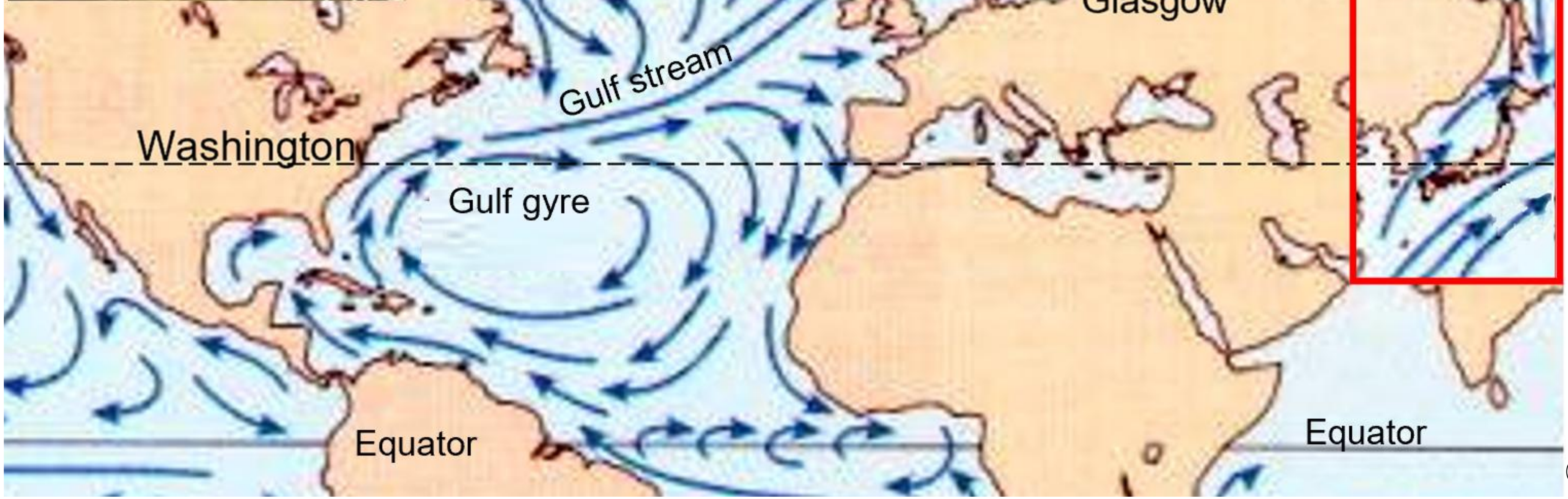
The warm Gulf Stream and the westerly winds keep Europe from suffering severe winters.




London doesn't get very cold even in winter.

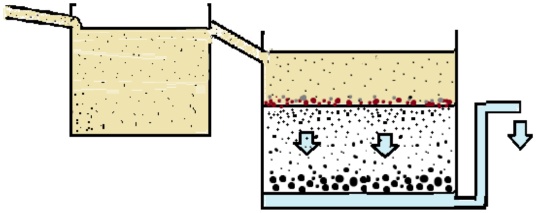
Covered filter, Albany, NY, US





**Development of rapid sand filtration with coagulation and chemical sedimentation treatment to combat turbid water.**

Winters in North America are extremely cold, so the water is very viscous.



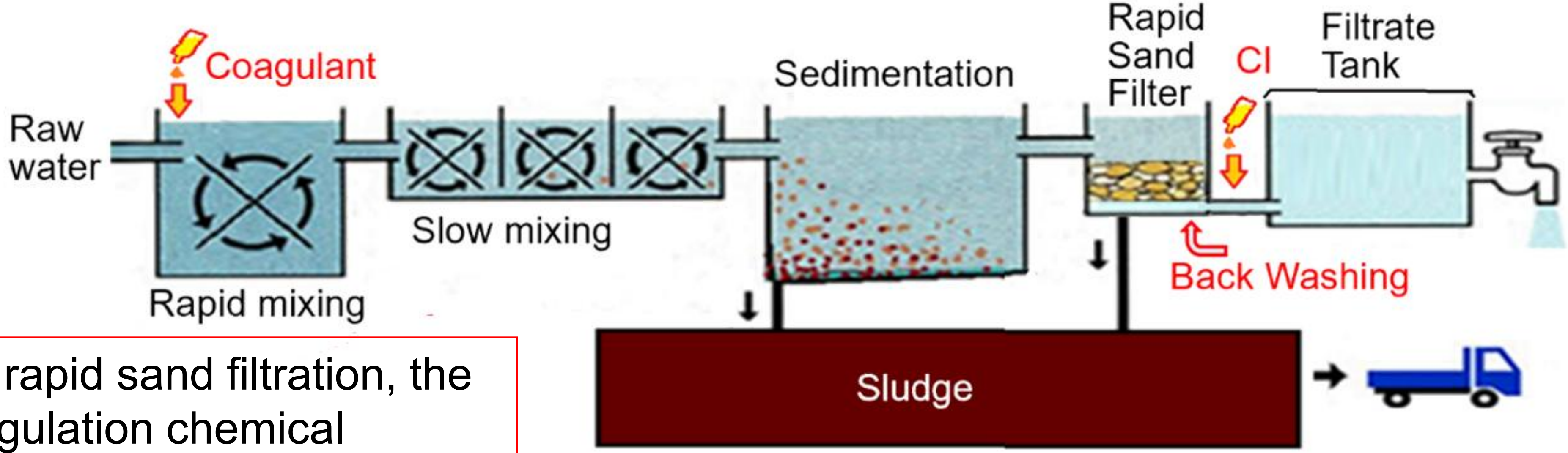
The muddy water in continental plain rivers is fine and does not sink.

The rivers of the New World were less polluted by farmland and cities.
⇒There was little food for living things.
⇒Biological activity was poor.

During extreme cold, the organisms were unable to active and the filtration ponds became clogged.

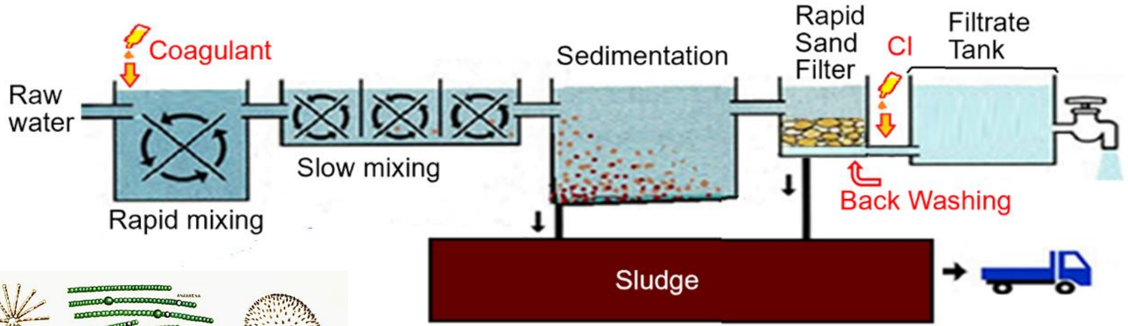
1882: New Jersey, USA: Coagulants used to combat turbidity: Origin of rapid sand filtration
1910: Safe water made safe by chlorine disinfection: Origin of American filtration
⇒ Spreads throughout the United States ⇒ Worldwide

**People love new things.**




Although it is called rapid sand filtration, the correct name is coagulation chemical sedimentation and filtration processing.

## From Rapid Sand Filter to a Safe Purification Method **without chemicals**: Rediscovery of Slow Sand Filter.

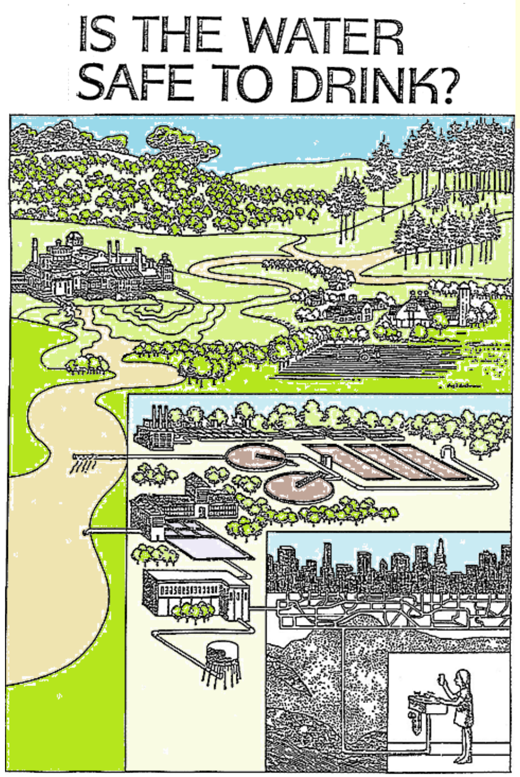



Tast, Odor algae

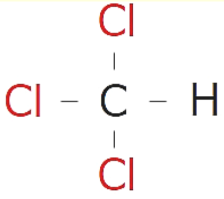
Filter clog algae

Algaecide is common practice in rapid sand filtration.

In 1962, R. Carson published Silent Spring. It warned that the pesticide DDT was causing biological condensation, killing not only insects but also other unexpected organisms. It warned of the dangers of chlorinated compounds.

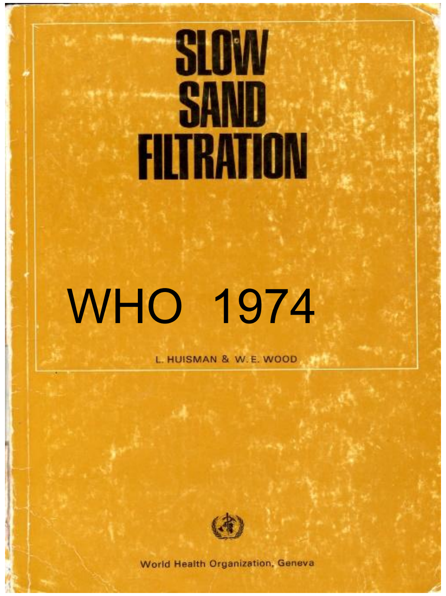

Robert H. Harris and others Consumer Report, June, 1974.




Tri-halo methane

They point out the risk of carcinogens in chemically treated tap water, the risk of asbestos pipes, etc.

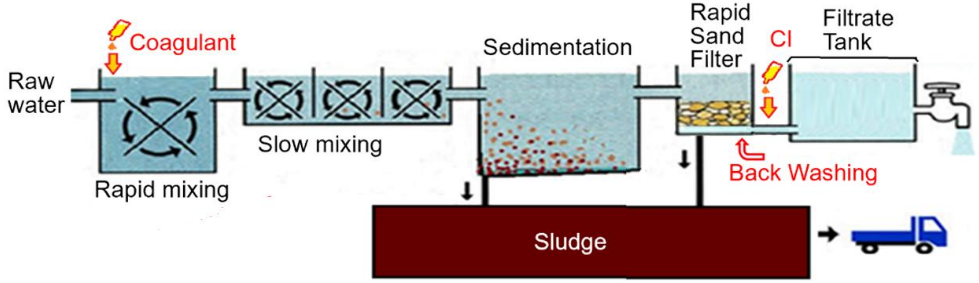
Slow Sand Filtration: a safe chemical-free purification method, by Huisman and Wood, 1974




WHO 1974

## A large-scale outbreak of diarrhea caused by Crypto zoa that had passed through rapid sand filtration.

## Rediscovery of slow sand filtration without backwashing




In April 1993, an outbreak of diarrhea caused by Cryptozoa occurred in Milwaukee, USA, affecting 400,000 people. Rapid sand filtration was carried out through the backwash process.

Backwashing lets everything pass through.

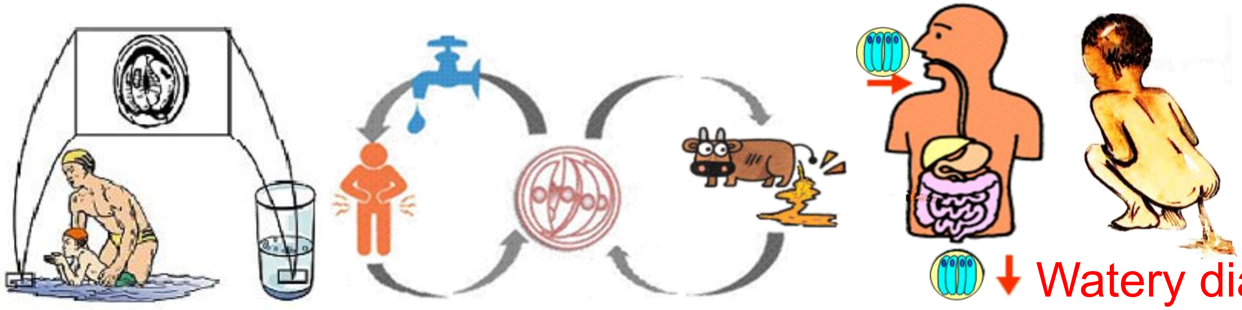

The dormant protozoa have a thick shell and cannot be killed by chlorine, so they pass through the rapid sand filter.

Rapid sand filtration is recognized as a completely defective process.

In September 1994, the American Water Works Association held a workshop on slow sand filtration in Salem, Oregon.

**Refocus, Rediscovery, Timeless Technology for Modern Application.**

## However, people loves New Technology.



Watery diarrhea

Only mammals with long intestines get diarrhea.

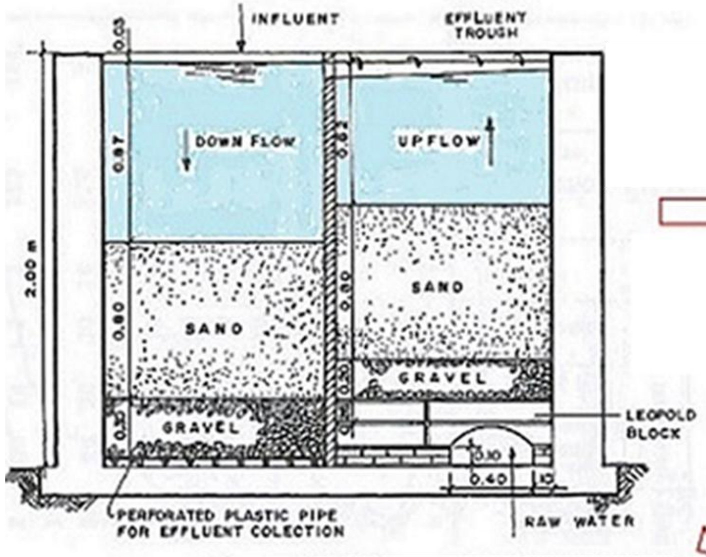
June 1996: Mass diarrhea in Ogose, Saitama Prefecture

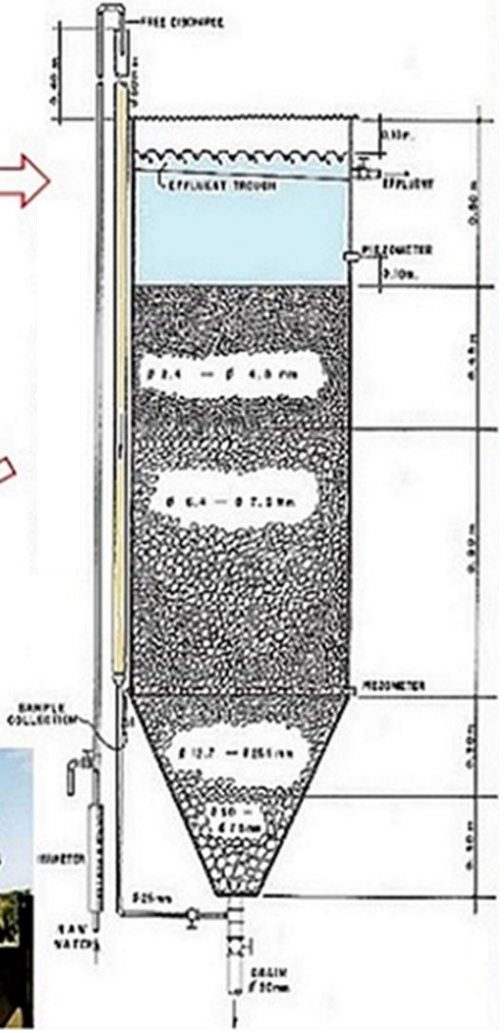
Japan recommended membrane treatment.

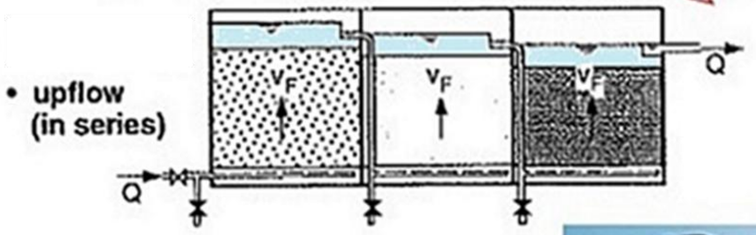
# Development of Eco-friendly and Chemical-free turbidity countermeasures: **Up-flow Roughing Filter.**

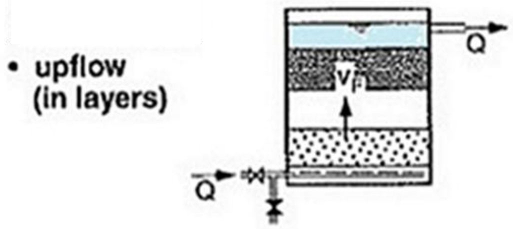
Luiz Di Bernardo 1980

Down Flow and Up-Flow Univ. São Paulo, Brazil

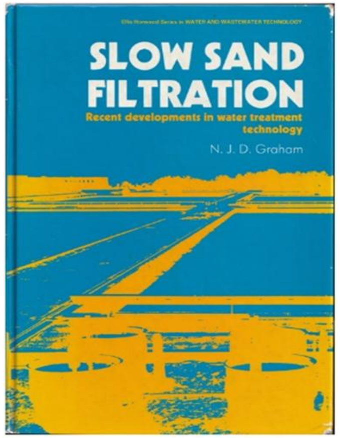


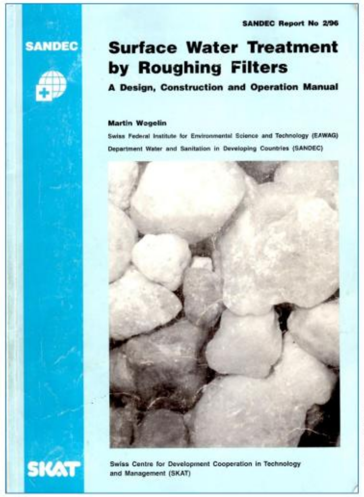




Up-flow Roughing Filter: presented at the International Conference on Slow Sand Filtration, London, 1988



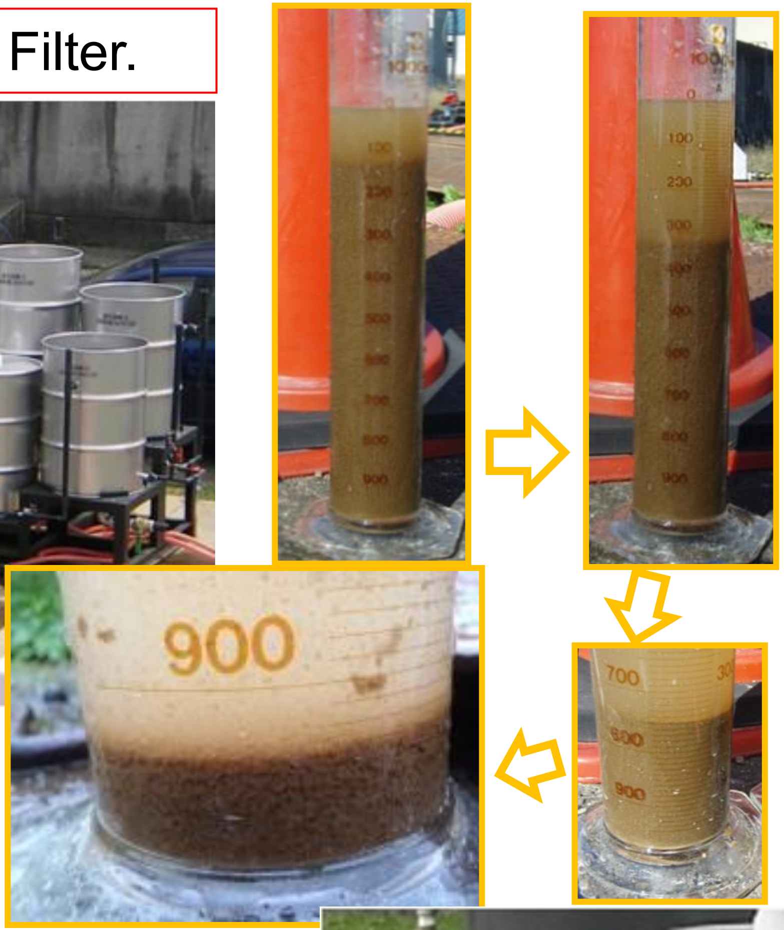

At the international conference in 1988, Martin Wegelin from Switzerland reviewed past roughing filters
⇒International joint experiment
⇒In 1996, a roughing filter manual was published in Switzerland.



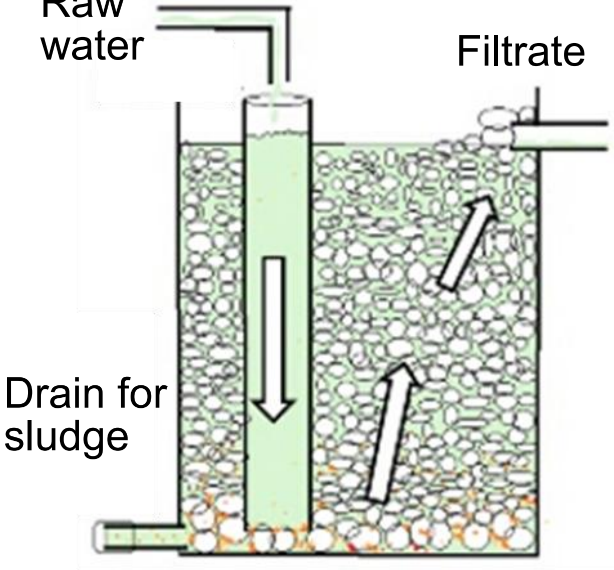

https://www.ircwash.org/sites/default/files/Wegelin-1996-Surface.pdf

Martin Wegelin
Swiss Federal Institute of Aquatic Science and Technology

# The role of the biological community was also key in Up-flow Roughing Filter.

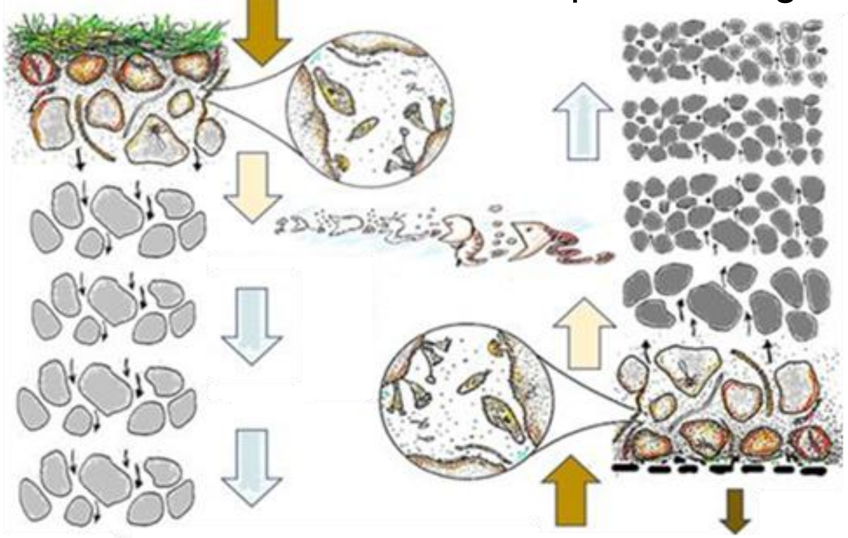



## Up-flow Roughing Filter

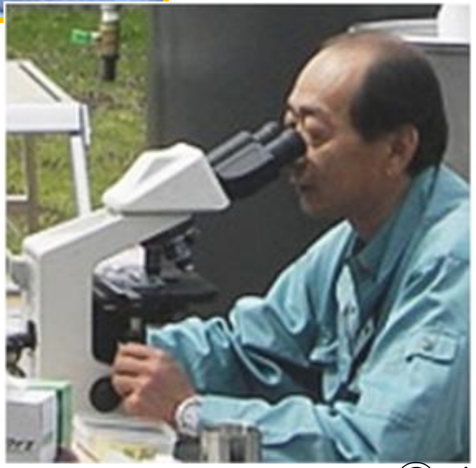



Slow Sand Filter

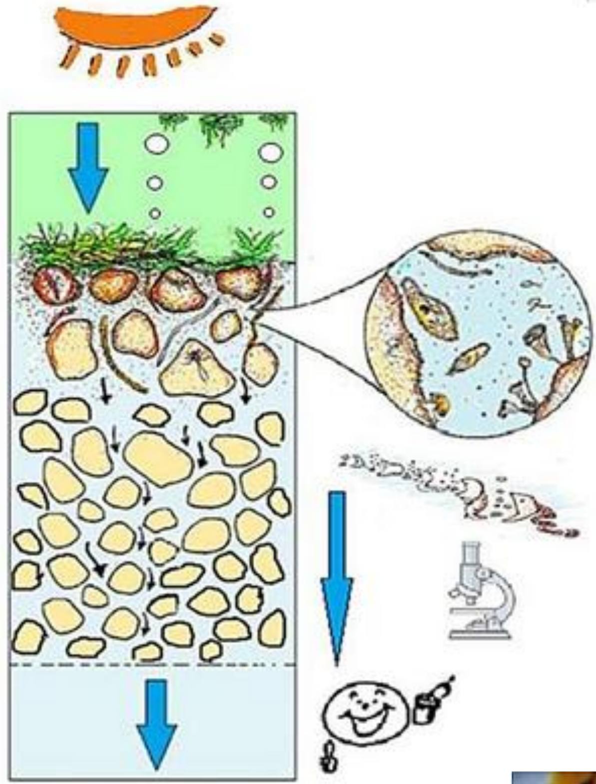
Up-flow Roughing Filter



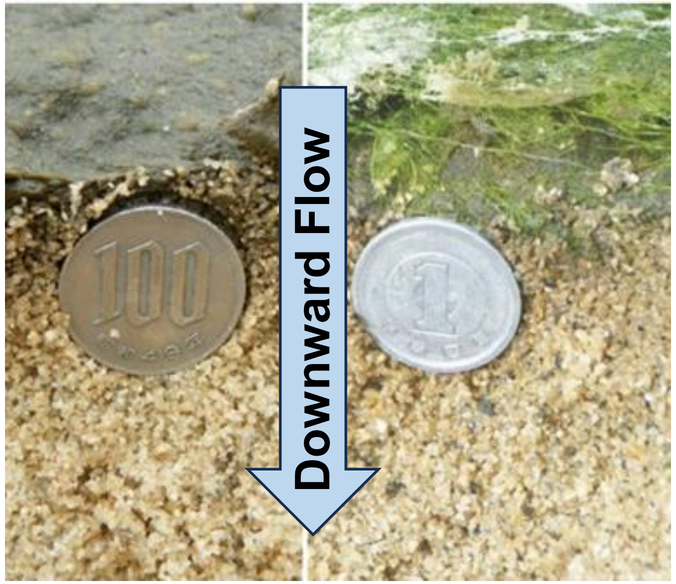
It has good settling properties and is similar to activated sludge in sewage treatment, where the biological community is active.



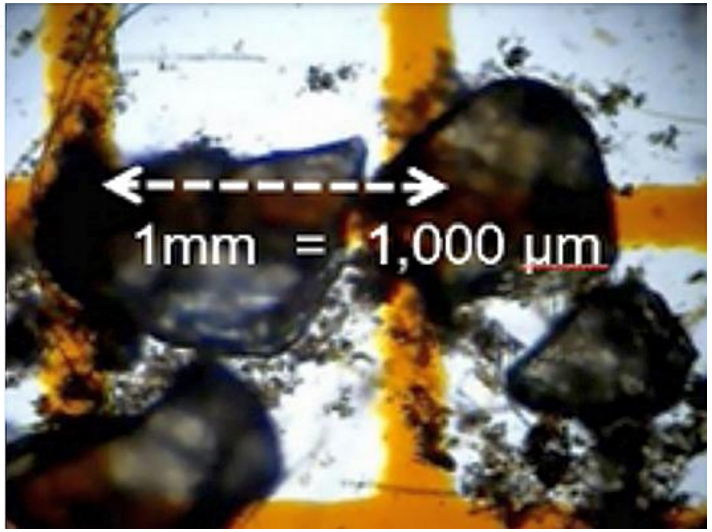
**The activity of biological communities is key.**



Artificial delicious spring water

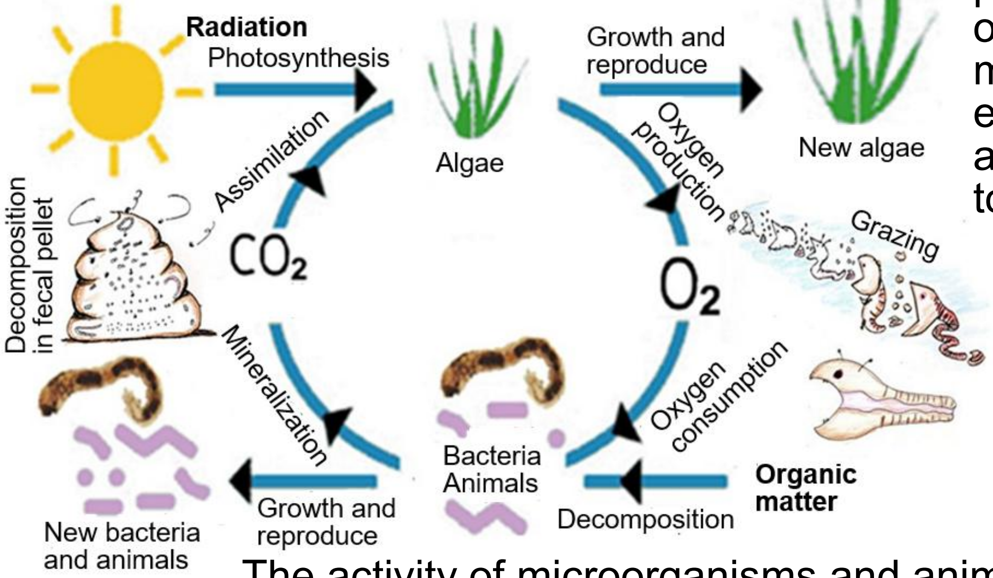



**Gentle for small organisms.**
The sand does not move even when the flow rate changes.



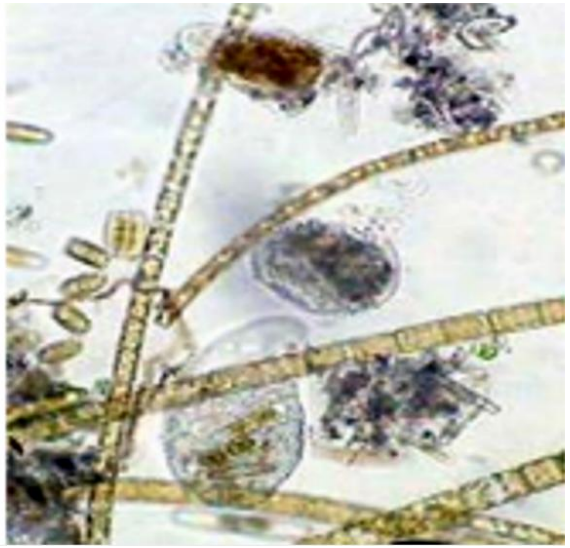

Organisms smaller than the size of sand are active here.

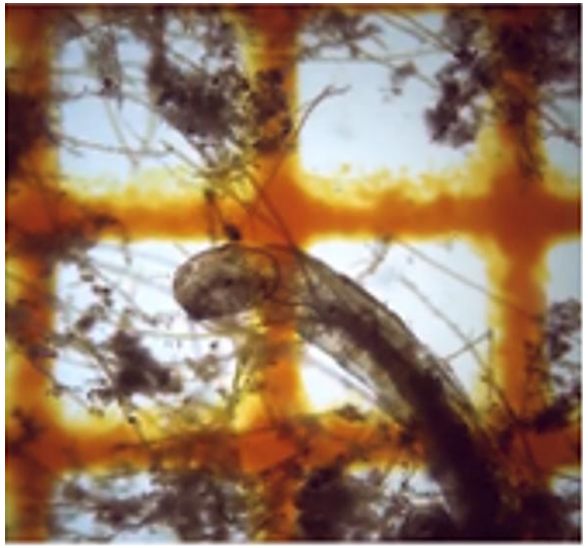
Photosynthesis is dependent on the amount of **solar radiation**.




Algae produce oxygen, making it easier for animals to thrive.

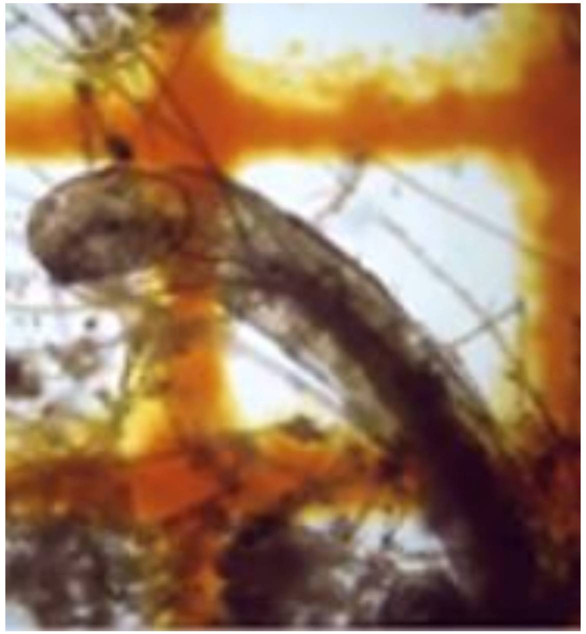
The activity of microorganisms and animals is related to **temperature**.





**Hungry microscopic animals will eat anything.**

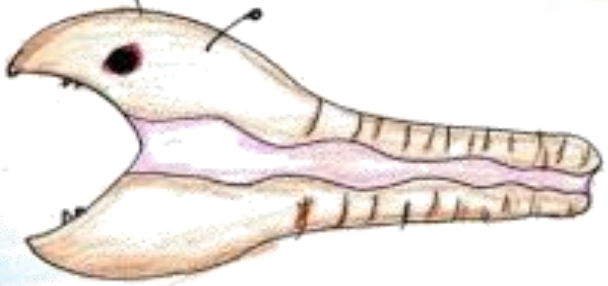
## Hungry animals move around in search of food and will eat anything they can.





### Short time work.

It only takes a split second for the microscopic organisms to capture food and any suspended matter.

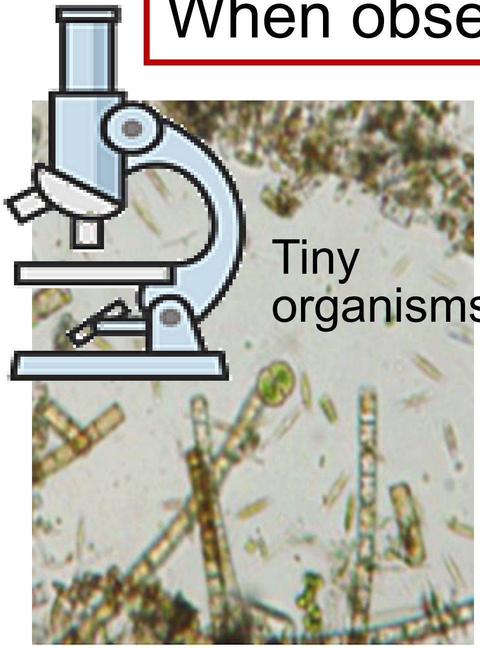


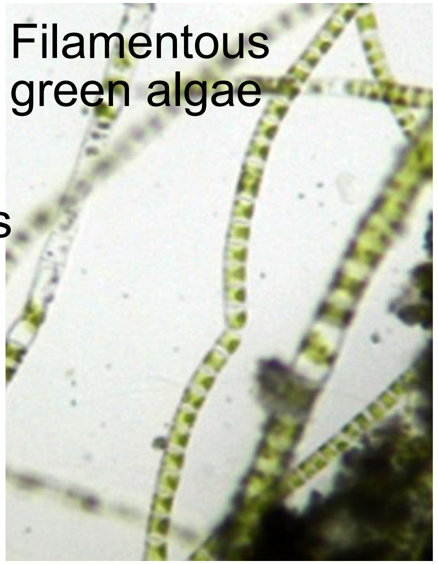
The food that is eaten passes through the intestinal tract in a short time and is immediately excreted as feces.

### Long-term action.

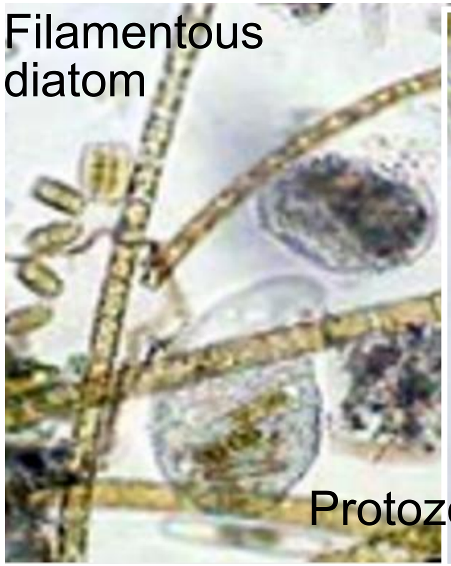
Decomposition takes place over a long period of time within the feces. Fermentation progresses in the anaerobic environment with a lack of oxygen, breaking down polymers into smaller molecules.

# When observed under a microscope, algae and other tiny organisms are at work.


Tiny organisms


Filamentous green algae


Protozoa Vorticella


Filamentous diatom


Protozoa Ciliate


Oligochaeta


Nematoda


Rotifer


Chironomid larvae


Carnivorous dragonfly nymph


The snail eats green algae.


There are clams in the sand layer.

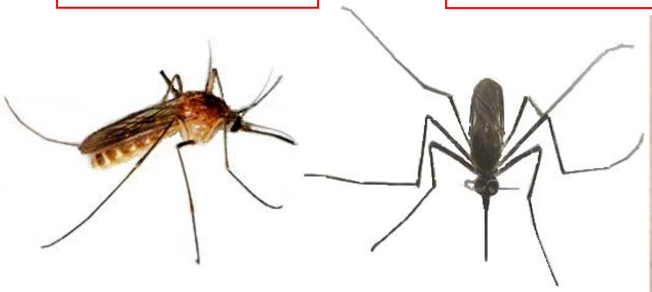
In slow sand filters, the **food chain** is the key to purification - eating and being eaten.

# **Chironomid** is not same as **Mosquito**.

*Chironomid*

*Non-biting Mosquito*

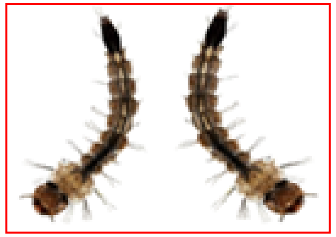
*Mosquito*



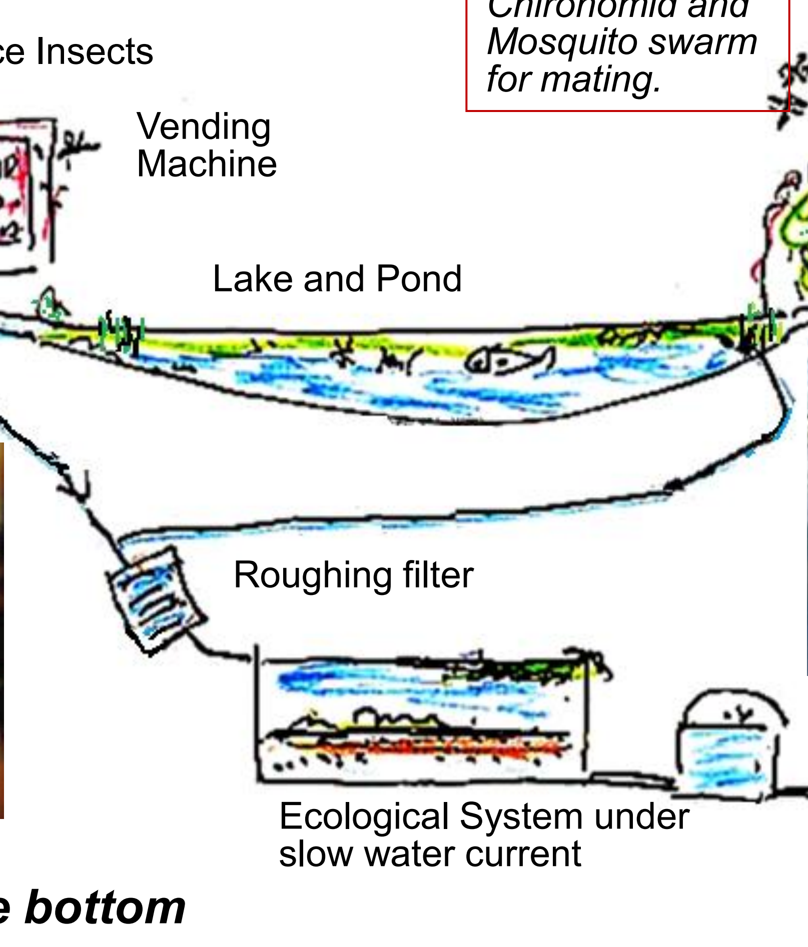
*Biting Mosquito (Female)*

*Both Midges of Chironomid and Mosquito swarm for mating.*

**Midge swarming**

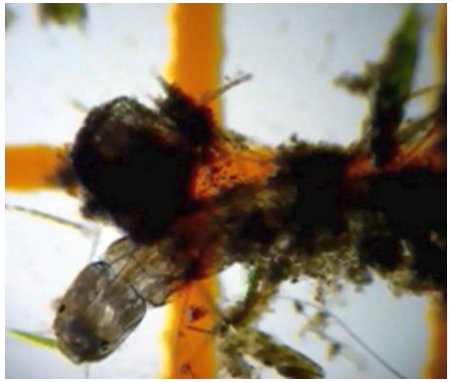


***Mosquito larvae live in stagnant environments.***

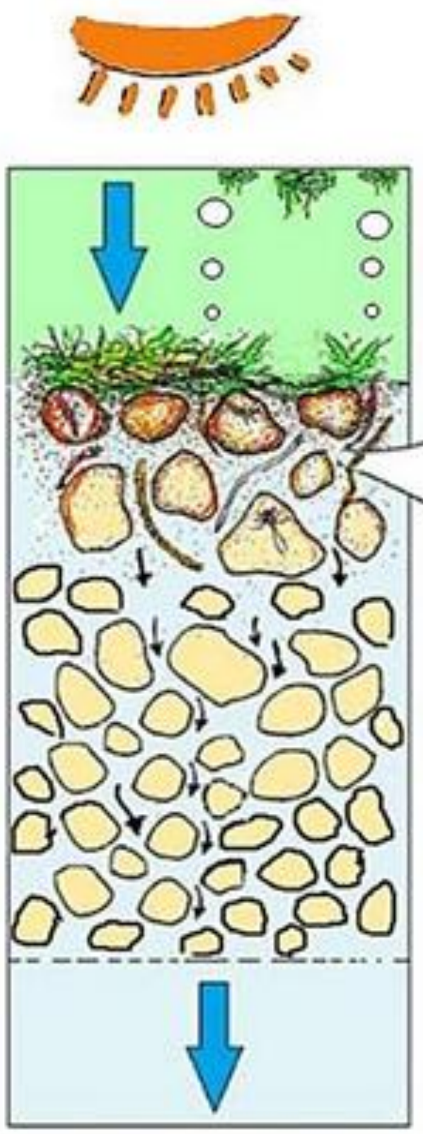



***The mosquito larvae float on the water surface, drifting with their tails up. Their tails act as respiratory organs, and they bring them to the surface to breathe.***

Chironomid larvae are active on the muddy surface, sandy surface, and upper part of the sand layer. These environments with currents have dissolved oxygen.

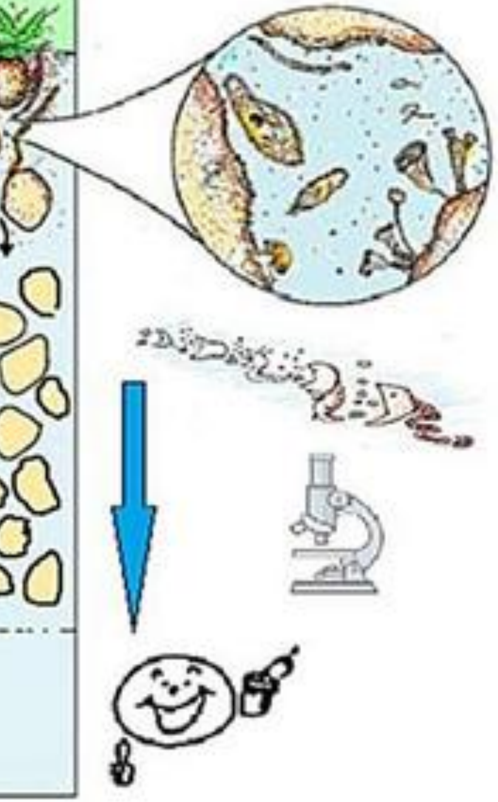


*Chironomid larvae:*
***making nest at the bottom***



Algae grow on the sand surface.

Animals work near the surface of sand layer.



Hungry organisms works in this EPS.

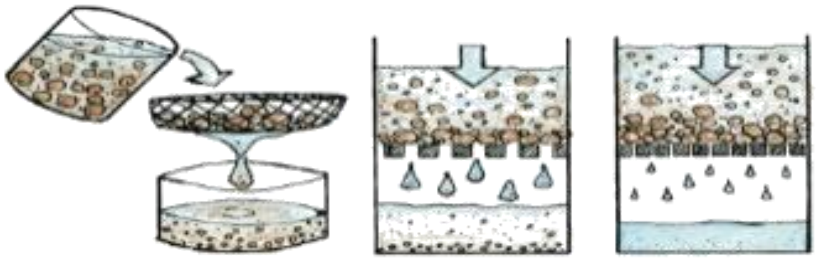
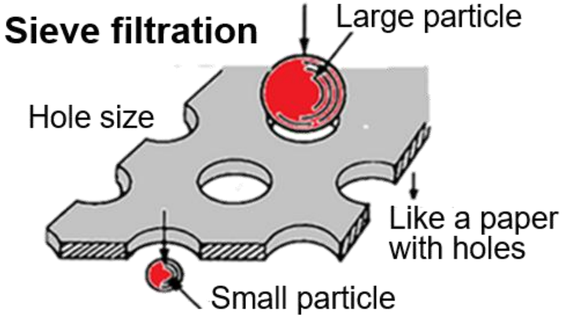
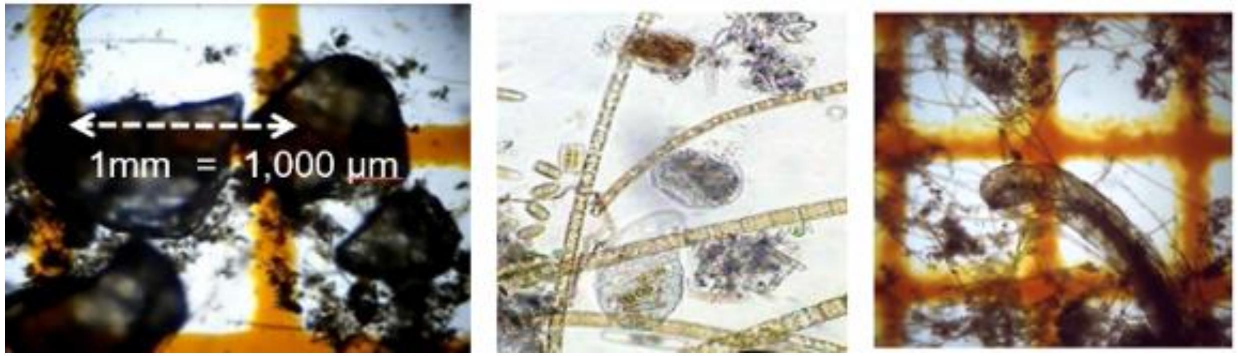


Image of Slow Sand Filter.



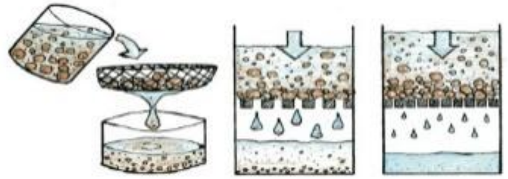

Slow Filtration with fine sand under slow current.

**Food chain is the Key.**

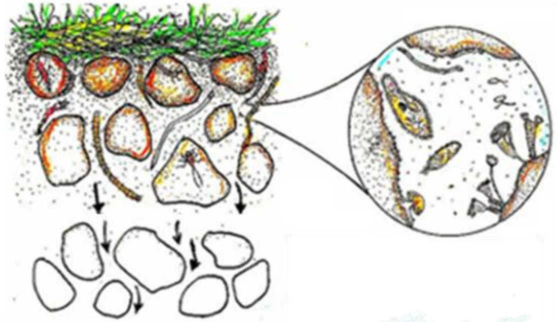
Slow Sand Filter → **Ecological Purification System**

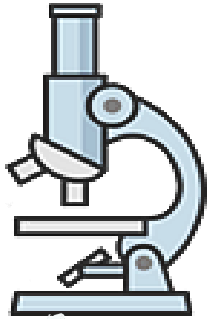
**slow** → **gentle**

**Slow Sand Filter**



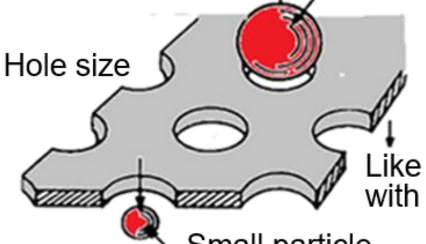
Purification mechanism of SSF was misunderstood by the name.

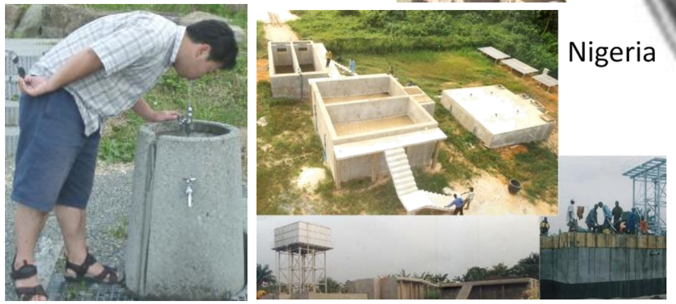


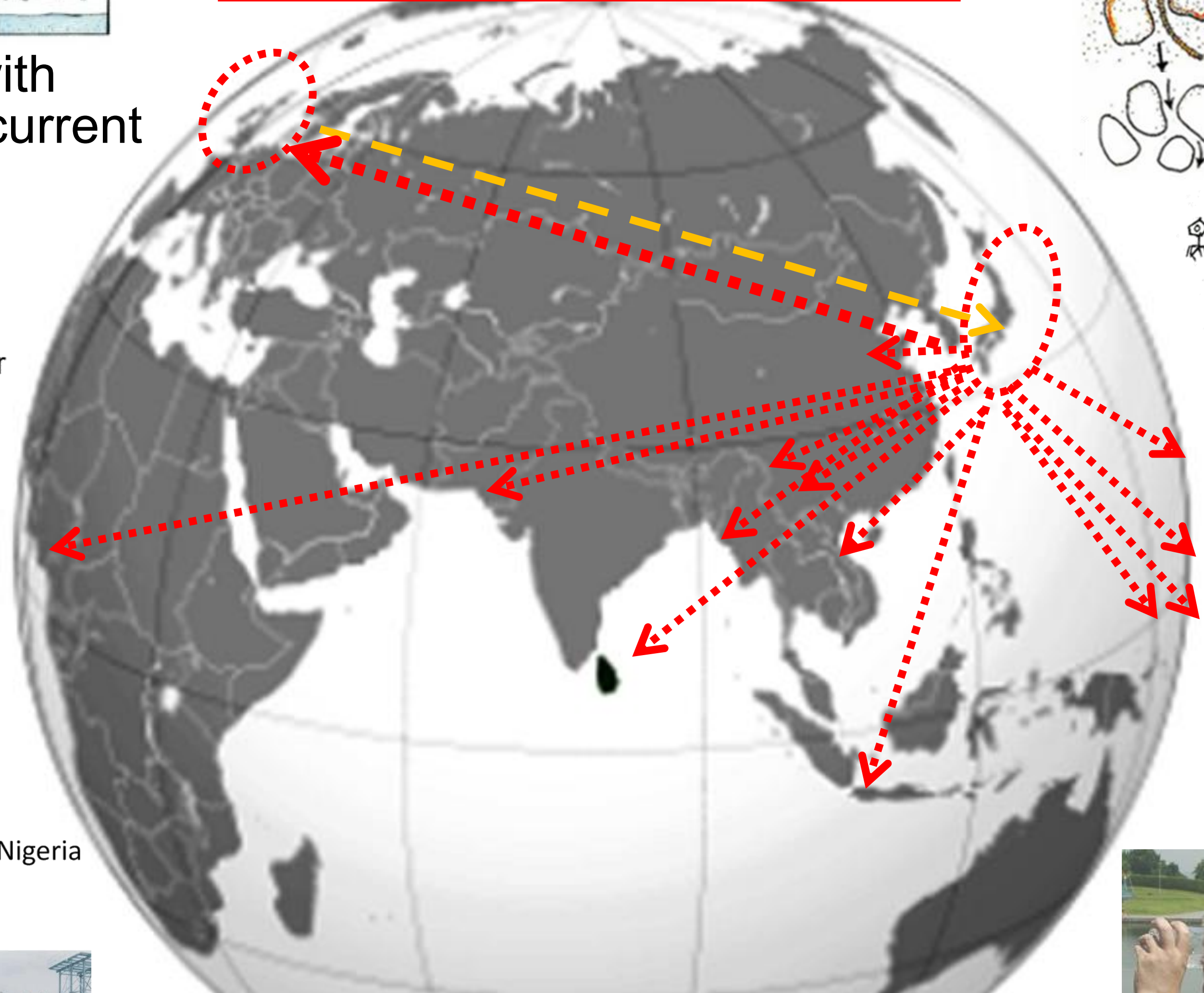


Mechanical filtration with fine sand under slow current

**Sieve filtration**



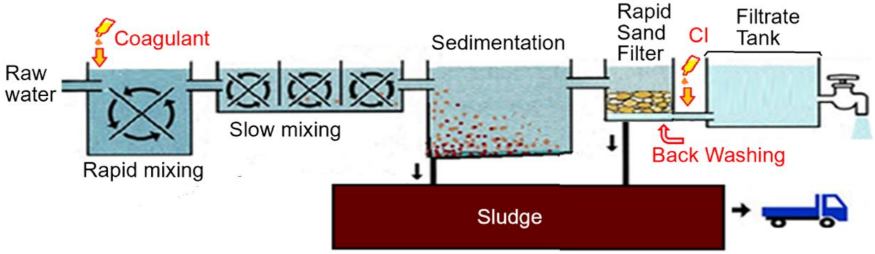
Slow sand filtration, which originated in the UK 200 years ago, was reborn in Japan as the Ecological Purification System (EPS). From Japan, EPS began to spread throughout the world.

# Ecological Purification System from Japan to the world

*Super clean delicious water*

*Trust Our Sense !*

A large-scale outbreak of diarrhea caused by Crypto zoa that had passed through rapid sand filtration in April 1993.




Backwashing lets everything pass through.

Refocus to Slow Sand Filtration after the large-scale outbreak of diarrhea caused by Crypto zoa.